Revisiting the Biferno Valley: Understanding the Roman rural world through the application of legacy survey data in predictive modelling

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Figure 1. (Cover) Field-walking in the South Etruria Survey (BSR Photo Archive in Patterson et al., 2020, E)

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1. Introduction

1.1 General Introduction

The rural world and the people living therein played a major role in Roman economy and society in general. In fact, the majority of the Roman population worked in the agricultural sector, in which activities generally took place away from urban centres (Kehoe, 2007, p.1). As a result, the rural world was not only of great importance in providing subsistence to the ever growing population in Roman cities, but a potential source of great wealth too (Van Oyen, 2020, p.122). This led to people in the higher echelons of Roman society attempting to govern the farms and villas in the empire through institutions and contracts (Kehoe, 2007, p. 29). This attests to the close ties between rural farmland and urbanized centres.

For archaeologists, understanding the organization of the countryside thus brings knowledge not only on agriculture, but also on empire-wide connections between rural and urban, poor and rich. The primary method archaeologists have used to gather large amounts of data on the rural world is the archaeological field survey. By means of this type of research, it is possible to find and interpret sites across large areas, providing insights into the social and political circumstances of the past (Alcock and Cherry, 2004, p. 189). As such, projects of this kind have yielded incredible amounts of data over the past century. Nevertheless, there are numerous challenges that arise when attempting to use this data to construct archaeological narratives. For one, methodologies and logistics often vary significantly between different survey projects, as well as their research focus. Furthermore, surveying is inherently biased towards easily accessible terrain, as this is logically where the majority of field research takes place (Attema et al., 2020, p.7). Still, it is important to note that even a theoretically sound survey in which harsh terrain is also covered, does not necessarily signify a complete understanding of the region (Sullivan III et al., 2007, p.328).

This thesis addresses these two prevailing issues: the lack of understanding of the rural world and the challenges associated with using existing survey data. To address both the practical and the methodological aspects, the case of the Biferno Valley will be used.

This region, located in the Italian province of Molise, has been surveyed by the Biferno Valley Survey project from the 1970s to the 1990s. Despite the incredible amount of data gathered, challenges exist due to the changing methods employed and the fact that only part of the terrain was surveyed intensively (Barker, 1995, p.42-44). This project will serve as an example to find out how legacy survey data can still be used to gain new insights, in this case for the Roman rural world.

In this research, a predictive model of rural sites will be built for the entirety of the Biferno Valley. This will allow for a better understanding of the region on a large scale. This model will visualise the likelihood of a rural site having been present at specific locations in the research area and will allow for a more holistic analysis of the past. To ensure a proper functioning of the model, a solid theoretical framework needs to be in place. Therefore, a theoretical assessment of factors that influenced the location and findability of sites will take place first. Both human and natural aspects in the environment, as well as socio-economic processes, will be considered. These analyses will be carried out for a relatively long period of time, spanning from the early Roman Republic to the Imperial period. Therefore, the development of these factors over time will also be assessed. The predictive model will build upon the findings done in this research stage and will be validated through the already existing survey data of the region. In the rest of this first chapter, the state of background knowledge and the specifics of the research area will be elaborated upon. Then, the research goals and questions will be laid out, followed by an outline of this thesis.

1.2 Background Sketch

As mentioned, archaeological surveys are a commonly employed method of uncovering rural sites. However, there is no single unified way of carrying out such fieldwork. Over the years, new focal points and methods for surveying have developed. Despite the large number of archaeological surveys that have taken place over the past decades, collaborations between projects remain difficult (de Haas & van Leusen, 2020). Survey archaeology finds its origins in the nineteenth century, when ancient sites in the Mediterranean attracted many travellers who often drew or wrote about what they saw. In the twentieth century, surveys became less individualistic and more unified.

More sites belonging to other historic time periods became popular and more attention was paid to their layout (Corsi et al., 2014, p.192-193). The term ‘site’ has already been used multiple times in this text. Generally it indicates an area of high human activity. Still, the term remains quite broad, posing another challenge in archaeological research. A detailed explanation of this issue can be found in section 2.3. Throughout the twentieth century, surveys continued to develop. Initially, unsystematic field-walking was often used to document large areas in limited detail. This changed when processual archaeology rose to the front in the 1960s. This gave way to a more intensive way of surveying. In this wave, already known sites were disregarded in favour of random sampling of the surrounding terrain (Alcock and Cherry, 2004, p.3; Corsi et al., 2014, p.194-195). Since then, archaeological surveying has become more interdisciplinary. Studies of surrounding landscapes, for example, became an important aspect of surveys. This, together with the rise of the systematic use of relational databases and Geographical Information Systems, GIS in short, allow for more profound spatial analyses (Alcock and Cherry, 2004, p.3). Over the past years, remote-sensing and geophysical studies have been leading to a new, more detached kind of archaeological surveying, in which remote-sensing plays the most prominent role. For now though, surveying in the field continues to be paramount in forming an understanding of sites and the distribution of artefacts (Campana, 2017). This process of translating surface remains into an image of the past requires many practical and theoretical steps and agents. Figure 2 displays the large sets of factors and people at play in an archaeological survey. The image once again highlights how many variations can occur between projects as a result of differing metholodologies.

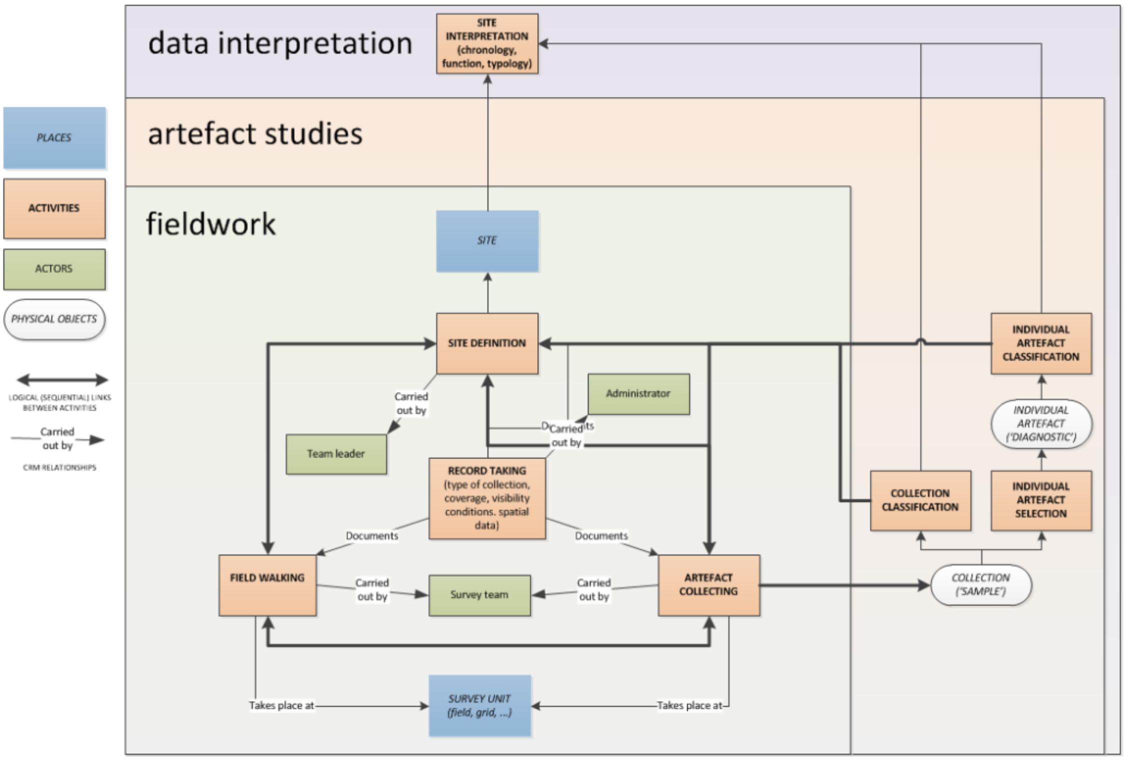


Figure 2. Schematic overview of archaeological surveying (de Haas & van Leusen, 2020, p.8)

In the research presented here, archaeological surveys perform the role of collecting primary data regarding sites. Completed surveys have yielded much information on the location, chronology and function of sites. Consequently, many archaeologists have performed statistical work on the gathered data (de Haas & van Leusen, 2020). However, many such attempts have focused heavily on the statistical side of things. Various tools are often used to analyse the archaeological record without first considering the meaning of the remains (Baxter, 2015, p.3-4). As such, the context of sites and their usage in the past is often forgotten. An associated risk is the disregarding of agency and intentionality of people, and perhaps materials, in the past. As a result, one could argue that people's worldviews are not considered enough. Therefore, this research focuses on creating theory-based hypotheses first. These hypotheses will be tested with the help of statistics and spatial analysis on the recorded sites, rather than the other way around. By combining survey data with information regarding landscape, infrastructure and social life, it is possible to grasp which role these sites fulfilled in the political and economic climate of the Roman period (Alcock and Cherry, 2004, p.189). Still, issues regarding the use of survey data, which will be discussed later, remain prevalent. For that reason, another technique, predictive modelling, is employed to present site patterns in relation to other environmental and human factors. This will be done for a large area in order to gain a more holistic overview of the organization of this part of the Roman world.

Simply put, predictive modelling estimates the location of sites or finds in a region, based on already existing information or on what we know of human nature (Verhagen, 2007, p.13). Predictive modelling itself originated in the 1960s. At this time, the ecological approach in 'new archaeology' found traction. This approach is based on the premise that humans are influenced by environmental factors, and as such, the location of sites is too (Verhagen, 2007, p.14). The use of predictive modelling was initially most popular in Cultural Resource Management in the United States, where the concept of identifying historic aspects in the landscape was in high demand. Together with the rise of quantitative methods in the following years, this formed the basis of predictive modelling as we know it. Since the late 1970s, the rise of more sophisticated computers allowed for more elaborate mapping through GIS-programmes (Verhagen, 2007, p.15).

In general, two main kinds of predictive modelling are applied. On the one hand, there is data driven modelling. This way of working consists of statistically analysing relations between archaeological sites and environmental factors. The findings are then projected on a larger area. In general, this approach has been the most often employed one (Verhagen, 2007, p.13). On the other hand, there is theory driven predictive modelling. This approach starts with the formulating of a hypothesis on the location of sites. Then, various environmental and social factors are selected and their importance assessed to form the basis of the model (Verhagen, 2007, p.14). Besides these factors, the impacts of taphonomy has to be taken into account. Such processes, both human and natural, influenced the location and visibility of sites since their abandonment. It is thus important to keep in mind that the observed pattern through surveying likely does not fully match the pattern that was in place in the past (Peters & Stek, 2022, p.1-2). Figure 3 illustrates that taphonomy is not unified and that it has a varying impact on the landscape and the archaeological remains therein.

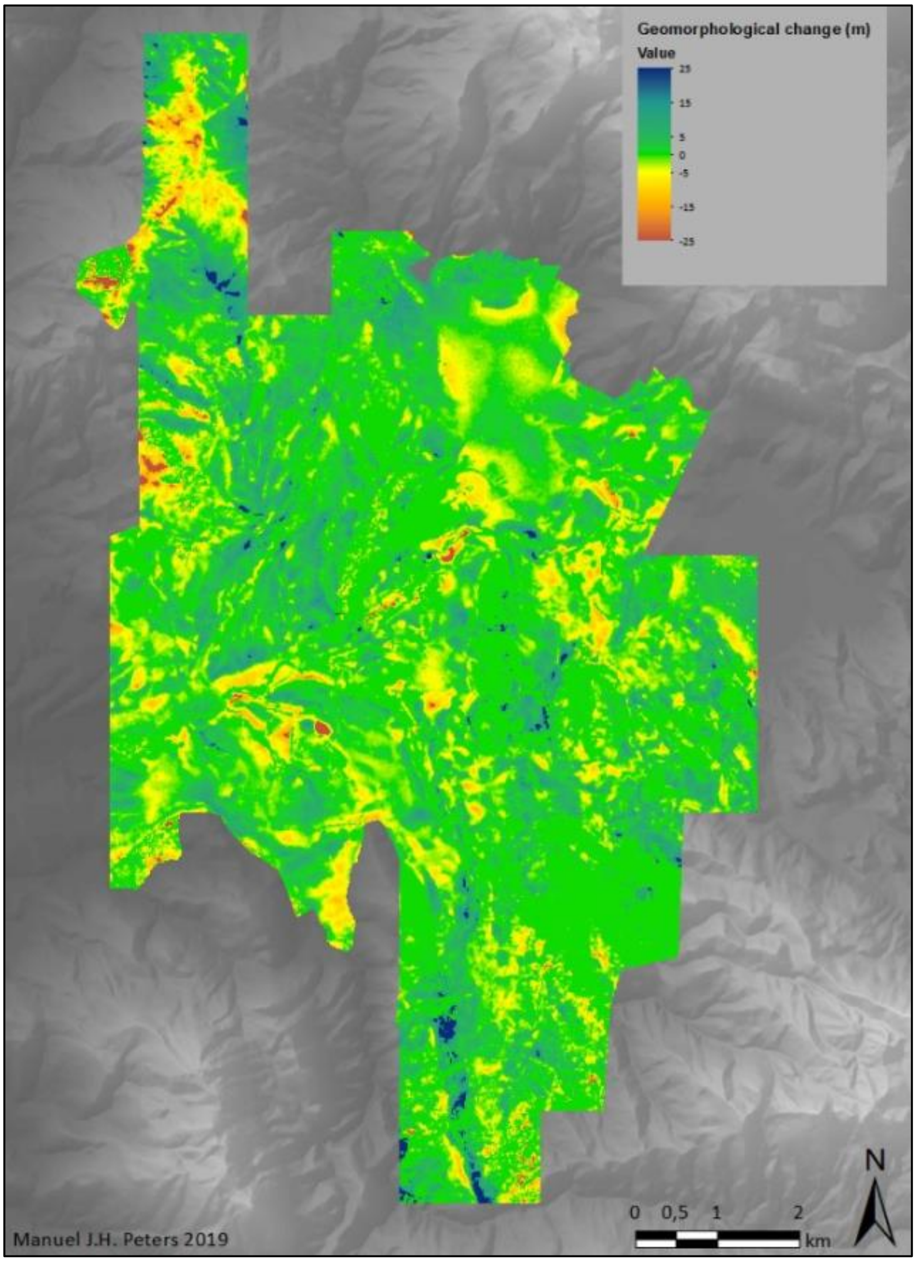


Figure 3. An example of geomorphological change in Molise visualised
(Peters & Stek, 2019, p.15)

In this research, the theory driven approach will be used. Firstly, a hypothesis will be based on a theoretical assessment of the Bifern o Valley. The model will then build upon the findings in this stage. This approach will, in contrast to a data driven one, serve the purpose of the research better. The goal is to better understand Romans and their interactions with the landscape of the Biferno Valley. Through the theoretical approach, an assessment of influential landscape components for the focus period will be conducted. The same thing will be done for aspects of social organisation. By following this procedure, the gap between the currently observed site patterns and human agency in the past is bridged. Basing the model only on statistical analyses would not allow for this integration and would provide little in the sense of a holistic understanding of the research area in Roman times. However, it must be noted that data still plays an important role in the building of the model. Even when establishing a theory first, views will always, at least in part, be influenced by what is known in the archaeological record already. As is commonly known, the risk of using a theory based approach is that it can become too speculative. To combat this, a link to a reliable data source is needed (Verhagen, 2007, p.15). In the case of this research, the survey data on sites will form the anchor. Randomly chosen subsets of the documented archaeological record will be used to validate the created model. If testing indicates that the model is flawed based on the available archaeological data, the model will be adjusted and tested again until an acceptable margin of error is achieved. By doing so, the risk of speculation is vastly diminished and the predictive model will be backed up by archaeological data.

1.3 Research area and legacy data

As mentioned, the research area of this study is the Biferno Valley. This valley, named after the 83,5 km long river flowing through it, is located in eastern-central Italy. The area consists of flat plains by the Adriatic Coast, the large river valley itself and rugged Apennine peaks with elevations of up to 2000 metres. In terms of geology, the region is just as diverse. In the mountains, limestone is the dominant underlying geological unit. In the middle-valley, clays, sandstone and conglomerates are mostly found (Barker, 1995, p.17). Towards the east of the Biferno Valley, close to the Adriatic Sea, the flat alluvial plain of the river is most prominent. Over the past few millennia, large quantities of clay and sand were deposited here, leading to very tall sediment packages (Barker, 1995, p.75).

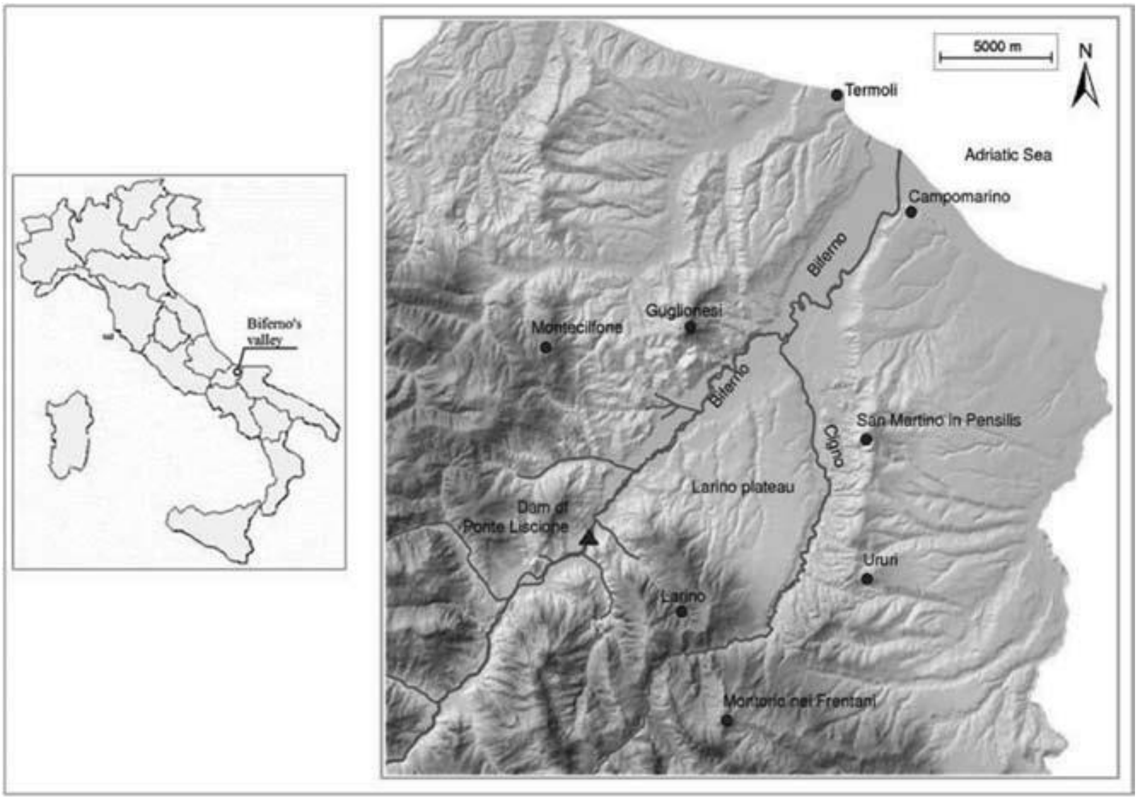


Figure 4. Topological map of the lower Biferno Valley (Guerrichio et al., 2010, p.684)

This region has been subject to archaeological surveying multiple times. The surveys usually served to study the surroundings of a certain urban centre. For example, the Aesernia Project was situated around the city of the same name and the Forma Italiae Survey was centred around Larinum (Stek, 2015, p.234; Witcher, 2008, p.11). Given that this research revolves around the role of 'old' survey data, the data from these more modern projects were not used here. Furthermore, the data from these surveys is not openly accessible. This research focuses on the role of already available data. Therefore, the Biferno Valley Survey is the source of the site data applied in this research. This project is the only one to cover the majority of this valley, having a total research area of 2250 square kilometres, although only 418 of these were surveyed intensively (Barker, 1995, p.41). This is still a lot for an archaeological survey. The project took up multiple phases in the 1970s, 1980s and the early 1990s. Throughout this time, various ways of documenting the landscape were employed. 50% of the research area saw intensive surveying, 40% was subject to extensive surveying and the remaining 10% was researched through reconnaissance. This led to a varying coverage of the landscape, depending on the employed method (Barker, 1995, p.42-44). In general, field-walking usually happened on ploughed fields, where walkers would collect finds in parallel strips. Clusters with an artefact density much higher than the surrounding terrain were marked as a site. Sites were further interpreted through the density and size of the clusters, as well as the types of artefacts found there. Over the years, over 750 sites were mapped this way (Barker, 1995, p.45;51).

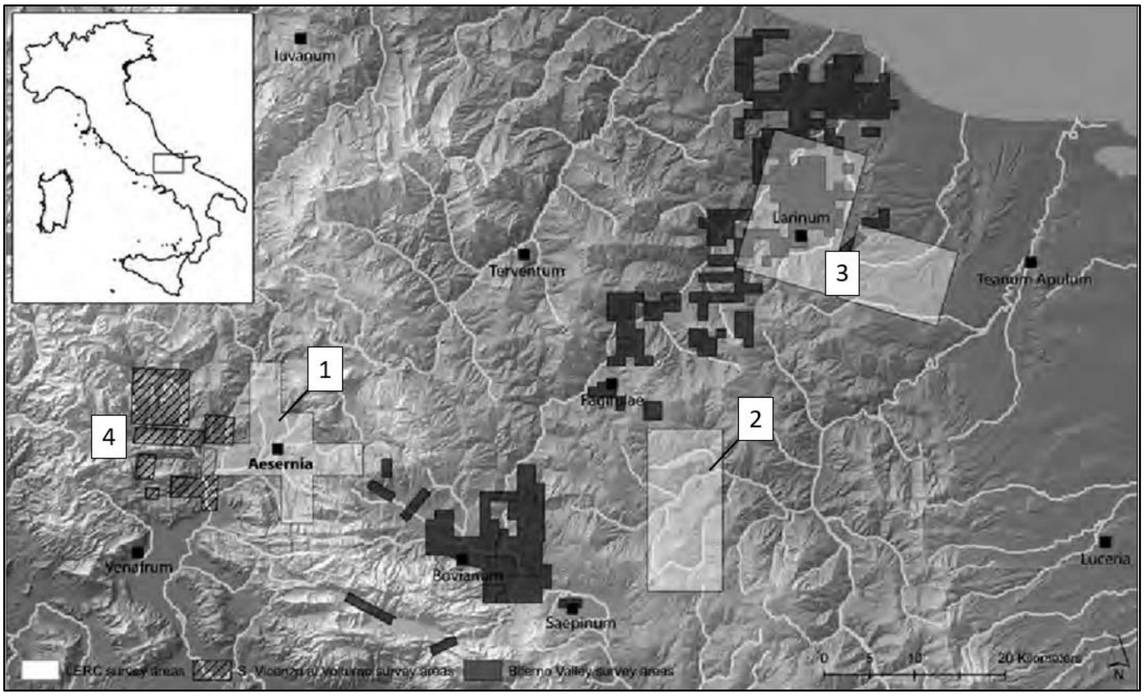


Figure 5. Areas surveyed during the Biferno Valley Survey (dark colour), the Aesernia Project (1), the Tappino (2) and Sacred Landscape (3) projects and the San Vicenzo al Volturno Project (4) (after Stek et al., 2015)

In the research presented in this thesis, data gathered in a past project, also known as legacy data is used to carry out analyses. Working with such data has the advantage of not having to set up new fieldwork to acquire data. Past surveys often took place on agricultural land, where human activity can quickly degrade the archaeological record. An added benefit of using legacy data is therefore that it portrays the archaeological record as it was decades ago (Witcher, 2008, p.4). However, the projects from which this legacy data is gathered are often methodologically incoherent. In the past century, archaeological methods have developed quickly. This means that surveys from several decades ago did not usually apply the same thorough methodology that is common today (Witcher, 2008, p.4). This also applies to the Biferno Valley Survey, in which sites were initially documented in little detail (Barker, 1995, p.44). Still, these old projects can perfectly be used to gain new insights. The large scale of some older surveys even suits itself much better to studying broad themes in the Roman world than many recent, small scale studies (Witcher, 2008, p.4-5). As such, the Biferno Valley Survey is well suited to the study of large-scale Roman settlement patterns, as is done in this research.

1.4 Research goals and questions

As revealed before, the main goals of this research are twofold. On the one hand, it involves the methodological aspect of attempting to gain new information through previously gathered survey data. On the other hand, the more interpretive goal is to form a broader understanding of the organization of the rural world during Roman times. This will be achieved by creating large-scale images of where Roman sites were likely located in the Biferno Valley throughout the Roman Republican and Imperial periods. The two main research questions are thus as follows:

1. How can legacy survey data contribute to our understanding of the Roman past?
2. How was the rural world in the Biferno Valley organised during the Roman Republican and Imperial periods?

Especially for the second of these questions, several sub-questions must be answered first. These questions are here structured according to the methodology employed, in which theoretical background research takes place before the quantitative assessment of sites and the building of the predictive model. With this in mind, the sub-questions are formulated as follows:

1. a) Which natural and social processes took place during the researched period that likely impacted the organization of the rural world?

   b) What impact did the observed processes have on the spatio-temporal distribution of rural sites?
2. a) Which natural, cultural and taphonomic factors are expected to be determining factors in the location of rural sites?

   b) How do the observed patterns in the survey data compare to the expected patterns?

c) Where are sites expected throughout the entire Biferno Valley in various timeframes in the Roman period?

d) What do the observation-induced expectations tell us about large-scale rural organisation during the researched periods?

Throughout this thesis, these questions will be answered in the order shown above. Each of these questions describes a different phase in the methodology of this research, which will be further described in chapter 2. At the end, the results will be synthesised in order to complete the main research goals.

1.5 Thesis outline

Following this introduction, the research methodology will be outlined in chapter 2. It will be explained how archaeologists have been using predictive modelling and how it is applied in this research. This chapter further describes the issues that arise when working with legacy survey data and how these issues are overcome in this project. Chapter 3 addresses the theoretical framework in which the research questions will be answered. As mentioned, the first steps in this research will be theory-driven. In this chapter, the processes at play in the research area and how they influence the archaeological record will be discussed.

Following this, the quantitative analyses will be covered. Chapter 4 describes the initial assessment of influential factors on site locations. In chapter 5, the results will be tested in a more statistical manner. This will lead to the explanation of the model building phase in chapter 6. Here, the process of model building and the results will be illustrated. The implications of this model for our understanding of the Roman rural world will be elaborated upon in chapter 7. A reflection on the methodology and workflow applied in this research is provided in chapter 8. Lastly, a conclusion chapter sums up the research.

2. Methodology

This chapter outlines in detail the methodologies applied in this research. Firstly, a short historical background of predictive modelling and of legacy survey data is provided. This leads to an explanation of the issues these two aspects face and how they will be addressed in this research. After this, a detailed approach to the data collection phase and the building of predictive models will be outlined. Lastly, this chapter explains how the chosen methodology serves in answering the research questions set out in the introductory chapter.

2.1 History of predictive modelling

Spatial analysis and with it predictive modelling are a key part of archaeology, as the location of objects and resulting patterns are crucial to the building of narratives about the past. Predictive modelling is a technique that attempts to predict the probability of the location of archaeological materials, including sites, based on studies of the landscape or of the people living therein (Kohler & Parker, 1986, p.400). However, the first iterations of predictive modelling were developed outside the field of archaeology. Instead, the technique was initially employed in governmental land management in the United States and gradually spread to Canada and Europe, instigating many debates about its meaning and use (Kamermans, 2006, p.35-36). While predictive modelling is now regularly used for academic purposes, this was not initially the case. The technique was rather seen as a planning tool. As Kohler and Parker noted in 1986, '*Through correct use of sampling procedures and statistical techniques, predictive models can be built that perform this management function adequately, while making little or no contribution to understanding locational processes'* (p.441). This presents a core challenge when employing archaeological predictive modelling: it lends itself very well to the production of results even without a firm grasp on the theory behind it. In other words: archaeologists can easily create predictive maps without actually understanding what they mean. Therefore, the methodology of this research is designed to overcome this issue.

Whereas the original applications of predictive modelling were not usually based on theoretical frameworks, this has vastly improved. Currently, there are two main types of predictive modelling. Even though they both start from the understanding that environmental factors are hugely influential in determining the location of archaeological sites (Verhagen, 2007, p.14), they differ fundamentally in their functioning. The first type of predictive modelling is inductive, building upon existing data regarding sites and materials. The second type, which is still the less often employed of the two, is deductive, working from theory as a starting point (Verhagen, 2007, p.13-14). Depending on the type of approach, researchers build a workflow that describes the process of translating knowledge into a model. Figure 6 gives an example of an inductive workflow. The research presented in this thesis applies a deductive method. Section 2.6 displays the workflow applied in this research.

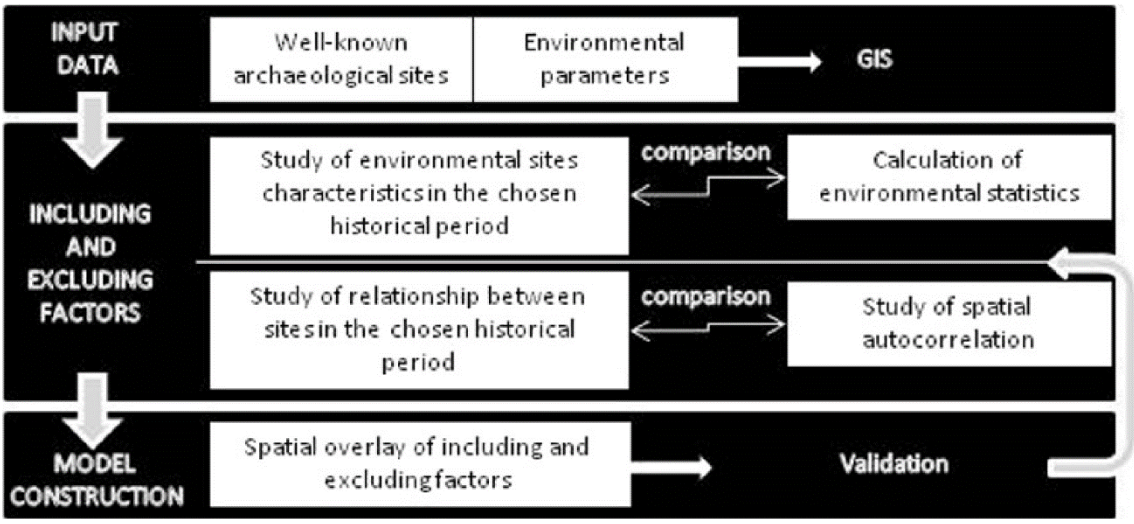


Figure 6. An example flow chart on the construction of a predictive model
(Danese et al., 2014, p.45)

2.2 Legacy Survey Data and its issues

With its long history, archaeological surveys have yielded incredible amounts of data. Already in the 19th century, the value of this method was recognised, leading to the documentation of many archaeological sites, especially Roman and Greek ones. Evidently, a lot has changed since then. Over the course of the past century and a half, many paradigm shifts occurred in archaeology, directly impacting the way in which surveys were carried out (Corsi et al., 2014, p.193-194). This development, in combination with increasingly high standards on the documentation of archaeological remains, means that archaeological survey projects carried out even a few decades ago barely hold up in terms of methodology (Verhagen, 2007, p.14). Nevertheless, the results these projects have yielded should not be ignored. By applying more modern techniques, new insights can still be gathered from legacy data. This is often necessary, as human activity regularly means that remains surveyed in the past have been degraded or completely destroyed since (Casarotto et al., 2021). In order to use legacy survey data however, multiple concerns and issues need to be addressed first.

The first issue related to legacy data is the lack of digital storage. In the present, almost all archaeological data is stored digitally, whether it be sites documented in a database or field drawings and photographs stored in an online repository. This was not always the case. Instead, paper forms were the norm for many decades. This method of documentation ran a greater risk of data loss (Casarotto et al., 2021) and still hampers further analysis, as it takes significant effort to translate large quantities of physical data into digital form, where more potent analytical tools are available.

One of the consequences of the lack of digital storage is the inconsistency in many legacy survey projects, especially in the data documentation phase. When using paper forms, it is very difficult to implement a strict quality control mechanism (Corsi et al., 2014, p.194). As such, archaeologists in the field can write down their interpretation of an artefact or a site in a way that they see fit. This might not be consistent with the way in which another archaeologist would write down their interpretation. As a result, field notes, even within the same project, are often difficult to compare and field forms might change throughout the course of a project in an attempt to combat this issue. Such a thing happened in the Biferno Valley Survey as well (Barker, 1995, p.45). A more challenging issue to overcome is the inconsistency in survey methodologies. As mentioned, vast paradigm shifts in archaeology have strongly influenced prominent methods in survey projects. At certain times in the past century, a non-systematic approach to surveying was favoured, in which sections of terrain are examined based on their characteristics. At other times, systematic surveying was preferred, which employs a more rigid approach in which sections of terrain are usually surveyed in fixed grids (Verhagen, 2007, p.12). These changes, together with shifting focal points for research and variations in documentation mean that legacy survey data is rarely consistent and comparable. This is especially true for projects which have run for prolonged periods of time, as differences occur regularly within these projects themselves (Corsi et al., 2014, p.13). Of course, these long-running projects are also the ones with the largest datasets, making it crucial to find ways to overcome the abovementioned issues.

2.3 The site issue

As was mentioned in the introduction, the term 'site' is quite vague. Even though it has been used here extensively already, the word can mean many things. In surveys, a site is generally identified as a cluster of artefacts or as a location with a higher-than-usual artefact density (Tartaron, 2003, p.24). This ambiguous definition means that criteria for site identification vary depending on the archaeological project (Casarotto et al., 2021). This is a challenge that affects all archaeological projects. This means that a 'site' can indicate the presence of large structures, whilst it can also simply indicate a small cluster of artefacts. Both sides of figure 7 therefore indicate what could be considered a site.

Figure 7. Left: Roman housing at Ostia (packer, 1967, p.80). Right: Surface remains of a Roman villa in the Biferno Valley (Barker, 1995, p.47). Due to differences between projects, both of these pictures display what could be considered a 'site'.

The issue does not only occur during site identification in the field. Rather, it is persistent in data analysis as well. Researchers often assume that the term site indicates a settlement of some sorts (McCoy, 2020, p.S22). The previous paragraph shows that a ‘site’ can indeed indicate a settlement, but that this is often not the case. Studies on large-scale patterns especially suffer from faulty assumptions. Furthermore, the term ‘site’ fails to capture all human activity in a region (Owen, 2015, p.75). The concept includes larger centres of human activity. Smaller centres that are spread throughout the landscape are however disregarded. As a result, the word ‘site’ contains a bias toward the largest scales of human presence (Owen, 2015, p.72).

2.4 Overcoming the issues

As previously explained, the primary concerns with using legacy survey data stem from the its inconsistent nature. In order to carry out analyses starting from these projects, steps must be taken to make the data comparable and representative. In this research, this will be achieved by using legacy survey data to test theories, rather than analyse patterns with site data as a starting point. What this means is that theoretical frameworks will be built first, based on a range of archaeological and historical sources. The findings will result in an assessment of influences on the location of Roman rural sites in the research area. Random selections of sites documented in the Biferno Valley Survey project will then be used to test the hypotheses on which the predictive model will be based. By following this approach, less importance is placed on the type of survey in which sites were found and doubts about the meaning of the sites are avoided. The established theoretical framework will be the main pilar on which this research builds, rather than the survey methodology.

2.5 Data

2.5.1 Collection of data

The first stages of this research involve the analysis of already processed data in the form of scholarly publications and historical sources. Therefore, the collection of raw data applies to the building and testing of the predictive model. The data to be collected for this purpose includes data on sites and on the environment. The site data originates from the Biferno Valley Survey (Barker, 1995). As mentioned though, this information was not well digitized initially. For that reason, the data regarding this survey must be accessed through a secondary source. This source is the FAIR Surveys project (de Haas

& van Leusen, 2020). This project aims to contribute to comparative studies based on archaeological survey data in Italy. For that purpose, the involved researchers have been working on collecting data from many archaeological surveys that have taken place in Italy and translating this into a structured database. This serves in making the data FAIR, improving accessibility and reusability of the data for other researchers (de Haas & van Leusen, 2020). The FAIR Surveys project leaders have gracefully allowed access to this database, which also includes the Biferno Valley Survey. The documented information on sites from this project includes location, interpretation, size, artefact count, surface state during documentation and artefact density, as they were written down during the duration of the survey project itself. The database will thus provide the perfect base from which to analyse site data. Furthermore, the location of these sites has already been translated into a GIS-file in the past, further facilitating this research.

Additional maps of human structures, such as roads and cities, in the research area are derived from the Barrington Atlas of the Greek and Roman World (Talbert, 2000). This map includes larger towns and cities, as well as significant roads. Unfortunately, it is very challenging to map small roads and pathways, as they are rarely visible in the archaeological record (Kolb, 2019, p.11-12). The analyses carried out must therefore focus on wheeled transport, and not on transport by foot. Paths such as the one shown in figure 8 are not a factor in this research. Topographic data is gathered through the Italian government, who have digitally made available slope and elevation maps. There are no high-resolution soil maps available for the Biferno Valley. This will be solved by using detailed geological maps, available through the website of Italy's environmental service (www.isprambiente.gov.it). Parallels will be drawn between the research area and other regions with similar geography, on which detailed soil reconstructions for the Roman period have been produced. By doing so, soil maps will be made for the research area based on its topography and underlying geology. Each of the factors described here will be translated into separate GIS-layers, allowing for the creation of detailed maps.

Figure 8. A droveroad (related to transhumance) in the Biferno Valley (Barker, 1995, p.35). Similar roads are incredibly difficult to trace in the archaeological record.

2.5.2 Presentation of data

The FAIR Surveys database included 775 sites documented in the Biferno Valley Survey. Of these sites, 38 were identified as a villa and 134 farms were found that were dated to the researched time frame. A detailed description of how these types were defined is present in chapter 5. Information on all sites was divided among two tables. The first table included general information on sites. The following parameters were recorded: Site ID, site name, state during fieldwork, notes, site area, preservation in situ (yes/no), coordinates, diagnostic sampling (yes/no), systematic sampling (yes/no), total number of artefacts and density of artefacts. A second table was used to provide interpretations on all sites. Here, site ID, period, interpretation and possible remarks were presented. A full list of sites is not provided in this thesis due to the ownership of the data.

The data gathered through the Italian government's environmental services were accessed in the form of maps that could either be directly imported into QGIS, or that allowed for the creation of own maps, is visualised in figures 9a through 9e. Here an overview of the original data in the research area is given. Important to note is that elevation, waterways and lithology were directly available in the presented form. Aspect and slope were derived in QGIS from the available elevation model. Information on the location of roads and towns was available in the Barrington Atlas of the Greek and Roman World (Talbert, 2000). The model creation presented in this thesis was built upon the data described here.

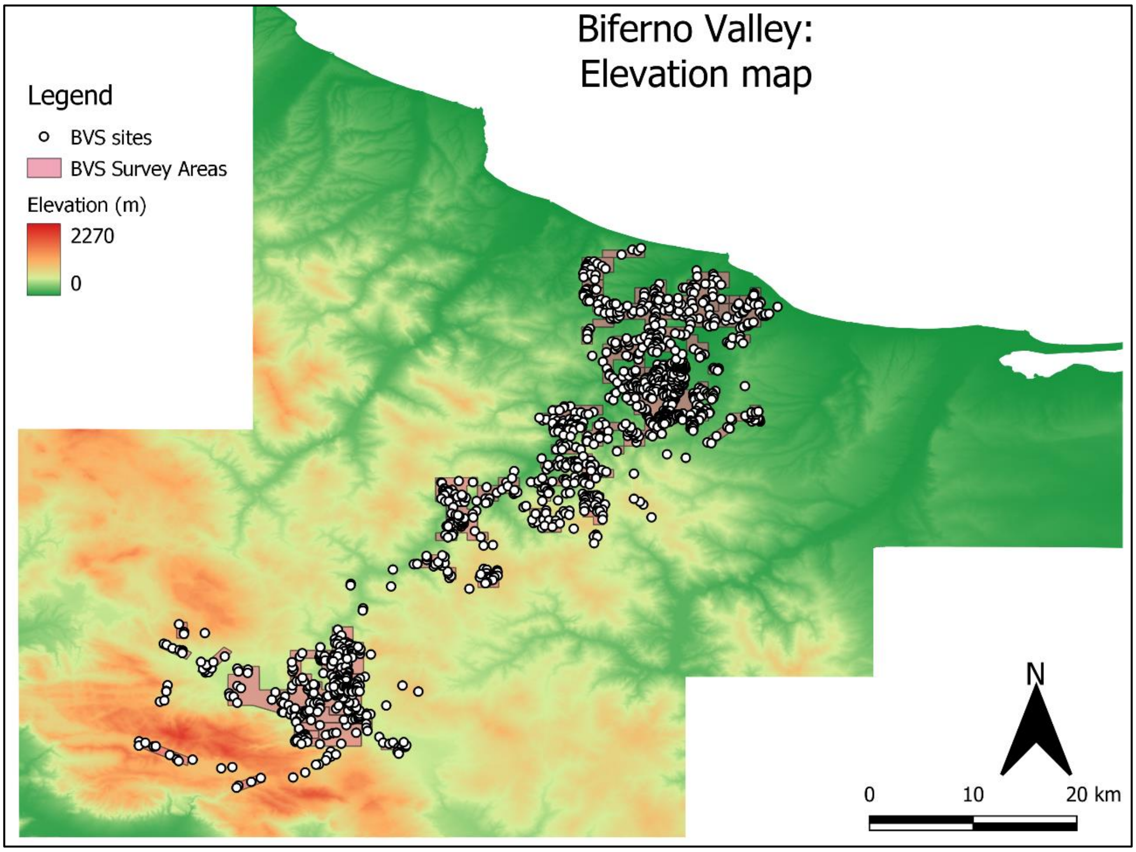


Figure 9a. Biferno Valley elevation map including all sites documented in the Biferno Valley Survey

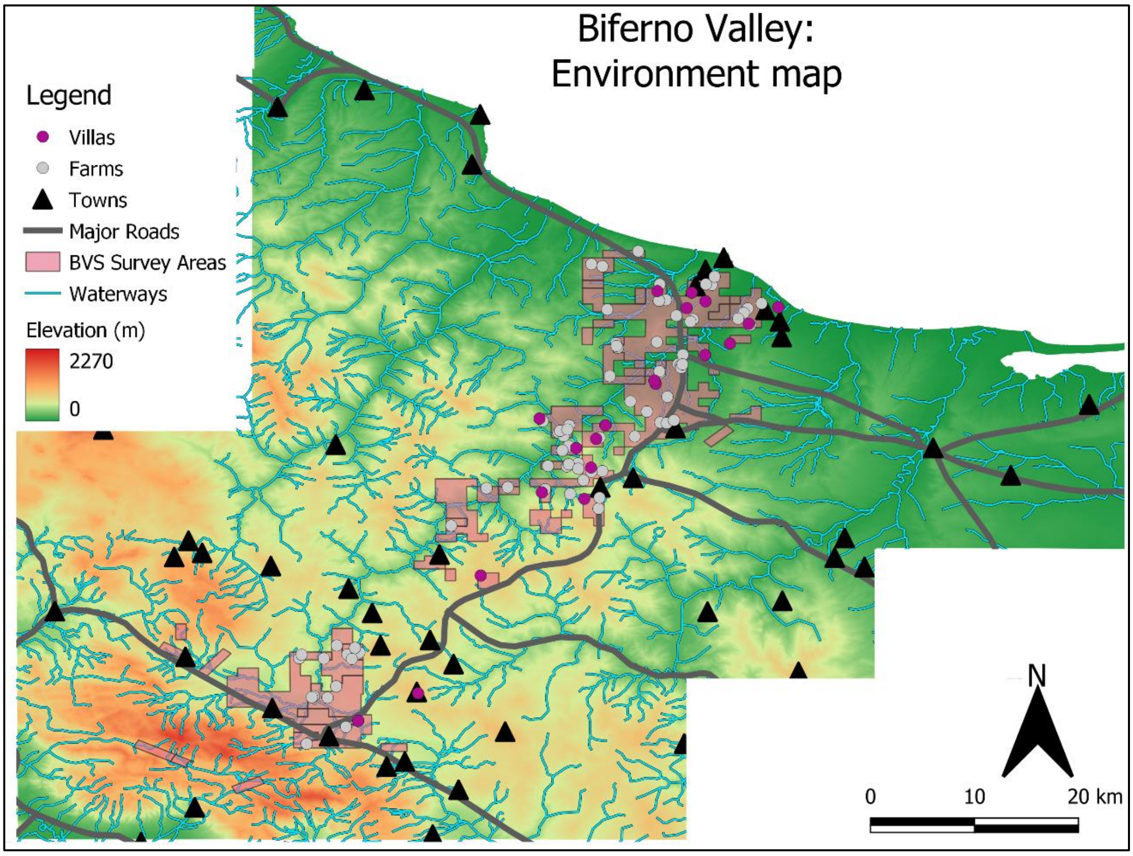


Figure 9b. Biferno Valley elevation map including farms and villas documented in the Biferno Valley Survey, Roman roads and towns, and waterways

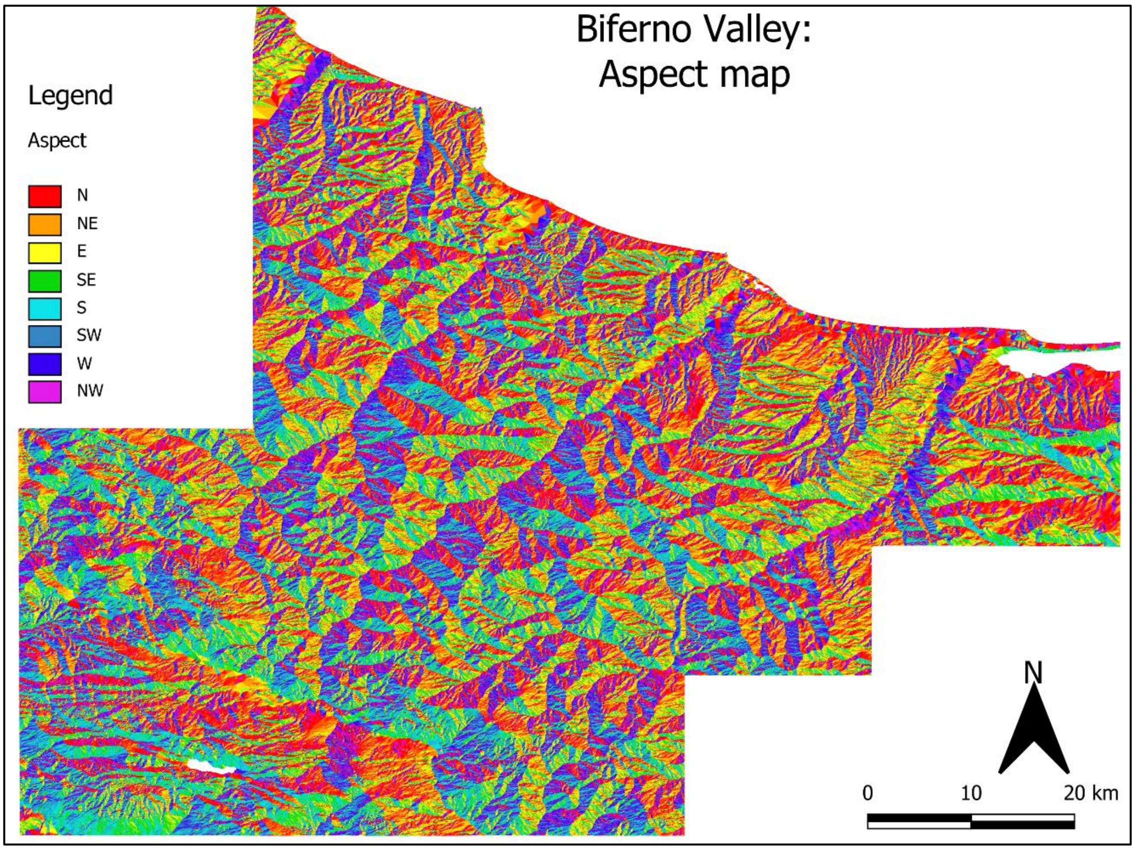


Figure 9c. Biferno Valley aspect map

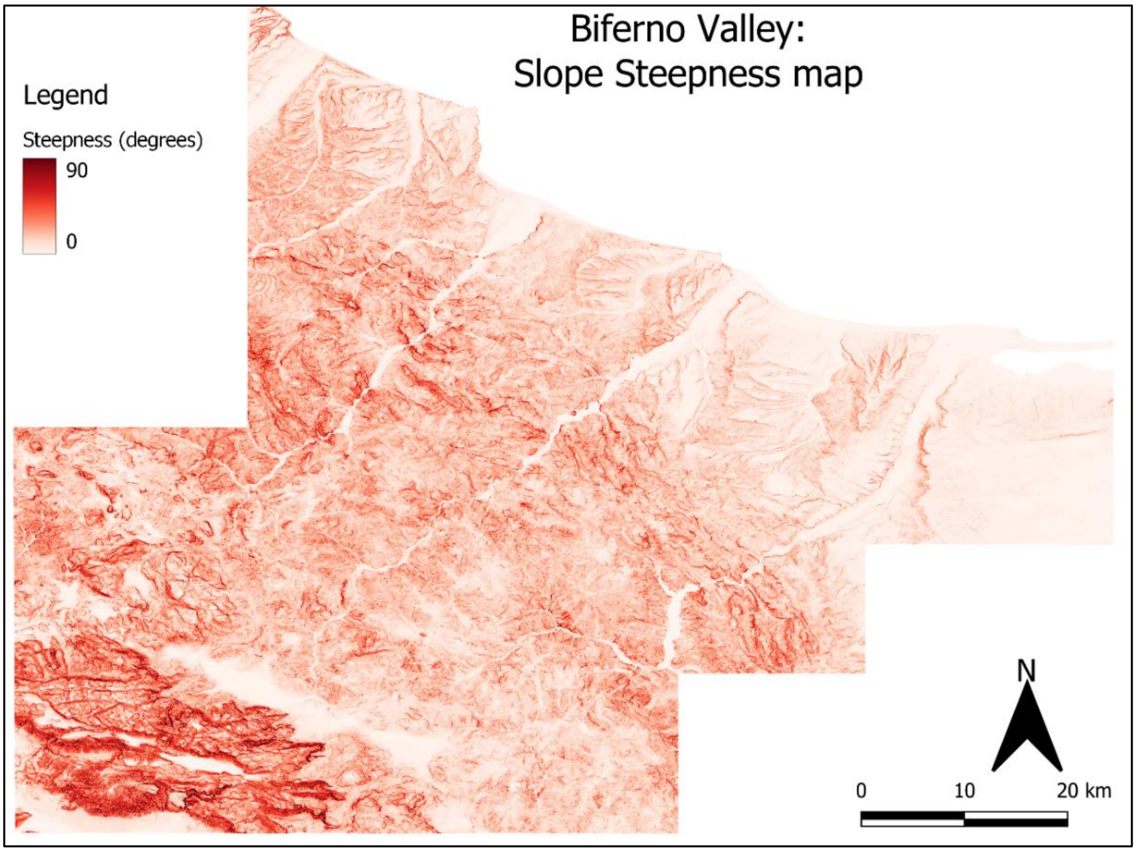


Figure 9d. Biferno Valley slope steepness map

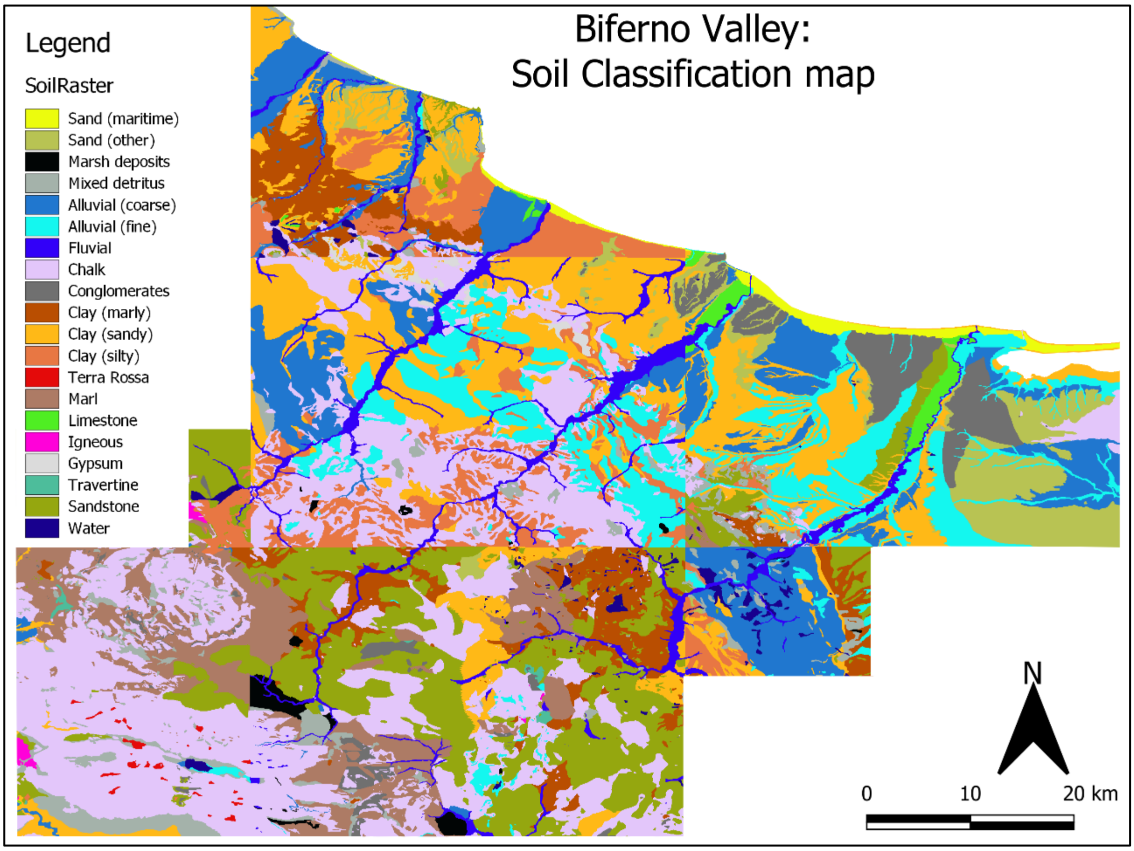


Figure 9e. Biferno Valley soil classification map

2.6 Predictive model building

The building and the application of the predictive model that will be constructed as part of this research consists of four phases. Firstly, there will be a theoretical assessment of influential factors on the location of Roman rural sites. Secondly, The findings done in this first stage are tested through an analysis of documented sites. The assessments on which the model are built will be kept or adjusted based on the results. The resulting parameters will then be incorporated into the creation of the model, which is step three. Lastly, the created models will be tested through a statistical test that includes the sites documented in the Biferno Valley Survey. Since the model is theory-based, the sites themselves are not used for model construction. Therefore, they can all be used in the testing of the results. Separately, all documented farms and villas will be divided into five groups. Each group can then be used in the testing phase. This will be done through the application of the Kolmogorov-Smirnov test. By sampling the generated probability values of the site samples and by comparing them to the total range of generated values, a significance is calculated. This indicates the probability of the results occurring at random. A low probability therefore means that the model has a high significance (Berger & Zhou, 2014). The test results will either lead to an acceptance of the model, or highlight factors that need to be changed. In the first step, many scholarly publications and other written sources will be consulted. The findings described therein will yield considerable information on the way in which Roman people themselves looked at agriculture and rural networks and how this changed throughout the period of Roman prominence. As such, the agencies of people and of the landscape in the past are acknowledged. This bottom-up approach is most suitable due to the unreliable nature of the survey data. As a result, it will be possible to note down the extent to which several cultural and environmental factors played a role in the organisation of Roman agriculture from the viewpoint of the people employed in it.

The following step, the actual building of the predictive model will take place through QGIS. Several methods were attempted, including model creation in Rstudio. However, a process that takes place entirely within QGIS proved to be most efficient at providing the desired results. After preparatory work, which will be described in detail in chapter

6, the raster calculator within QGIS allows for the creation of detailed maps. The choice of parameters and the extent of their importance depends on the results of the first phase as described above. Each iteration of the predictive model will be tested. This will be done by comparing the results to a random selection of sites from the Biferno Valley Survey. If significant differences occur during this comparison, which is likely in the initial stages, a reason for the discrepancies will be sought. If an explanation can be given, the model will be adapted to accommodate for the observed variation. The model will then be tested again. This procedure will be repeated until the model displays the desired significance. Figure 10 displays this workflow in schematic form.

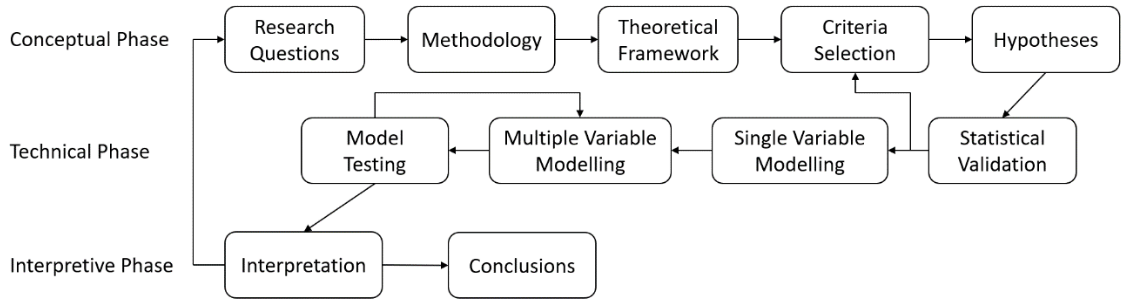


Figure 10. Applied workflow of modelling sequence. Inspired by workflows of Romanowska (2015, p.172) and Revert (2017, p.50)

2.7 Answering the research questions

In the end, the results of the steps taken above will be used to answer the main research questions as stated in chapter 1. In this chapter it was already explained how legacy survey data will be handled in this research, transforming it from a starting point of spatial analyses to a way to falsify results based on more thought-out theory. During the course of this research, it will become clear in detail which steps need to be taken to ensure proper use of this legacy data. In this way the first research question, which deals with the use of legacy survey data to gain new insights, will be answered.

The second research question, dealing with new information on the organisation of the Roman rural landscape, depends on the results of the predictive modelling. This question indicates that the predictive model will not be the end goal of this research. Instead, it is merely a method in order to gain knowledge on the Roman world in a broader sense. Therefore, the model will be further analysed and compared to our existing knowledge on the topic. The results of this step will form the answer to the second main research question.

3. Theoretical framework

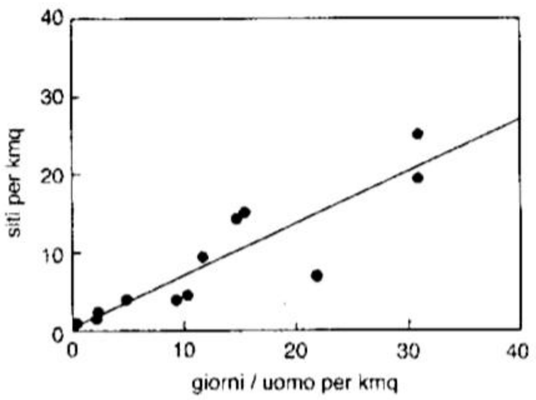
As established in the previous chapters, establishing a well-founded theoretical background is a crucial step in this research. In this chapter, the theoretical background of survey archaeology will first be outlined. In this section, it will be explained how variations between survey methods have differing impacts on the results. The types of methods employed in the Biferno Valley Survey and their implications for the observed site patterns are explored as well. An analysis of predictive model building will follow. Here, it will be explained how archaeology and model building can be integrated in a way that produces meaningful results. Lastly, there will be an in-depth study on developments in Roman agriculture and life in the Roman countryside of central Italy, based on archaeological and literary sources. Factors that were deemed important for agriculture in the Roman period, and the extent of their importance, will be identified.

3.1 Survey methodology

In the introduction, an overview of how the archaeological survey developed through time was given. Here it became clear that paradigm shifts and technological advancements in archaeology have had close links to prevailing survey methodologies. One of the main issues regarding the use of legacy survey data stems from the inconsistency of this type of data. This section will outline why this is a problem. Further on, the impact of the type of survey on the archaeological narrative will be discussed, and a suggestion for how to properly use survey data will be given.

Already half a century ago, archaeologists were becoming generally aware of the use of archaeological surveys (Ruppe, 1966, p.313). However, survey techniques depend on field conditions and rare or very clustered remains are unlikely to be mapped in most surveys. For that reason, it was also understood that an 'ideal' survey methodology, whatever that meant at the time, was rarely applicable in the field. (Schiffer et al., 1978, p.1). Of course, a survey will never be able to capture all sites in a given region. Nonetheless, the goal of archaeological surveying is generally to provide a representative sample of archaeological remains (Redman, 1974). This is often equated to an ‘unbiased’ view, although this is arguably an incorrect way of thinking. Archaeological research is always biased in a way, as results depend on the methods employed and the interpretation of those involved. This applies to archaeological surveying too, as the way in which sites are defined, dated and categorised are fully up to the archaeologist (Feiken, 2014, p.40).

It has been proven that an increase in survey intensity, or the distance between field-walking transects, directly corresponds to an increase in documented site density (Van Leusen, 2002, ch.4 p.12). The same thing can be said for surface visibility: the higher this is at the time of surveying, the higher the observed site density will be (see figure 11) (Van Leusen, 2002, ch.4 p.13). Survey archaeologists can also determine the degree of systematism in their surveys. From systematic field-walking in straight lines at fixed distances to unsystematic surveying based on landscape characteristics, every method impacts where archaeological remains can be found (Tartaron, 2003, p.23). Together with the natural degradation of these materials and changes in the landscape, this means that one must be aware that patterns observed in surveys do not represent the actual situation in the past (Tartaron, 2003, p.24). Moreover, surveys are not comparable one-to-one. Instead, survey data represent a mere sample of the sites that were present in the past. The representativity of this sample depends on the factors outlined above.



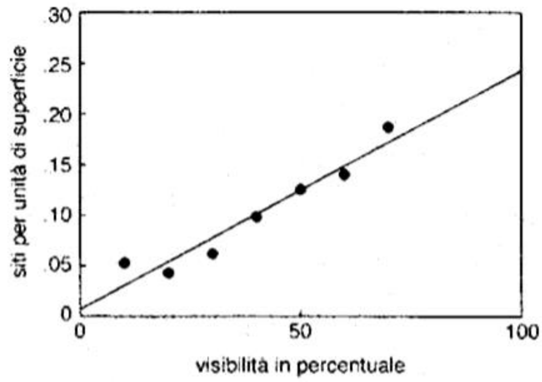


Figure 11. Left: Plotted relation between survey intensity and documented site density in the southwestern United States (Plog et al., 1978 in Van Leusen, 2002, p.4.13)
Right: Plotted relation between surface visibility and documented site visibility for the Kleos Survey (Cherry et al., 1991 in Van Leusen, 2002, p.4.13)

In the context of the Biferno Valley Survey, various changes in methodology can be observed over time. This resulted in various ways of field-walking being used. Around 50% of the 418 km^2 in which the survey project took place was surveyed intensively, with all accessible land in research units being examined. A further 40% of the research area saw extensive surveying, in which 50-75% of the units were searched (Barker, 1995, p.42-43). The remaining 10% was subject only to reconnaissance work, which means only the accessible parts of the landscape were assessed. In all cases, field units were divided in a grid, along which field-walking took place (Barker, 1995, p.44). Figure 12 displays the survey grid and the areas in which each type of survey was applied. This is a clear example of systematic surveying. Important to note is that even intensive surveying does not cover 100% of the surface. As stated, this method indicates that field transects were fully walked. However, field-walking in this project was organized in parallel lines 15 paces apart (see figure 13). Finds were then picked up in strips along these lines, each with a width of 1 metre. The majority of the fieldwork happened in ploughed fields, as these are best suited for the recognition of surface finds (Barker, 1995, p.45).

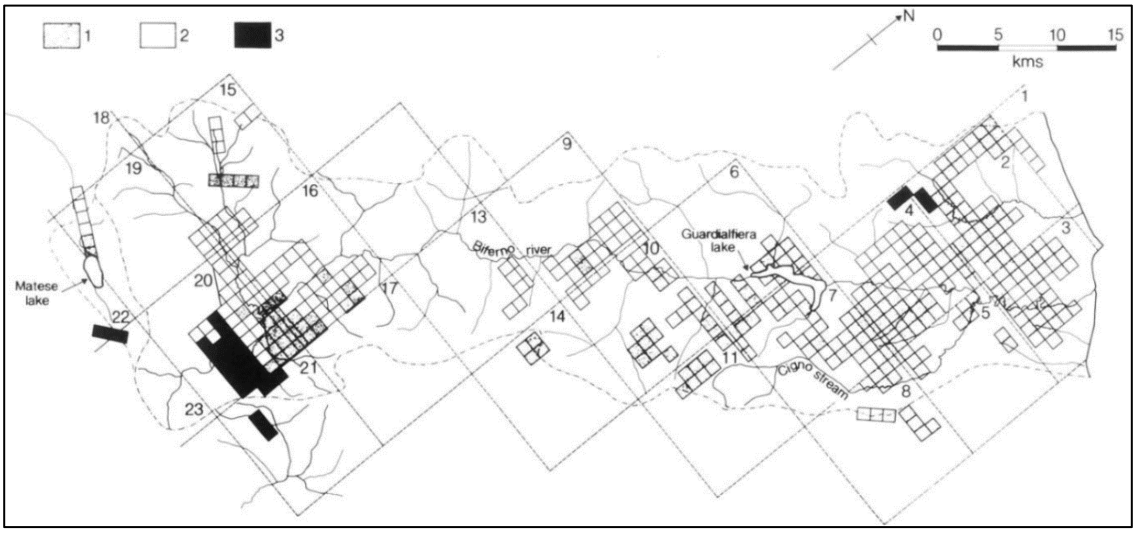
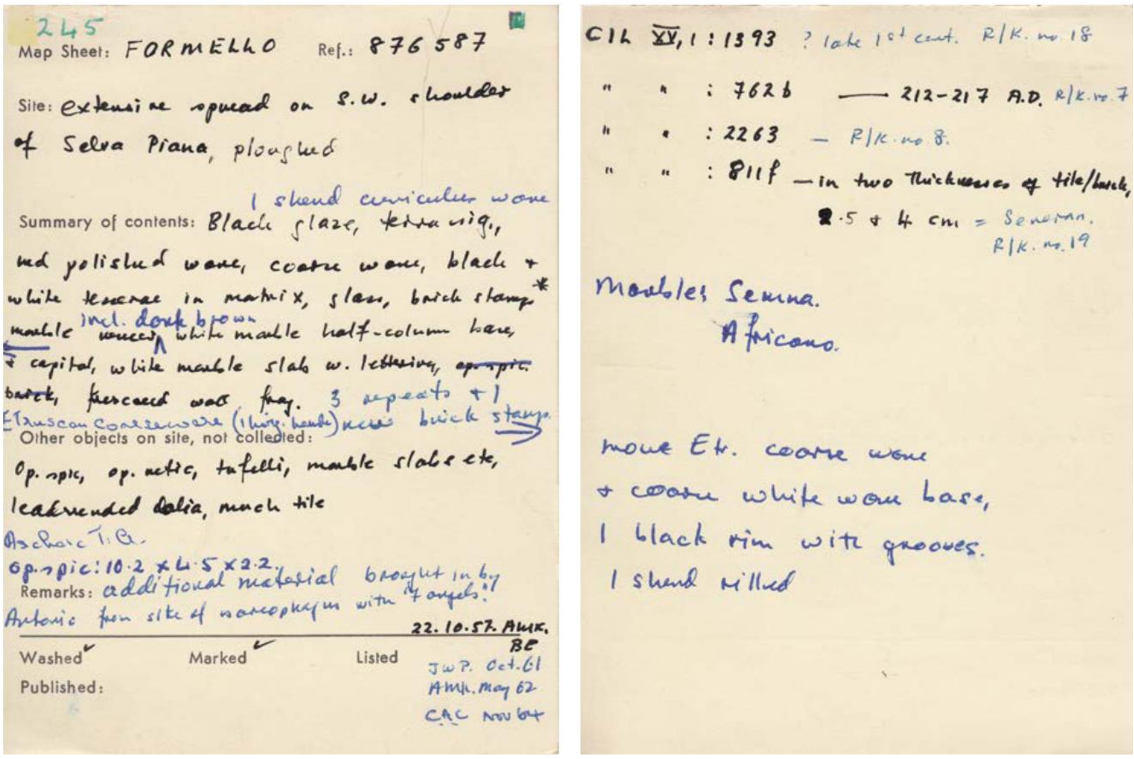


Figure 12. Map of the grid used in the Biferno Valley Survey and the type of survey employed: Intensive survey (1), Extensive survey (2) and Reconnaissance (3) (Barker, 1995, p.43).

Figure 13. Typical field-walking in the Biferno Valley, with archaeologists 15 metres apart (Barker, 1995, p.45)

Besides impacts from the type of field-walking, choices on documentation are also an important facet to understand. Initially, sites in the field were documented quite liberally. Each site was located and interpreted, including information on the finder and the terrain (Barker, 1995, p.43). The forms used in this phase resembled the ones used in the South Etruria Survey (see figure 14). However, the way in which this was set up resulted in large variations in how detailed the site information was written down. Consequently, the project switched to a more elaborate file for site documentation. Besides more detailed interpretation of site type and period, these new files also required a sketch of the site and a description of the type and size of find scatters (Barker, 1995, p.44). In fact, these find scatters were crucial in identifying sites. Sites were defined as locations with relatively high artefact density, although more precise requirements are lacking Site typology was based on the nature of artefacts and ecofacts and the activities to which these were related. On top of this, clusters were divided into three categories, based on size: large (with an area of more than 1ha), medium (0,25 to 1ha in size) and small (less than 0,25 ha) (Barker, 1995, p.51). Due to the many changes that occurred in the survey's methodology, some parts of the terrain were resurveyed. Comparison of the results indicated that clear changes were present (see figure 15). However, it was argued that the related site density models proved reliable enough, as archaeological surveying does not produce 'real maps' of the world in the past. Rather, it produces models of settlement forms and patterns, which were deemed sufficiently comparable between the survey phases (Barker, 1995, p.51).


245
Map Sheet: FORMELLO Ref.: 876 587

Site: extensive spread on S.W. shoulder of Selva Piana, ploughed

Summary of contents: Black glaze, terra sig., 1 sherd curvilinear ware, red polished ware, coarse ware, black + white tesserae in matrix, glass, brick stamp*, marble incl. dark brown veined white marble half-column base, capital, white marble slab w. lettering, brick, frescoed wall frag. 3 repeats + 1 new brick stamp

Etruscan coarseware (1 imp. handle)

Other objects on site, not collected:

Op. spic, op. retic, tufelli, marble slabs etc, lead-mended dolia, much tile

Op. spic: 10.2 x 4.5 x 2.2

Remarks: additional material brought in by Antonio from site of sarcophagus with 4 angels!

22.10.57. AMK.

Washed Marked Listed BC JWP. Oct. 61 AMK. May 62 CAC Nov 64

Published:

CIL XV, 1: 1393 ? late 1st cent. R/K. no. 18

" " : 762b — 212-217 A.D. R/K. no. 7

" " : 2263 — R/K. no. 8.

" " : 811f — in two thicknesses of tile/brick, 2.5 + 4 cm = Severan. R/K. no. 19

Marbles Serena. Africano.

more Et. coarse ware + coarse white ware base, 1 black rim with grooves. 1 sherd rilled

Figure 14. Example survey recording sheet from the South Etruria Survey (BSR Photo Archive in Patterson et al., 2020, p.38)

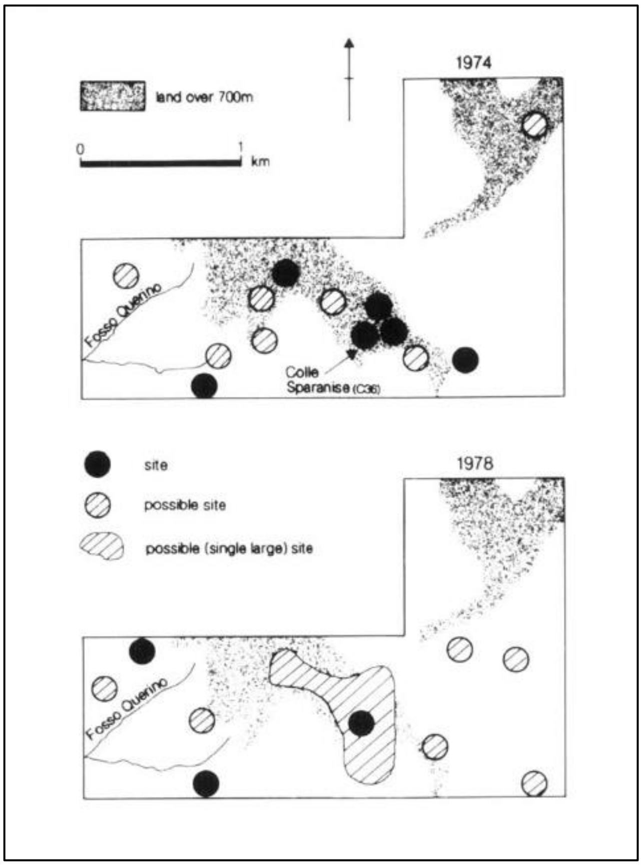


Figure 15. Comparison of resurveying results in part of the upper Biferno Valley (Barker, 1995, p.50)

Whilst size and period of the sites are reasonably well-defined, the site interpretations remain quite vague. It is known that site types are based on the sorts of finds in a cluster, but this is still very much subject to the archaeologist's own interpretation. Furthermore, sites found during the early stages of the project often lack detailed interpretation altogether. Since much of the terrain was not surveyed intensively either, the prevailing image of the Roman landscape generated through this project must be compared to other sources, offering another type of data besides survey finds. Therefore, the views presented at the end of this chapter are necessary in making sense of the information that is available.

3.2 Theory of Model Building

Predictive modelling in archaeology can take on many forms. At its core though, the basic principle remains the same: to predict where archaeological materials are, including sites, based on a sample of what has already been found or on general ideas of how humans acted in the landscape (Kohler & Parker, 1986, p.400). These models do not give a yes or no prediction for specific points in the landscape. Instead, they calculate the probability that archaeological remains of a certain type can be found in a specific area. The type of remains that are represented and the size of the zones for which the probability measurements are made vary between research projects (Verhagen et al., 2009, p.20). In this common description of the technique, a clear distinction is made between models based on spatial samples and those based on theoretical thinking about humans in the past. However, since its conception, archaeological predictive modelling has moved away from this division. At present, the method is generally used separately from archaeological theory. Predictive modelling has thus become merely statistical in nature (Verhagen & Whitley, 2012, p.50). The reasons for this dichotomy are found in the differing ways of thinking between processual and post-processual archaeologists. A large group of archaeologists continue to favour processual approaches, although often enriched with humanistic perspectives. Furthermore, other researchers in the field have struggled with the creation of a theoretical framework which applies post-processual thinking. As a result, processual approaches have remained in regular use. Because of the lack of theoretical integration in predictive modelling, many archaeologists dislike using the technique for academic purposes. (Verhagen & Whitely, 2012, p.50).

This research employs a method of predictive modelling in which theory does play a central role. Nevertheless, the archaeological sites and their locational patterns are an important facet in the analysis, in the form of testing hypotheses. In this approach, just like approaches that are more statistics-centred, site sampling is a crucial concept. It was explained in the methodology that a random selection of sites will be made to test the theory. The sites will first be selected based on their categorisation and dating. The resulting groups will be divided truly randomly through the random selection tool in QGIS. This can be described as a form of probability sampling. Important to note here is that probability sampling includes the implementation of strategies that attempt to ensure that a sample represents the complete assemblage of sites in this context (Banning, 2021, p.44). In this research, the model is not built upon site locations, but rather on theoretical assumptions. Therefore, the documented farms and villas will both be randomly divided into five groups. Whenever the model is adjusted, a different subset will be used for validation. Using the sample of sites as a reference rather than the base for analysis prevents circular reasoning and also addresses the main concern that post-processual archaeologists have about probability sampling: the use of inadequate samples and the dehumanisation of archaeology (Banning, 2021, p.49). Even with the steps above in action, a concern regarding the factors on which predictive models are built needs further consideration. Such a model generally builds on environmental factors in relation to site locations. This is not surprising, since these are the factors that are most directly measurable. However, many have argued that this leads to 'environmental determinism' (Wheatley, 2004). In this research, socio-economic factors will be assessed besides the environmental ones in order to acknowledge the agency of people living in the past. This will take place during the phase of theoretical assessment. Here, fundamental shifts that resulted in behavioural changes of people in the rural Roman landscape will be identified. Nevertheless, the notion of environmental determinism raises an important question: What does a predictive model actually represent?

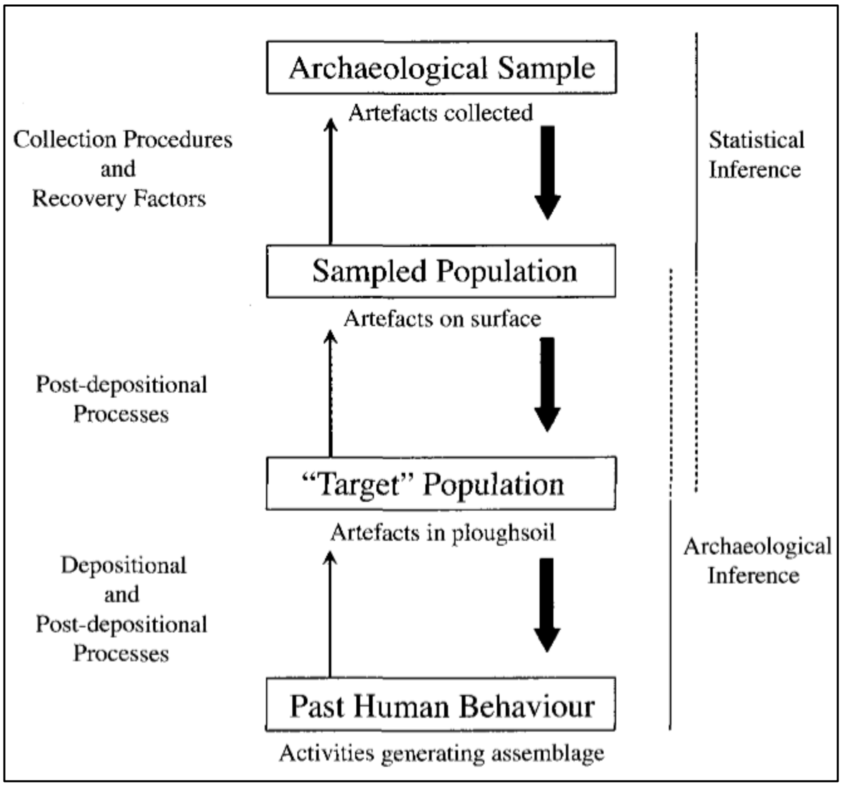


Figure 16. Inference model for artefacts in plough-soils
(Haselgrove et al., 1985, p.38)

Just as survey archaeology only succeeds in documenting a sample of the sites that were once found in the landscape, a predictive model only portrays the probability of sites at a given moment. In no way does a predictive model convey the precise locations of actual sites in the past. Such a model is a translation of the archaeologist's expectations into a visual format. Furthermore, one predictive model only does so for a certain moment in time (Verhagen et al., 2009, p.20). Of course, this does not mean that predictive models cannot be an asset in developing a better understanding of past societies. However, to do so one must be aware of its constraints. Predictive models can pave the way for further analysis, but it should not be an end product in itself. Therefore, the models produced in this research are used as an intermediate step in gaining further insights into the Roman rural world. On top of this, multiple maps will be created for various times. When necessary, the model will be adapted to fit the requirements for the time period in question. In the end, the created maps will be traced back to the expectations and general ideas concerning Roman agriculture and the socio-economic circumstances of the time. This will indicate whether the common conception of this culture is accurate or not.

3.3 Quantifying the model

With the preconceptions regarding survey data and the creation of predictive models explained, the next step is to apply this knowledge to the research area and period. This will be done in a broad context, outlining wide-range developments in the Roman world. This will lead to an overview of impactful changes in the agriculture and socio-economics of the Biferno Valley throughout the Roman period.

3.3.1 Terminology of Roman agriculture

Before delving deeper into developments over time, it is important to first outline some general terms and notions about Roman agriculture. First of all, the Mediterranean generally saw two main types of agriculture. The first of these was seasonal pastoralism. This type of agriculture consists of the keeping of a herd of livestock, usually sheep and/or goats, which was moved to different locations depending on the time of year. The animals tended to spend the winter in lowland plains, whilst they were placed in upland pastures during the summer (Van Joolen, 2003, p.13). The other dominant type of agriculture is a polycultural system of peasant economy. This system focused on the growing of crops, with a small amount of stock being kept. Within this type, three crop groups can be discerned. Firstly, grains made up the largest part of the Roman food supply. The soil used for the cultivation of these grains was worked with hand implements or simple ploughs, designed to scratch the ground. These tools saw developments in form and material throughout the Roman period, but their basic functioning remained the same. Besides this, garden crops, fruits and legumes, complimented cereal consumption (Kron, 2000, p.277). Lastly, there were cash crops, most notably olives and grapes, which were used as luxury products rather than for extensive food production. Olives and grapes could either be grown together or separately, depending on the desires and investments of the farmer (Van Joolen, 2003, p.14).

Within these two main types of practices, it was up to the farmer to decide which crops to cultivate to which degree. As estimates show that around 8 out of 10 people in the Roman world were employed in the agricultural sector, variations in farmland were great. It is noteworthy that this number includes people working in agriculture related transportation and production (Erdkamp, 2005, p.12). Nevertheless, it is clear that the majority of Roman inhabitants were in some way involved in agriculture, even though the Roman world, especially during the days of the empire, is traditionally often seen as an urban environment (Hanson, 2016, p.1). Indeed, many large cities emerged and flourished during this period, with Roman Italy at the forefront. This large occupation rate in agriculture is said to be needed to fulfil the food requirements for the entire population. Figure 17 displays the mechanisms that are at play in the provision of food to the entire Roman population. Others argue however that such a large agricultural workforce is unnecessary, as examples have shown that there are often more people employed in the agricultural sector than strictly necessary (Solonakis, 2017, p.112). In fact, it appears that in the Mediterranean regions of the Roman Empire, more agricultural surplus was created than was required for the population that was not employed in this sector. Unfortunately, there is more uncertainty on the situation during the Roman Republic (Erdkamp, 2005, p.13).

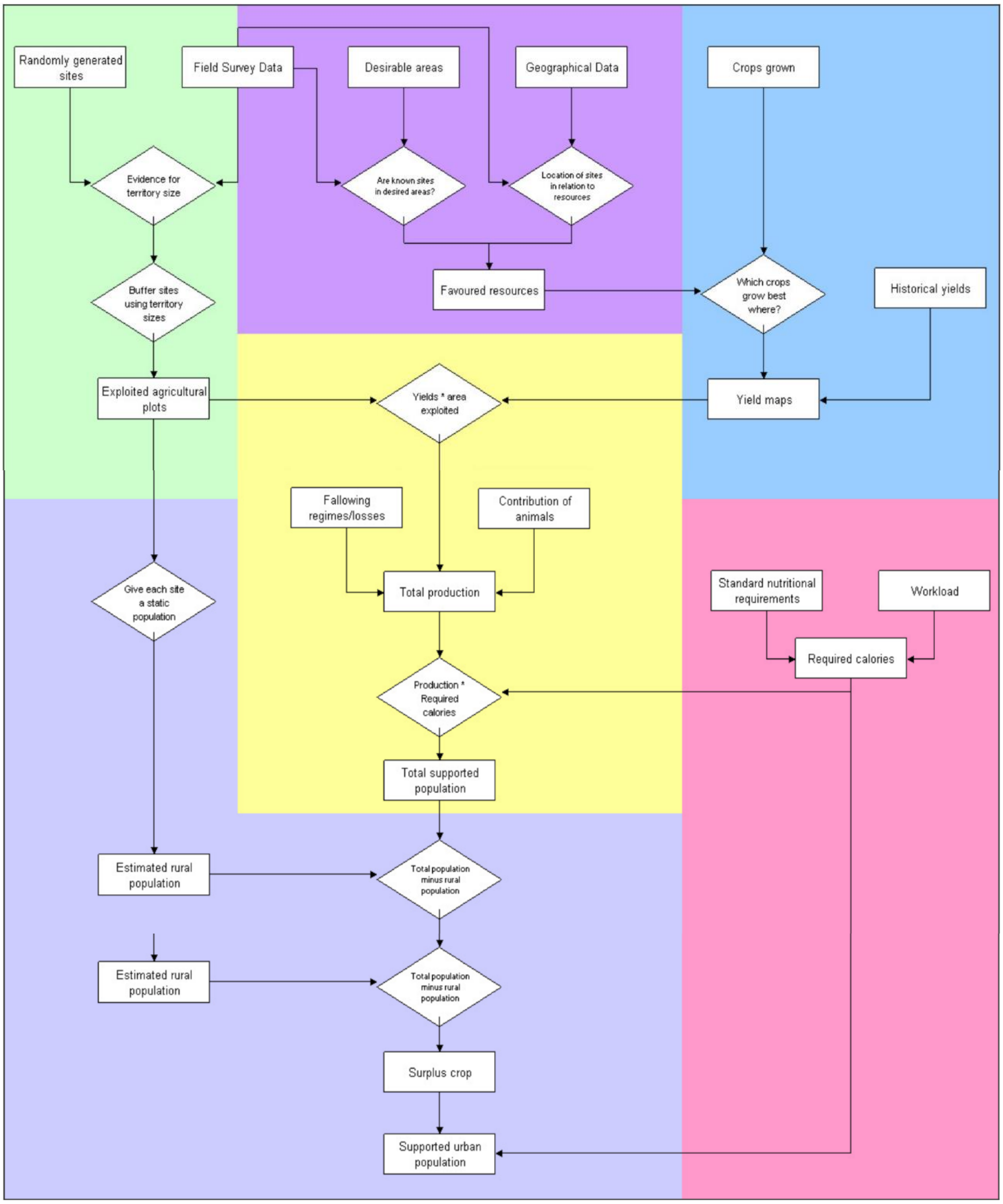


Figure 17. Model of agricultural production (Goodchild, 2007, p.12)

Just like in other facets of life in the Roman world, agriculture saw great differences in wealth and comfort. As such, different types of farms can be discerned. In a basic form, farms can be described as being either an estate or a smallholder (Erdkamp, 2005, p.171). The estate was usually, but not necessarily, larger in size and focused generally on selling goods on the market. This means that cash crops were commonly grown here.

Still, cereals and legumes were often cultivated to feed the inhabitants of the estate, who were usually tenants or labourers hired by the estate-owner (Erdkamp, 2005, p.172). In contrast, smallholders, especially peasants, were usually not so market-oriented and instead consumed most of their produce themselves. Therefore, cash crops were less commonly seen on their farms. The distinction between peasant farms and other smallholders can be made by the application of labour. Peasant farms employed labour to fulfil the needs of the people living there. On top of this, the workforce is made up of people living on the farm in the case of a peasant household (Erdkamp, 2005, p.58). Of course, these distinctions are not clearly defined. It is thus difficult to differentiate between an estate and a very market-oriented smallholder for example. Nevertheless, the abovementioned farm types form the general outline of rural organization and indicate the differences in the needs and possibilities of people in different echelons of Roman society. In this research, challenges in relation to site documentation exist. Therefore, in the rest of this thesis, a 'farm' is equated to a smaller agricultural site, whereas a villa simply stands for a larger, wealthier agricultural site. These terms differ somewhat from the terminology that would have been used in Roman Antiquity.

The classifications made here stem from neo-classical economic theory. This theory states that there are three standard ways of production in agriculture: capital, land and labour. Through investments in these facets, farmers can improve their production (Erdkamp, 2005, p.14). There are various methods in which someone can gain the same yields. One could for example invest in tools or certain crops, leading to increased efficiency. On the other hand, it is also possible to buy more land or increase the workforce. This is a useful way of looking at Roman agriculture, as tenancy can be viewed as a means of access to production factors. As someone becomes a tenant, they receive access to land and indirectly also to capital. At the same time, the landlord of the property gains labour and capital through rent (Erdkamp, 2005, p.14). In this way, neo-classical economic theory embodies the complex interactions and considerations that are at play in Roman agriculture in an understandable manner. Furthermore, it is not far sought at all to apply the theory to this period in the past, as notable Roman authors, such as Cato, also talk of these terms in relation to agriculture (Van Oyen, 2020, p.19).

3.3.2 Developments in Roman agriculture

This section will examine the developments that occurred in Roman agriculture. These developments will indicate preferences in land types over time. These choices will be translated into the further analyses of this research. It will be explained how different types of crops were grown on different kinds of farmland. As a result, differences in preferred qualities of a location in the landscape reflect the developments described here. The findings made in this section therefore aid in determining which factors will be built into the predictive model by exploring emic perspectives.

Ancient literature is a great source for understanding the view Romans had on agricultural practices. Ideas on how to perform farming and how to sell goods were centrally engrained in the identity of many Romans. In his 2nd century BCE work *De Agri Cultura*, Cato even elevates the concept of a good farmer to be an example of what a good man should be(Cato, agr. 1, 1). Especially amongst elite farm owners, unspoken rules dictated social interactions (Van Oyen, 2020, p.19). Cicero writes, for example, that elites should always put products on the table produced on their own farm. It was heavily frowned upon for an elite to buy their bread or wine (Cicero, Pis. 1, 66, 67) Comments such as these give clear indications of the types of farming activities that could be expected. Advice on where a farm should be best located in order to maximise profits is also present in similar literature. The prosperity of a farm depended on factors in its surroundings, mainly those influencing opportunities for buying and selling goods. Authors such as Varro and Columella both mention road connectivity as being very important (Columella 1, 3, 3; Varro, Rust. 1, 2, 22). Interestingly, they do not distinguish between the transport of goods to the farm and the transport away from the farm. A good source of supply was thus seen as just as important as a way to transport crops elsewhere, given that lower supply costs also lead to more profit (Erdkamp, 2005, p.112). Important to note too is that goods were not necessarily sold on markets or in cities. In fact, it was often advised to sell on estates themselves, where individuals could strike deals or auctions could be held. These auctions were even stimulated through the appearance of *argentarii*, who gave out loans to middlemen for use at such auctions, further enhancing trade (Erdkamp, 2005, p.113). These attributions attest to the large importance paid to roads. However, Varro mentions safety as being the most important, even more so than connectivity (Varro, Rust. 1, 16, 2). No one would go to an estate if there was a high chance of robbery. Nevertheless, this was most applicable to tumultuous regions and not so much to central Italy (Erdkamp, 2005, p.111). It seems that cities did not play a huge attracting role for farms, especially larger and wealthier ones. Instead, the choice of crops to cultivate depended on the volatile urban market in case of relative proximity. If located further away from cities, farmers generally moved away from flowers and other garden crops in favour of an intensified cultivation of grain, for which there was always demand (Erdkamp, 2005, p.111). In practice, this means that villas and farms in the Biferno Valley were not necessarily found near urban centres. Instead, a close proximity to roads is more likely. The roads we can find in the archaeological record are large ones that facilitated wheeled transport. Tracing movement on foot is unfortunately not feasible due to the poor preservation of smaller paths (Kolb, 2019, p.11-12). Spatial patterns in relation to roads can appear very differently depending on the classification of roads. This is illustrated in figure 18, which gives an example of how Roman roads can be categorised.

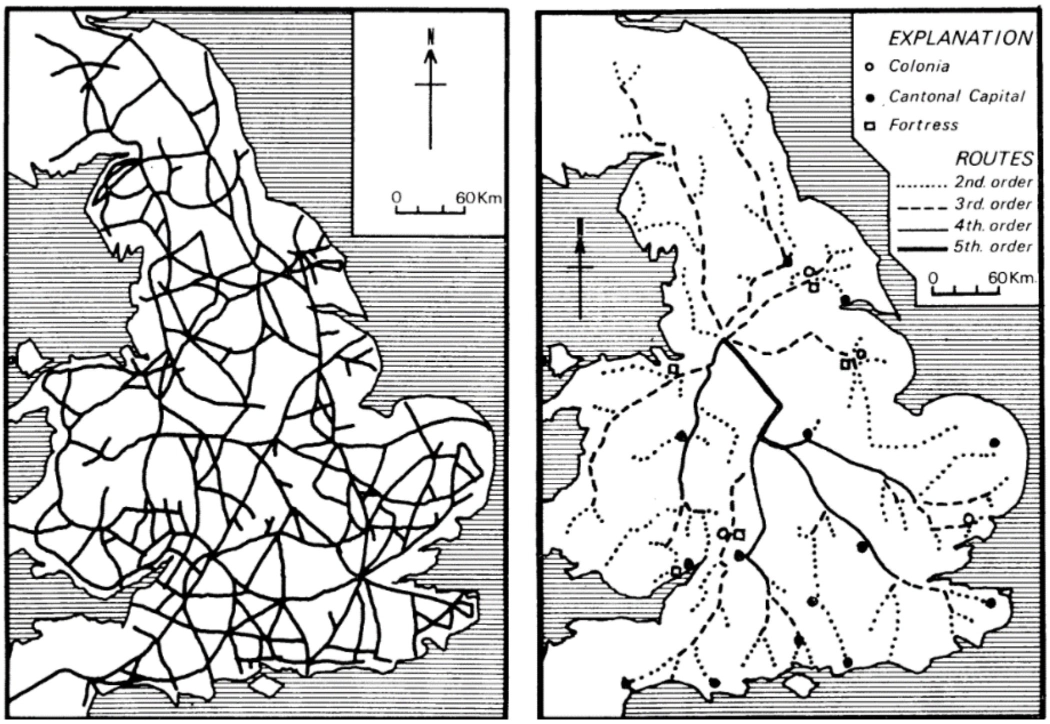


Figure 18. Map of different orders of Roman roads, example of Roman Britain (Langton et al., 1972, p.139)

On the one hand, farmers were influenced by human infrastructure in their interaction with the market. On the other hand, it could be said that natural factors contribute most to the functioning of a farm. In his *Natural History*, Pliny mentions the large impact nature has on a person's living standards (Plin., HN, 18, 1, 1). This work, written in the 70s CE, is strongly influenced by a stoic way of thought. As such, Pliny describes nature as divine. The author gives specific examples of appropriate and of inappropriate ways to exploit nature (Saller, 2022, p.49). Further on, Pliny talks extensively about economic growth in relation to agriculture. He attributes great value to innovation (Plin., HN, 33, 2, 4). New knowledge needs to be acquired for there to be sustained economic growth. In Pliny's view, there are two main sources for innovation: the gods and chance (Plin., HN, 27, 5, 7-8). These sources yielded the most when there was competition. In periods of limited competition, such as under the Pax Romana, there was little incentive for innovation (Saller, 2022, p.70). On the flipside, it could be said that the expansion of the Roman realm promoted innovation, as contacts were laid with new peoples and competition was fierce. Indeed, Pliny acknowledges the value of an empire in promoting trade (e.g. Plin., HN, 3, 3, 21; 5, 5, 34; 6, 32, 149). However, looking at commerce, there seems to be no direct correlation between the extent of the Roman Empire and economic welfare for the general population. In fact, scholars have long argued that the Roman economy grew steadily during the early empire, but that this came to an end with the Antonine Plague of 165CE (Saller, 2022, p.3). However, this idea of constant economic growth has become criticized. Whilst the general consensus remains that living conditions improved during the first 2 centuries AD, various sources show no indication to marked economic growth in this period (Saller, 2022, p.10-12). It is of course incredibly difficult to measure a term such as economy in the past. Nevertheless, there are proxies that can be used to estimate economic activity. Data from ice cores for example shows levels of lead and copper pollution, related to mining and smelting of metals (De Callatay, 2005, p.363). This data source indicates that these activities declines slightly in the first century and a half of the empire, although its reliability can be questioned (Saller, 2022, p.17). Another proxy that has been used is the emergence and decline of cities. In Roman Italy, a significant increase in urban centres can be observed up until the first century BCE. After this point in time however, this increase levels out, once again giving no indication to continued economic growth (Saller, 2022, p.14).

These ideas about economic growth relate to agriculture in that the production of farms experienced a lot of influence from the working of the market. Of course, concepts such as economic growth are much more abstract than the functioning of a farm in itself. Furthermore, it is doubtful that the general farmer was even aware of such notions. It is still under debate whether the Romans had a system in place to rationally calculate the best course of action in terms of maximising profits at any given time (Saller, 2022, p.84). It could thus be questioned whether farmers made conscious choices in relation to the surroundings of their farms. Nevertheless, a qualitative approach to making such decisions seems to have been in place (Saller, 2022, p.85). Established authors, such as Pliny and Cato, have written extensive pieces of advice on what to look for in the landscape, although their advice differs in some points (Saller, 2022, p.86). The material record also shows that even peasant farmers were not isolated from the general economic and social world (Erdkamp, 2005, p.56). Even more so, skeletal data indicates that the general population experienced shifts in health and body stature as a result of empire-wide processes, such as urbanization and consolidation (Saller, 2022, p.21). As a result of these points mentioned above, it can be said that people in the agricultural sector underwent changes as a result of large-scale developments, but that they also made conscious decisions on the functioning of their farms. This could go from choosing which soils to work and which crops to plant to determining the size and location of storage facilities to manage surpluses (e.g. Van Oyen, 2020, p.38). This would have meant that there was not a fixed cut-out for a perfect farm location. Instead, farmers decided which features in their surroundings were desired based on their objectives. When researching this topic, various points of view must therefore be considered and represented in the results.

Site locations also depended on choices people had made in the past. It was often easier to occupy an existing farm than to create a new one. Therefore, it is important to look at long-term developments in the research area. When looking at the Bronze Age and Early Iron Age, the Italian peninsula shows a land use pattern dominated by extensive pastoralism. In these periods, inland hills and plains were most often occupied, with the coast being remarkably more abandoned (Van Joolen, 2003, p.14). During this time, most people lived in hierarchical societies. Agriculture was still relatively primitive, with two predominant types. The first of these is sedentary mixed farming with grain and legume cultivation and stock raising. The second type is a more specialised transhumant pastoralism where grassy areas were used for winter pasture (Van Joolen, 2003, p.15). In the Late Iron Age, before Roman colonization, agriculture started developing further and fortified settlements appeared in the hills and mountains. In the period between 700-600 BCE, the typical Mediterranean polyculture was established, with the cultivation of cereals besides that of olives and grapes. The agricultural production was expanded in this way because it added to traditional agronomics (Nijboer, 1998, p.245). It was thus during the Iron Age that cereal production increased quickly. Emmer and naked wheat saw the most drastic increase, with significant legume cultivation and an increasing importance of grapes and olives as well. The increase in population during this time led to a larger number of crafts being practiced, as well as more mining and commerce and an expansion of arable land. For this purpose, oak and beech forests were taken down and fertile alluvial plains were brought into use. However, coastal swamps and mountains continued to be avoided (Van Joolen, 2003, p.112).

The sixth century BCE was a period of rapid innovation and change. Rural sites across Italy, but mostly in the south, increased in number and size under the influence of Greek immigrants. The culture of grape and olive cultivation kept expanding, which further incentivised the clearing of forests (Van Joolen, 2003, p.112-113). It was also at this time that leasing systems and geometric land divisions, *centuriations,* came into use. The spread of iron ploughs meant that also quite dense, clayey soils could now be cultivated. Different cereals became cultivated in larger areas, with wheat being the most extensively cultivated crop in central Italy (Van Joolen, 2003, p.113). Moving into the Archaic and early Roman periods, agricultural developments continued. Initially, olive production was quite small-scaled. However, this gradually changed in the centuries to come. Further technological advancements meant that continuously more types of land could be cultivated (Van Joolen, 2003, p.140).

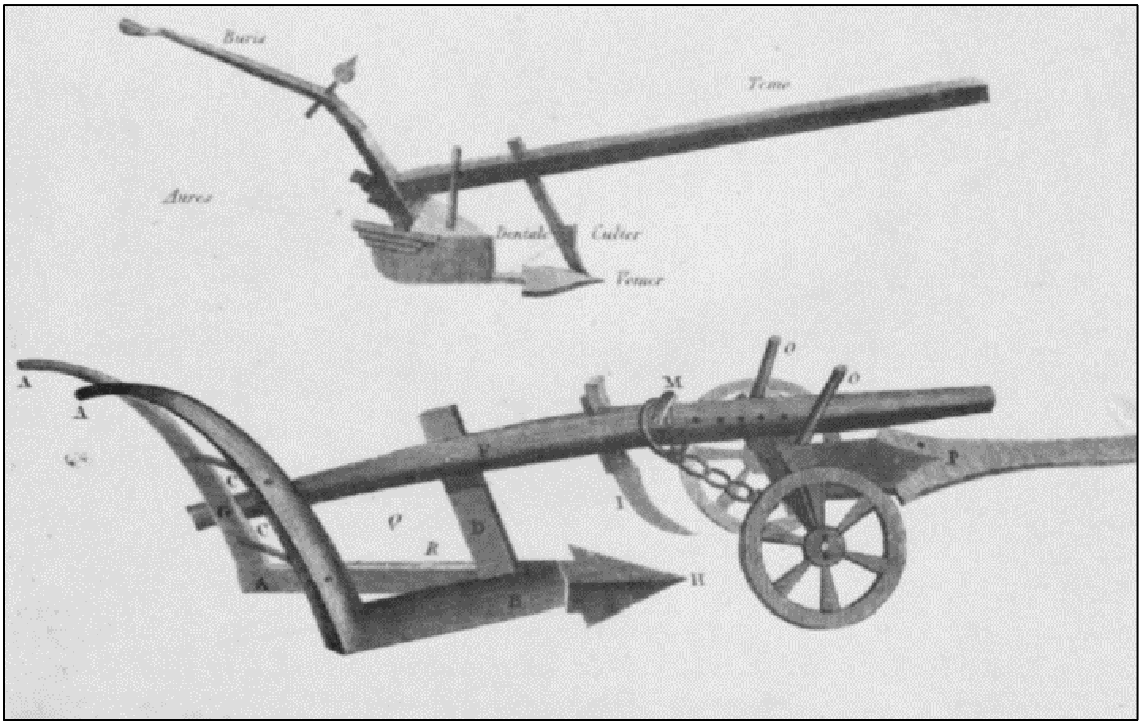


Figure 19. 18th century drawing of a Roman plough (Fussell, 1967, p.22)

Traditionally, the emerging farm types in Roman Italy have been divided into three types: small farms, larger/medium-sized farms and large farms. The first of these saw a polyculture of cereals for domestic purposes. Millet was commonly grown here because of its low requirements in soil and climate. These farms generally had one plough, which was used on all soil types in small fields. Plots of land were alternately left empty to regain fertility, a practice called *vervactum* (Spurr, 1986, p.170-171). The second type, larger farms, still focused on self-subsistence. Nevertheless, specialisation in other crops occurred. The produce were largely used to feed the workforce, but a rotation of various kinds of crops, including millet and fodder crops, was present on the plots of land of each farm. Multiple ploughs were present for use on different soil types (Spurr, 1986, p.171). Lastly, the large farms focused on selling cereals, of which there was a polyculture. Food for the workforce was bought from elsewhere, as only cereals were grown here. This meant that multiple types of farm were often found in the near vicinity of large farms. The use of multiple ploughs for even heavy soils and spade working of arable land took place from the Late Republic onward (Spurr, 1986, p.172). Besides these main types of farm, there were also common practices for various types of terrain. Permanent pastures were located on land with a high ground water table for example.

Mountainous and remote areas were often subject to slash and burn agriculture, where only small-scale tillage could take place because of the steepness of the terrain. For short-distance transhumance, a location near a river was preferred, as the animals moved near these streams for several months each year (Van Joolen, 2003, p.115). In the researched area, a fairly wide range of landscapes is expected to be occupied, owing to the varying types of farms that existed. Unfortunately, the nature of the source data does not allow for a separate analysis for each type of agricultural site. Instead, generalisation has to occur when determining the suitability of certain types of terrain.

Besides general geographical tendencies, Romans had clear ideas on which types of crop to grow on certain types of soil. These ideas differed somewhat from what we argue now. According to most Romans, olives and wheat needed to grow on fertile soil, which is now perceived differently. At the time, soils suited for the cultivation of cereal or grapes and olives were seen as fertile. These soils included chalky soils with good water retention and rather dry calcareous soils. (Van Joolen, 2003, p.120). Soils were often categorized based on their relation with tools. As such, four main types were distinguished: 1) soils naturally suitable for grapes, in the past mostly covered by mixed oak forest, 2) soils that need to be drained and irrigated because they are too compact, with a large fraction of very fine clay or a large marble substrate, 3) sandy, alluvial, hydromorphic and saline soils which can be used to grow vegetables and cereals if water and salt are continuously battled, and 4) soils on which cultivation is not possible. When large tools and heavy equipment were unavailable, light and dry soils were generally preferred over heavy and humid ones (Van Joolen, 2003, p.120).

When attempting to establish ideal growing conditions for certain crops, one cannot just look at current day variants, as modern crops usually have an altered genetic makeup (Van Joolen, 2003, p.122). Wheat, mostly emmer, and olive trees underwent limited change and ancient requirements must thus not have been very different from present ones. Luckily, descriptions of other crops give an indication to the preferred growing circumstances in Roman Antiquity. As mentioned before, wheat (*Triticum*) was one of, if not the most important crop for food production. Six varieties can be discerned: einkorn, emmer, durum, spelt, bread and club. Of these, emmer was initially likely the most common one. In Late Antiquity however, the kind was often replaced with other types of grain. In terms of preferred growing conditions, the type overall resembled other kinds of wheat (Van Joolen, 2003, p.122). Both autumn-sown and spring-sown emmer wheat performed best in non-calcareous, moderately fertile soils. Clayey or sandy-clayey soils at least 30cm thick with moderate to poor drainage were ideal for this purpose. Rotation with other crops was ideal, but irrigation, weeding or manuring was not needed in the Italian peninsula. Because of climatic requirements, emmer wheat was preferably not planted more than 1100m above sea level (Van Joolen, 2003, p.123). As established, these requirements went for various kinds of wheat. Some variations occurred in einkorn wheat, which was not very common in Roman agriculture, and spelt wheat, which often replaced emmer wheat in the late Roman period. The latter was best sown in clayey, fertile calcareous soils with moderate to poor drainage. Ideally, south facing hill slopes were used (Van Joolen, 2003, p.125).

Another commonly cultivated cereal during Roman times was barley (*Hordeum vulgare*). Even though this crop was mostly used as animal fodder, it was also consumed by humans in times of scarcity. There were two predominant types, with slightly different preferences. Firstly, 6-rowed barley grew best on loose, dry ground which was either very rich or very poor. In the case of the latter, the land had to be left empty for a year after cultivation or manured. 2-rowed barley was best sown in very rich soils which were dry, loose and fertile. This usually meant it was placed on dry sandy soils. Since barley does not require a lot of nutrients, it was most often found on thin soils, although it could perform well on deeper soils too (Van Joolen, 2003, p.125). The last cereal to be discussed here is millet (*Panicum miliaceum*), which was often used to make bread or porridge. Millet was mostly cultivated in light, loose soils. Even though the grain grows well in gravelly or sandy soils, it does need good watering. As a result, sandy calcareous soils in a moist climate were preferred (Van Joolen, 2003, p.126).

Figure 20. Pompeii wall painting featuring millet (Murphy, 2016, p.66)

The choice of where to grow cash crops seemingly depended more on the situation of the market and the opportunity to sell. For grapes (*Vitis vinifera*) it was said that trading only became profitable when located close to a village or larger urban centre. Furthermore, which circumstances were ideal also depended on the type of grape that was grown. In general though, it was advised to grow this cash crop in quite loose soils which were rather fertile. It was not recommended to use very fertile soils, since cuttings would root very quickly here. Instead, slightly elevated plains with sandy soils were ideal. Loamy soils were marginally suitable too (Van Joolen, 2003, p.126). Lastly, several types of olive tree (*Olea europea*) existed as well. Larger olives were eaten directly, whereas smaller ones were used to produce oil. This crop needed to be grown on well-drained soil. This means that slightly inclined slopes were ideal, along with gravelly soils, especially when chalk and sand were present in the topsoil. Rich sand or more dense soils were also suitable and even steep, rocky slopes were moderately suitable. Muddy or marshy areas, as well as lean sand and bare gravelly soils were to be avoided though. Climate wise, olives thrived in mild climates, with limited temperature shifts (Van Joolen, 2003, p.127).

3.3.3 Choice of factors impacting site location

Given the developments outlined above, it has become clear that determining natural factors remained quite constant. As polyculture was very common, ideal locations were those where various types of soil were present. For farms where grain was the predominant crop, fertile sandy-clayey soils were sought after. When olives and grapes were cultivated too, looser soils such as sands were needed. In terms of topography, alluvial plains and steep mountains were not well-suited. Instead, elevated areas were preferred. This means that a lot of farms are to be expected in hilly patches, especially on south-facing slopes where certain types of grain grew best. As the overall mix of cultivated crops changed only minimally during the Roman period (Van Oyen, 2020, p.41), there is no reason to assume that these factors greatly changed in importance. Therefore, the weight of soil type and slope will be kept similar in the model for the entire researched time frame.

What did change throughout the research period in regards to farm's locations is the impact of economic circumstances. As the Roman world expanded and its population grew, interactions between all layers of society changed. Given the crucial position of the agricultural sector in providing subsistence, this was certainly felt here too. Since the Early Republic, grain transport was an important business (Van Oyen, 2020, p.129). As the production of cash crops was not as big at this point as it would later become, small farms dominated the countryside (Erdkamp, 2005, p.74). Products were mainly sold to nearby villages and towns in bulk, making locations in close proximity to these centres ideal. In the Late Republic, especially from the 2nd century BCE onwards, Roman dominance over large parts of the Mediterranean meant that new economic opportunities arose. A new era of Roman politics started in an attempt to carry on Alexander the Great's legacy in the east. This resulted in the rising of wealthy generals to the forefront of Roman governance. With this process came a larger desire for luxury products, such as wine and olive oil (Van Oyen, 2020, p.21). The export of these products to newly conquered territories grew enormously. As a result, Central Italy became a region focused heavily on production in villas. Generally, production sites close to the sea were focused more on long-distance trade, whereas those more inland supplied mostly to urban centres closer by. In both situations, small distances to major roads were sought after (Erdkamp, 2005, p.111; Van Oyen, 2020, p.21). The rise in villa numbers did not mean that small farms disappeared. On the contrary, the two were often found close to each other. Trends in the number of villas and farms throughout time are visualised in figure 21. Agricultural produce and finished goods could be traded and large estates often relied on seasonal labour from inhabitants of small farms in the vicinity (Van Oyen, 2020, p.22). For villas focused on wine production, extra close proximity to either an urban market or waterways was needed, given the high price of land based wine transport (Erdkamp, 2005, p.172). Even though naval trade was very important to the Roman economy, the Adriatic Sea had the reputation of being dangerous during the Republican period because of pirate activity and the lack of safe natural harbours (Erdkamp, 2005, p.197). Therefore, the attractional force of the sea in the early Roman Biferno Valley must have been minimal in comparison to that of roads, cities and rivers.

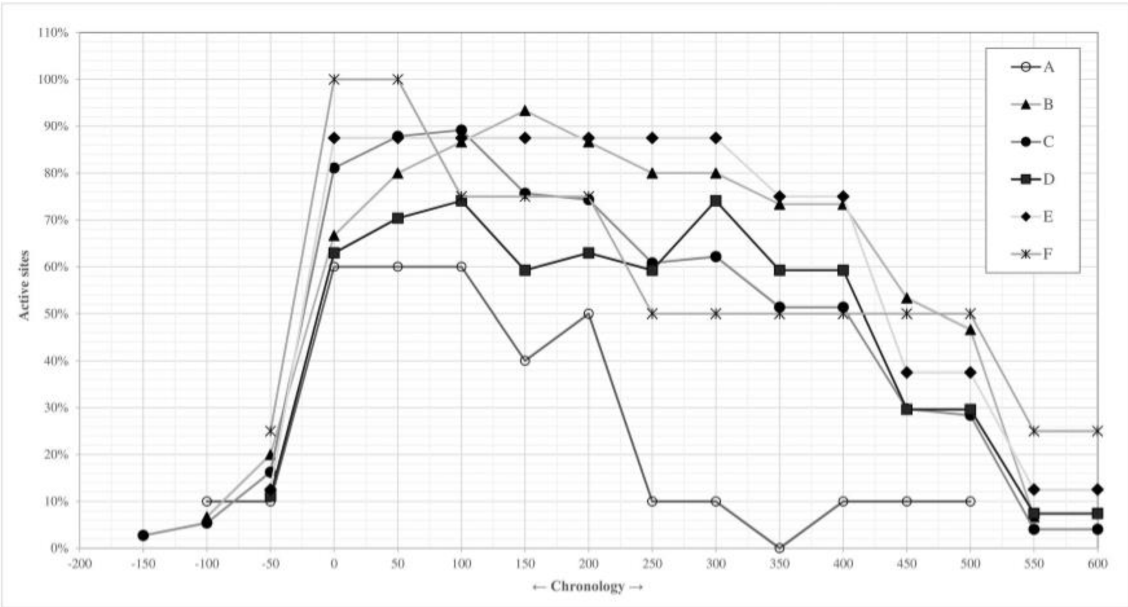


Figure 21. Trends in number of Roman farms (A & B) and villas (C, D & E) through time in northern Italy (Marzano, 2020, p.25)

Moving from the Republic into the Empire saw continuous growth of villa numbers. As the empire grew, so did the influx of new people into the Roman countryside. Whether it be veterans, traders or other people, they did lead to an increased connectivity between the centre of the Roman Empire and the newly acquired provinces (Van Oyen, 2020, p.59). The emergence of new connections and the introduction of new types of agriculture, such as sharecropping around 100 AD, meant that the market relied more on social hierarchy and prices than on proximity alone. Trading of agricultural produce, especially wine, started to occur more often through embedded social networks (Van Oyen, 2020, p.81). Combined with a largely unsupervised urban food supply, which was left to the market, the importance of proximity to cities diminished compared to the centuries prior. However, it became even more beneficial to have farms located relatively close to each other due to the benefits of tenancy. Tenants and members of extended households were regularly valuable additions to the labour force, especially on large market-oriented farms (Erdkamp, 2005, p.70). Another expectancy is that the role of the Adriatic Coast increased in importance. Larger quantities of goods being transported over vast distances and a strong Roman grasp on the sea meant that naval trade grew larger than before. Nevertheless, a law change in the 70s BCE meant that ship ownership among landowners decreased. Some villa owners still possessed smaller boats to ship their own produce, but the scale of such movements remained limited (Erdkamp, 2005, p.119). As a result, it was beneficial to occupy a location near major roads close to the shore, but the advantages of being directly on the coastline were slim. Even though a lot changed moving into the centuries of the Roman Empire, there was not enough change to warrant a complete change of model building strategy. Even though social networks became prominent, the market system remained in place and overall production strategies remained very similar despite technological advancements. Furthermore, it is incredibly difficult to differentiate between public and private mechanisms, as they were so intertwined (Erdkamp, 2005, p.279).

4. Empirical Assessment

This chapter contains a consideration of various factors to be used in the model creation phase of the research. The discussion is based on the theory developed in the previous chapter. The influence of several high-impact variables will be examined in more detail. In chapter 5, the formulated views will be quantitatively tested using the existing survey record. As such, hypotheses are formed in this chapter and will be tested subsequently.

4.1 Terrain

It should be clear that terrain had a strong impact on the functioning of agriculture. Landscapes dictate in which areas certain types of farming can be practiced. In general, groups employing more primitive tools and methods were more strongly influenced than those with many innovations in use, as the latter could more easily transform their environment, forming proper cultural landscapes (Mottet et al. , 2006, p.297). It has to be clarified that such landscapes comprise a large array of interlinked agents, many of which are immeasurable. Therefore, this research focuses on the steepness and the aspect of slopes. Logically, it would seem that the flatter the terrain, the more suitable it would be to agricultural activity. Still, in an innovating world with a growing population it was rarely possible to avoid slopes altogether. This is especially true for a Central-Italian valley during the Roman period (Goodchild, 2007, p.126).

In the previous chapter, seasonal pastoralism was marked as a major type of Roman agriculture. As stated, this strategy involved moving animals seasonally from lowland plains to upland pastures during summer (Van Joolen, 2003, p.13). Since pastoralism is hampered less by steep slopes than the cultivation of crops, this could take place in relatively mountainous areas as well. In fact, archaeological projects in the Alps and the Apennines have unearthed pastoralist sites deep into the mountains at very high altitudes. Some of these sites date back as far as the 6th millennium BCE, with intensified pastoralism occurring here from the 4th millennium BCE onwards (Carrer, 2015, p.4). In the Biferno Valley, a high continuity of sites was observed. Pre-Roman sites occupied much of the upland hills in this region (Van Joolen, 2003, p.14). For these reasons, sites must have been found here in the Roman period as well, especially the early phases. Of course, the steepest hills in the mountains remained unsuitable, but many moderate slopes in the uplands must have been suitable to pastoralism. In practice, this means that in Roman Republican times, smaller agricultural must have been present on steeper slopes than larger villas, as these did not engage as much in pastoralism. It is expected that a similar pattern can be observed for the Imperial period.

Another way to turn relatively steep slopes into farmland is by constructing terraces. Through terracing, in which retaining walls were outlined on hillsides, crops could be grown in more rugged terrain. Whereas archaeological projects have yielded evidence for such practices in Roman Antiquity, literary sources lack such descriptions (Foxhall, 2013, p.46). This does not indicate that terracing did not occur. Instead, it attests to the discrepancy between different types of farmers in their representation in the works of well-known writers. Most literary works describe the situation for wealthy landowners rather than peasants (Foxhall, 2013, p.45). It is therefore believed that terracing was more often employed by smallholders than by owners of large estates. Once more, these observations make it likely that small farms were generally found on steeper slopes than villas, and therefore at higher elevations as well.

Whilst the aspect of the slope, the direction it faces, must not have had much importance for herding, it did matter to the growing of crops. Certain types of grain, such as several types of wheat, grew much better on south facing slopes (Van Joolen, 2003, p.125). Again, this mattered less for flat lands in the lower valley, where gradients were minimal. However, it was definitely considered heavily in the hills. Also for olive trees, slight slopes were ideally suited, although the aspect was not as crucial as it was for wheat (Van Joolen, 2003, p.127). All of these factors combined mean that slight south-facing slopes were the ideal farmland. Flat terrain was the next best thing, whilst not south-facing slopes were less preferable. These last lands were often exploited for raw materials, mostly wood, but were not heavily sought after regardless (Foxhall, 2013, p.54). This will be incorporated into the model. Hillslopes will be marked as more suitable to smallholders, whilst less so for large estates. Furthermore, cereals in particular grew poorly above an elevation of about 1100m (Van Joolen, 2003, p.123). Higher terrain was thus not suitable to farmers, especially those on market oriented estates and large farms. Therefore, high elevations will be marked as unsuitable for smallholders and very

Figure 22. Terrace excavation on Enveitg Mountain, southern France (Harfouche, 2007, p.320)

unsuitable for owners of large farms. These preferences do not seem to have changed much throughout the period of Roman occupation.

4.2 Soils

When it comes to soils, one might think all types of farmers would seek out the most fertile patches. However, reality was much more complex than this. As was discussed in the previous chapter, the Romans had strong opinions on which types of soil to use for certain types of crops. These views often differed from present ones (Van Joolen, 2003, p.115). It has also been explained that the makeup of the cultivated crop types varied depending on the size, wealth and integration of a farm into the trade market (Van Oyen, 2020, p.38). This must have led to differences in the types of soils sought after by owners of small farms compared to owners of large estates.

Market-oriented farms, usually large estates, grew large quantities of crops. As established earlier, those that found themselves close to urban centres often focused on the production of large amounts of cereals. Those that were more isolated generally grew many cash crops, such as olives and grapes. This was especially the case for later Roman periods (Van Joolen, 2003, p.140). For farms where much cereal was grown, large plots of non-calcareous and moderately fertile soil were needed. Moderate to poor-drainage requirements meant that clayey or sandy-clayey soil was desired (Van Joolen, 2003, p.124-126). For the cultivation of olives and grapes, less fertile and loose soils were best. Therefore, these crops were generally found on sandy or loamy grounds. With many resources to invest into their farms, estate owners could afford tools, such as ploughs, that facilitated the use of denser, more clayey soils. This was especially the case for later periods, after several innovations in the field. Being able to afford multiple farms, estate owners could occupy terrain where several types of soil were to be worked (Van Joolen, 2003, p.113). Generally, it can thus be said that larger types of farms would have sought out locations with large sections of sandy-clayey soil or with loamy and gravelly soils. Sections of mud or marsh deposits were to be avoided throughout the Roman period (Van Joolen, 2003, p.127).

This picture differs from what is observed in small farms. Here, cultivation strategies revolved around providing food for the household itself (Spurr, 1986, p.172). This meant that a larger variation of food was grown on smaller areas. Also, the growing of cash crops was less prominent in exchange for a larger amount of garden crops (Van Joolen, 2003, p.14). Practically, this means that smallholders must have needed locations where all types of produce could feasibly be grown. As such, it could be argued that the soil quality of a plot of land was less important than its overall variation in soil types. Of course, deeper soils with many nutrients must have still been preferred, but since the subsistence of the farm's household depended on what was cultivated locally, land in which many crops could be grown was surely ideal. This idea is reinforced by the argument that smallholders did not usually own more than one plough, which would be suited for one type of soil (Spurr, 1986, p.172). Unfortunately, the available sources on soils in the Biferno Valley do not offer enough detail to accurately map small patches of varying soil types. Therefore, it is only possible to assess the suitability of each type of terrain separately. Looser loamy and sandy soils must have been quite ideal, as this terrain is suitable to many types of grain and other crops. Once again, later periods must have seen an increased working of dense clay, although the increase is expected to be less than for large estates, owing to the limited means of investment into small farms (Van Joolen, 2003, p.127).

4.3 Waterways

Needless to say, water always plays an important role in agricultural practices. Roman Italy was by no means an exception. Throughout the peninsula, waterways were used and irrigation systems laid out in order to aid farming (Willi, 2019, p.33). Quickly, landscapes of forests were transformed into farmland through the construction of canals and reservoirs. This happened in increasing measure after the 3rd century BCE, when dams and barrages made its way into the Roman world from the east (Willi, 2019, p.34). Around the same time, the Italian climate became very similar to what we know today. With mild and somewhat wet winters, but with dry summers, water catchment became vital to being able to grow crops throughout the year (Keenan-Jones, 2013, p.234).

Figure 23. Pondel aqueduct bridge, Italy (Willi, 2019, p.78)

Even though the Romans are known to be able to efficiently transport water over long distances, this was not common practice in agriculture. As irrigation systems could be quite expensive, a close proximity to rivers or lakes was still a great way to keep costs low (Ronin, 2020, p.4). Furthermore, rivers were incredibly important in providing a means to cheaply transport produce to urban centres (Ronin, 2020, p.5). This means that market oriented estates would benefit most from access to a larger river. On top of this comes the fact that garden crops, usually grown close to urban centres, saw the most advantages from irrigation in terms of agricultural efficiency (Ronin, 2020, p.4). Of course, other types of agriculture, including transhumance, increased in efficiency and yields as a result of irrigation as well. Therefore, water must have been a large attractional force to all kinds of farms, but likely the most to estates whose focus lied on selling to the urban market.

As with many things in the Roman world, the control and use of water was well regulated. One could not simply channel water from any source to their own land. Whilst some water sources were made publicly accessible (*res communis omnium*), others were owned by municipalities (*res publica*) or by private owners (Willi, 2019, p.245). Unfortunately, it is not entirely clear which waterways fell under which category. In general though, larger bodies of water were controlled by municipalities. Small streams and springs were often owned by the owner of the land in which they laid (Willi, 2019, p.246). Roman texts describe that large perennial rivers and the sea were considered public (Willi, 2019, p.247). However, it is unclear what their definition of such a river would entail. Still, it can be said that the Biferno river would likely be considered public water. It was however unlikely that the regular farmer had access to an advanced irrigation system due to the associated costs. Shared systems could be constructed with municipal funds, occasionally sponsored by wealthy individuals. In some parts of the Roman world, communal use of irrigation systems was common (Bruun, 2015, p.142). In Roman Italy however, competition for water was fierce and limited information exists on such collaborations (Bannon, 2020, p.4). Furthermore , shared irrigation systems on the peninsula were mostly limited to urban environments, to the disadvantage of isolated farms (Ronin, 2020, p.16). Overal proximity to a large river was quite important to all farms and villas. In general larger estates must have been found closer to natural water sources, owing to their more substantial production and their larger means of investment. In late Republican and early Imperial times, distances could likely increase thanks to the introduction of newer methods for irrigation (Willi, 2019, p.34).

4.4 Infrastructure

4.4.1 Urban Centres

The concept that urban centres and farms were quite connected during the Roman period should surprise no one. Much research has attested to the great importance of agriculture in providing food to Roman city dwellers (Erdkamp, 2005, p.13). This was especially the case for large estates. As explained in chapter 3, this type of farm, run by wealthy individuals, produced large amounts of produce, often cereal, to be sold on the market. Nevertheless, the always present demand for food resulted in farmers not being forced to be very close to cities. As outlined earlier, road connectivity was more important (Erdkamp, 2005, p.111). Still, cities did play the role of large nodes in market and exchange networks. This must have been at least somewhat important to farmers during the Republican period and certainly so during imperial times. This rise in importance is due to an increasing emphasis on overseas trade during the latter period. This resulted in an increase in villages and large estates near trade hubs, in exchange for a decrease in smaller settlements further away (Witcher, 2017, p.42). With this move of villas, small farms did not fall behind. As the two were reliant on each other for produce and labour (Van Oyen, 2020, p.22), a similar change must have occurred for smallholders. Therefore, the model will include a moderate attraction to urban centres for all farm types. This attraction will be larger in the Imperial period compared to the centuries prior.

4.4.2 Roads

The relation between roads and farms in the Roman world is an interesting concept. It is clear that there is a spatial correlation between the two. This has been reflected in the archaeological record, as well as ancient literary sources, as described in the previous chapter (Witcher, 2017, p.38). Nevertheless, a debate about causality has arisen. One the one hand, it could be argued that roads likely arose before the creation of many nearby farms. Long-distance roads were initially a way for the Romans to establish military and political control over the Italian peninsula and economic growth could later occur around these transportation nodes (Kolb, 2019, p.9). However, it is likely that some form of farmland was already present in some locations, especially when already inhabited in the Bronze Age, as is the case for the Biferno Valley. These farms should have been connected in some form. Then, the Roman road system could be seen as a method of connecting various smaller networks together and tying them into the urbanizing Roman world (Witcher, 2017, p.39).

Either way, it has been mentioned before that roads did play a significant role in rural site locations. It was said that especially larger estates, which more often traded significant quantities of produce, were generally found in the vicinity of at least one large road. For smaller farms, smaller roads were suitable too. This picture is indicative of a network of sites that each had a certain function and occupied a certain niche in the landscape. In reality, villages and other settlements were also involved in that they provided an intermediary between rural and urban. Settlements were generally well connected to the Roman road system, and thus cities, which in turn connected them to food growing estates (Bertoldi et al., 2019, p.193). Spatial analyses for large agricultural sites have shown that these sites are found close to major roads (Bertoldi et al., 2019, p.199). Because of the findings outlined in this research so far, smallholders must also have had a connection to the road system, although often less direct than that of larger farms. The difficulty in building this into the model lies in the visibility of the archaeological record. Whilst enough is known about major roads, side streets are incredibly difficult to trace in a rural setting (Kolb, 2019, p.11-12). Nevertheless, a general proximity to major roads must be assumed. Therefore the model will incorporate a very large correlation between large agricultural sites and major roads, whilst building upon a lesser, but still quite large, correlation between small farms and these roads. As trade and connectivity, as well as road construction, increased quite rapidly during the early Imperial period (Witcher, 2017, p.35), these influences will be stronger in this period.

4.5 Taphonomy

Besides understanding which processes took place in the past in terms of human decision making, it is also crucial to understand the working of the landscape in which they took place. Even if one were to perfectly understand the choices that went into forming settlement patterns, they would almost always find that this pattern does not fully translate itself into the archaeological record of today. The reason for this is that weathering, erosion and sedimentation impact many landscapes in such a way that traces of past sites get altered, moved or even destroyed (Attema, 2017, p.460). Unfortunately, such processes are often overlooked and not considered when theoretically interpreting survey records, leading to biases in our view of the Roman world (Witcher, 2006, p.40). This, in combination with a lack of sufficient theoretical grounding has meant that many surveys have attempted simply to gather as much data as possible. However, without consideration of the landscape and the meaning of sites, the results are often no more than dots on a map (Witcher, 2006, p.44).

The Italian peninsula is a region in which taphonomy should definitely be considered heavily. With its mountainous inland and many river valleys, erosion is strong here. This is only amplified by heavy seasonal rainfall and centuries of intensive agriculture (Feiken, 2014, p.11). As these points are all applicable to the Biferno Valley, it is crucial to understand the landscape processes before attempting to reconstruct settlement patterns. In this valley, rainfall has a significant impact on erosion. Figure 24 shows rainfall patterns throughout the year in part of the research area. When considering that sites are usually defined in archaeological surveys through concentrations of small artefacts, mostly ceramic sherds, this becomes even more important. This is because such finds are not a directly measurable link to ancient activities to begin with and because they are easily altered in condition and location by natural processes (Witcher, 2006, p.47).

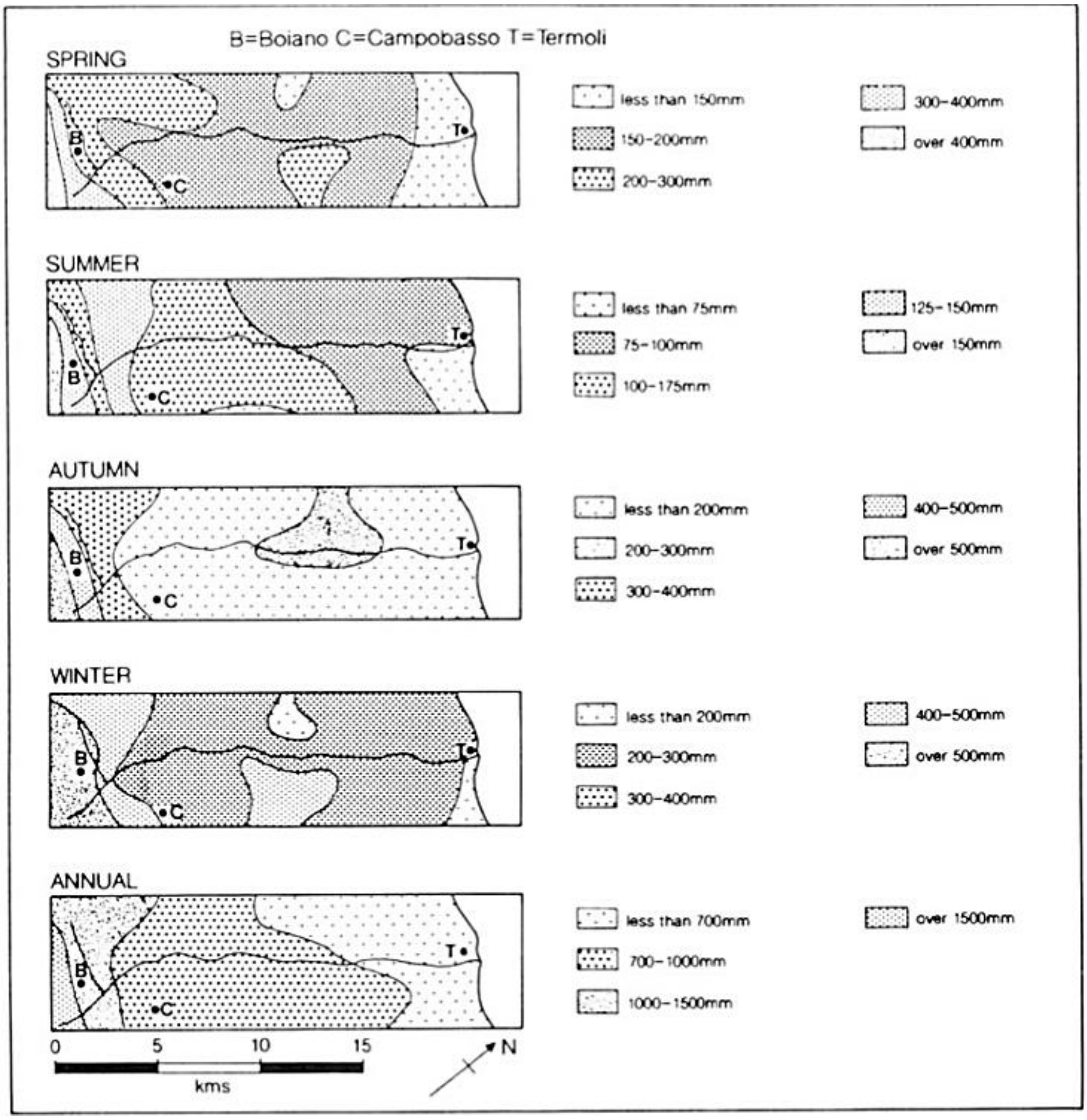


Figure 24. Biferno Valley Rainfall patterns (Barker, 1995, p.29)

Whilst a detailed landscape analysis on the Biferno Valley has not been made, the region can be understood by comparing it to similar areas for which the landscape has been studied extensively. The image of a river valley flowing through mountainous areas to then reach the sea in a coastal plain is not rare in the Italian peninsula. In such areas, the upland generally sees erosion, whilst sediments are deposited in the lowland (Attema, 2017, p.460). Especially on the coastal plain, sedimentation has a great negative effect on site visibility. As such, many sites in these locations are missed in archaeological surveys (Attema et al., 2019, p.485). Furthermore, this part of the landscape currently undergoes the most construction and agriculture. This once again has severe consequences for the findability of archaeological remains. Figure 25 displays modern land use in the Biferno Valley. Locations close to a river, such as the Biferno, further undergo episodes of drastic erosion and of sedimentation (Attema, 2017, p.461). Also in higher elevations, erosion and deposition both occurred. At the bottom of slopes, sediments from above often accumulated. Near water flows, fans of poorly sorted materials accumulated as a result of the stream breaking its banks. Without these breaks, alluvial depositions were better sorted, including coarser grains near the water flow and growing coarser as distance to the water source increased (Malone & Stoddart, 1994, p.29). Luckily, these sorts of sediments are well defined in the geological maps used in this research. Combining this geological knowledge with slope maps and information on where rivers flowed will allow for taphonomy to be taken into account when testing the model. More details on how this was done can be found in the following chapter.

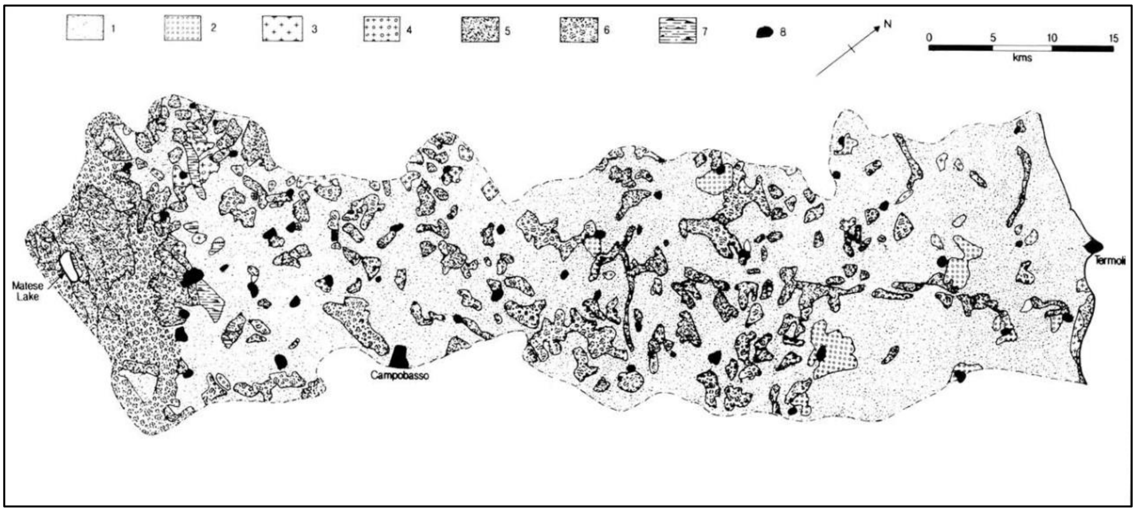


Figure 25. Biferno Valley simplified modern lands use. 1. Arable, 2. Olives, 3. Vines, 4. Mixed olives and vines, 5. Pasture and rough grazing, 6. Woodland, 7. Irrigated land, 8. Settlements (Barker, 1995, p.30)

5. Statistical Assessment

In this chapter, the observations made in the previous chapter will be tested statistically. By doing so, the theory is tested before the predictive model builds upon it. In order to carry out these tests, choices in the selection of sites must first be made. To differentiate between different kinds of farms and between sites of different periods, certain criteria in the labelling of the sites documented in the Biferno Valley Survey must be set.

As can be seen in table 1, the dating methods used in the Biferno Valley Survey were not entirely straightforward. This is a result of changing methodologies over the years the project ran. Therefore, there is no direct correlation between these dates and the three focus periods of this research: archaic/early Roman (only for contextual analyses), Republican and Early to Mid-Imperial. Still, the transparency in the dates that define each period makes it possible to choose fitting interpretations. The earliest period this research focuses on will be marked as 'Iron_Age_BVS' and 'Bronze_Iron_Age_BVS'. These periods encompass the period of transition between pre-Roman and Roman in the valley, stretching from 1000 BCE to 500 BCE. The republican period will be indicated by 'Samnite_BVS', marking the period between 500 and 80 BCE. Importantly, the term Samnite is used here only in a chronological sense and does not relate to site interpretation otherwise. Lastly, the last period this research focuses on is indicated by 'Early_Roman_Imperial_BVS', 'Middle_Roman_BVS' and 'Early_Imp_Mid_Roman_BVS', as these periods correlate to the Early Imperial period, with sites dated between 30 BCE and 250 CE. Numerous other labels encompass, but do not isolate, these periods ('Classical_BVS' or 'Roman_BVS' for example). These periods will be used when large-scale, long-term patterns are of concern. When attempting to observe differences within the period of Roman reign, these labels are unsuitable to use.

Earlier_(Low,Mid)_Palaeolithic_BVS		-40000	BP. Period 1
Later_Palaeolithic_BVS	-40000	-12000	BP. Period 2
Epipalaeolithic_BVS	-10000	-4500	BC. Period 2
Neolithic_BVS	-4500	-3000	Period 3
Eneolithic_BVS	-3000	-2000	Period 4
Bronze_Age_BVS	-2000	-1000	Period 5
Iron_Age_BVS	-1000	-500	Period 6
Samnite_BVS	-500	-80	Period 7
Early_Roman_Imperial_BVS	-30	100	Period 8
Middle_Roman_BVS	100	250	Period 9
Late_Roman_BVS	250	600	Period 10
Early_Medieval_BVS	600	1100	Period 11
Medieval_BVS	1100	1500	Period 12
Post-Medieval_BVS	1500	1800	Period 13
Recent_BVS	1800	1995	Period 14
Classical_BVS	-500	600	Period 7/10
Roman_BVS	-30	600	Period 8/10
Post_Medieval_to_Modern_BVS	1500	1995	Period 13/14
Neolithic_to_Bronze_Age_BVS	-4500	-1000	Period 3/6
Bronze_Iron_Age_BVS	-1000	-500	Period 5/6
Iron_Age_Samnite_BVS	-1000	-80	Period 6/7
Early_Imp_Mid_Roman_BVS	-30	250	Period 8/9
Mid_Late_Roman_BVS	100	600	Period 9/10

Table 1. BVS site dating framework

Similarly to the chronology, the way in which sites were interpreted does not allow for a one-to-one correlation to the types outlined in previous chapters. Whereas it was explained that there are traditionally at least three main types of agricultural site in Roman archaeology, such classification does not exist in the Biferno Valley Survey. Instead, only the distinction between larger, wealthier farms and small, poorer ones is possible. The former of these would be labelled as ‘villa_BVS’ or ‘villa_or_village_BVS’. The latter would be ‘farmstead_BVS’. It is possible that other classes also include sites where agriculture was performed. However, this would not have been their main activity according to the interpretation made at the time. Therefore, only the labels indicated here are used. Still, the interpretation of villages will be useful in the identification of relations between sites and population centres, as these villages often formed the middle ground between agricultural sites and cities.

cemetery_BVS	'cm'
deserted_medieval_village_BVS	'dmv'
domestic_site_BVS	'ds', used for prehistoric settlement site, and for (
farmstead_BVS	'fm'
ritual_site_unspecified_BVS	'rs'
tomb_BVS	'tm'
town_BVS	'to'
tower_BVS	'tw'
villa_BVS	'vi'
village_BVS	'vl'
working_site_BVS	'ws'; e.g. a flink knapping site or pottery kiln site
sporadic_or_off-site_BVS	'sp'
unclassified_BVS	'un'
off-site_or_domestic_BVS	'sp/ds'
villa_or_village_BVS	'vi/vl'

Table 2. BVS site interpretation framework

The scatter plots shown in this chapter were created by using measurements of all sites in the Biferno Valley Survey that fit within the categories described above. Dependent variables are plotted on the y-axis, and period is projected on the x-axis. Sites were dated only in rough terms. For that reason, intra-period variation in the graphics does not represent differences in site chronology in reality. Instead, the chronology of sites is randomly distributed within each period to enhance the clarity and legibility of the graphics. Differences between the three main periods as described in this section are thus visualised, but short-term variations cannot be inferred from the analyses presented here.

5.1 Terrain

In the previous chapter, a hypothesis on the terrain requirements for various kinds of farms was set. This hypothesis stated that slight south-facing inclines were the ideal location. Villas in particular should not be found above 1100 metres of elevation and on steeper slopes, whereas requirements for small farms should have been similar, but less strict.

5.1.1 Elevation

The elevation measurements appear to align with the hypothesis. For all Roman periods, no site was found above 930 metres of elevation in the Biferno Valley Survey. However, it is important to note that higher terrain was only minimally surveyed, due to its low accessibility. Nevertheless, a vast range of elevations was covered. This means that the findings are still meaningful in some way when further analysing the data.

For farms, the average elevation during the three studied time periods remained quite comparable, ranging from 307 metres in the Republican to 350 metres in the Imperial period. Interestingly, there is more variation in the median value. For the early Roman period, it is still similar to the average elevation, at 335 metres. In the Republican and Imperial periods, this value is quite a bit lower, at 227 and 251 metres respectively. This seems to point to an increased number of sites in lower parts of the terrain, with a smaller portion at high elevations. The maximum elevation for the three periods is however very similar, ranging from 707 to 724 metres.

For villas in the Republican and Imperial periods, a comparable pattern can be seen. Barely any variation occurs here in terms of elevation, with mean elevation sitting around 324 metres for both periods. The mean remains exactly the same, at 238 metres, even though slightly more Imperial sites have been attested to. Something different can be seen in the early Roman period, with both values ranging around 517 metres of elevation. However, these early numbers are based on a very small sample pool and are thus not reliable.

Interestingly, elevation measurements for villages in the area are higher than those for the previous two site types. Mean elevation ranges from around 490 to 560 metres, with the medians falling in the same range. This can possibly be explained by looking at the defensive function of early settlements. High terrain would be easier to hold down, leading people to live there. The site record shows that about half of the documented Imperial sites already existed in early Roman times, indicating strong continuity.

Overall the numbers show that the hypothesis was mostly correct in that high elevation seems to have been avoided. However, the theory that small farms would generally be found at higher elevation is not reflected here and will thus not be included in the model.

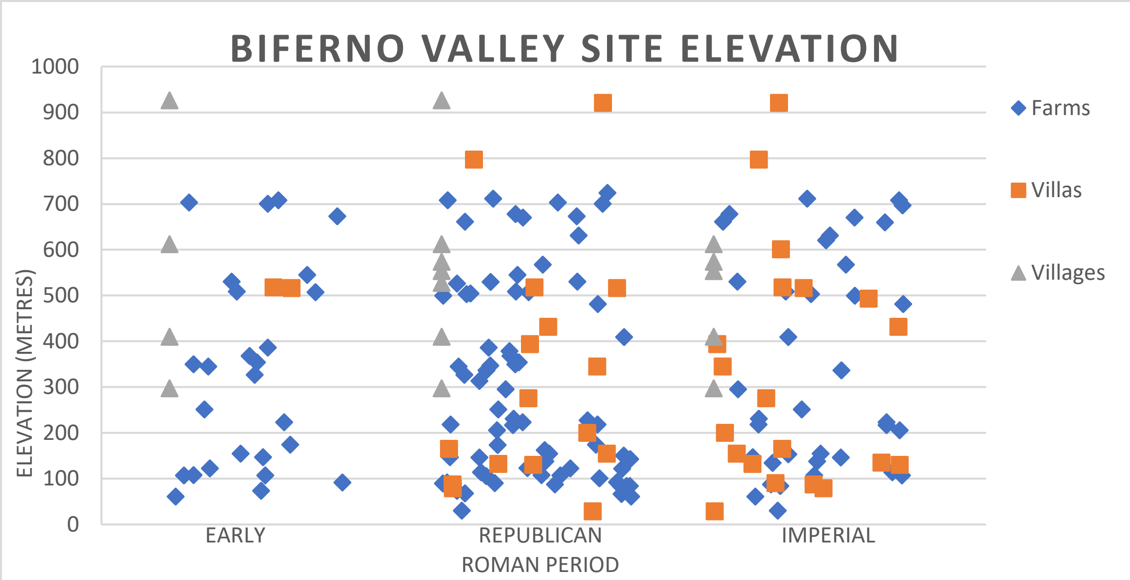


Figure 26. Graphic displaying elevation measurements of farms, villas and villages throughout the Roman period

5.1.2 Slope Steepness

When assessing the steepness of slopes on which sites were documented, few surprises occur. In chapter 4, it was explained that moderate slopes (roughly 5 to 15 degrees) were likely preferred for all kinds of farm. The slope measurements reflect this presumption. Both in terms of type of site and in terms of period, very little variation can be observed. For all datasets, the mean slope has a steepness of about 12-14 degrees, with median values sitting a few degrees lower. There are a few outliers that display much higher values. It is suspected that this is a result of the way in which the data was gathered. Slope steepness was derived from the digital elevation model and subsequently sampled per site, based on a point that represented the sites' locations. Because the resolution of the digital elevation model is 10m, and because all sites are represented as a point, the landscape and the steepness for a certain site are not represented with full accuracy. This is likely the cause of the outliers. Disregarding these sites shows an image that supports the hypothesis outlined above.

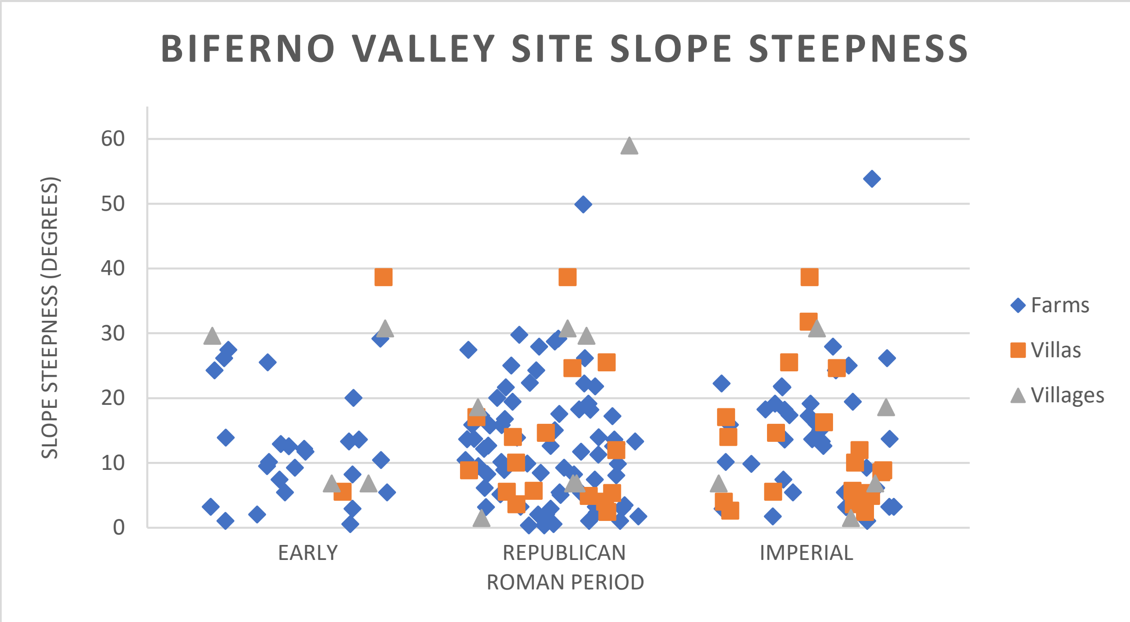


Figure 27. Graphic displaying steepness measurements of farms, villas and villages throughout the Roman period

5.1.3 Slope Aspect

Analysing the slope aspect gives indication to a different pattern than the one that was expected. Whereas it was assumed that south-facing slopes were heavily sought after, sites in the Biferno Valley do not reflect this. As can be seen in table 3, there is no larger number of sites on south-facing slopes than on slopes facing other directions. Furthermore, slopes facing north do not display low numbers either. In fact, a relatively large number of farms can be found here, especially during the Roman Republic. For all periods and site types, a similar trend shows. This cannot be explained by very slight slopes, as only few sites were found on slopes with a steepness below 5 degrees. Instead, the observation might be explained by the nature of the terrain. In an east-west oriented river valley with limited space available for agriculture, it is likely that few options were available and that farming had to occur on slopes facing all directions. Furthermore, the major roads and towns are found south of the Biferno River. Because of the valley's orientation, a larger number of north-facing slopes would be found here, which could explain these statistics. Regardless, it is clear that slope orientation must not have played a decisive role in agricultural sites in the Biferno Valley during the Roman period.

Count of Aspect	Column Labels												
	Farm			Farm Total	Villa			Villa Total	Village			Village Total	Grand Total
Row Labels	1	2	3		1	2	3		1	2	3		
0-20	4	4	2	10			1	1	1	2	2	5	16
20-40		1	2	3		3	3	6					9
40-60	1	5	2	8		1	1	2					10
60-80	1	5	1	7		1	2	3					10
80-100		3	4	7									7
100-120	2	3	2	7		1	1	2		1		1	10
120-140	1	3	1	5		2	3	5	1	1		2	12
140-160	3	3	2	8		1	1	2					10
160-180	2	4	2	8		1	1	2					10
180-200	1	1		2									2
200-220	2	5	2	9	1	2	2	5					14
220-240		2	1	3									3
240-260	2	3	1	6		1	1	2					8
260-280	1	4	2	7					1	2	2	5	12
280-300	4	7	4	15	1	1	1	3					18
300-320		7	4	11		1	1	2					13
320-340		2	2	4									4
340-360	2	9	3	14		1	2	3	1	1	1	3	20
Grand Total	**26**	**71**	**37**	**134**	**2**	**16**	**20**	**38**	**4**	**7**	**5**	**16**	**188**

Table 3. Aspect measurements (degrees from north) for farms, villas and villages in 1. Pre-/early-Roman period, 2. Republican period and 3.Imperial

5.2 Soils

In the previous chapter it was statedthat villas were likely found in the vicinity of sandy-clayey soil or near loamy and sandy soils. For ease of work, soil types were assigned codes. An overview of these codes can be found in table 4. Table 5 shows limited variability over time. In all three periods, soils of types 6, 8 and 9 are most prevalent. These constitute of alluvial material, chalky grounds and more gravelly conglomerates respectively. Clayey soils seem to be mostly absent, indicating a possible stronger preference for sandy terrain, which is indeed shown here.

For farms, a similar preference to alluvial soils can be seen, especially in the earlier stages of occupation. A relatively larger number of sites can be found on chalky soils in the Imperial period. In the Republican period, soils of types 11, 12 and 19 are heavily represented. The first of these two stand for clayey soils, sandy and silty, whereas the last indicates sandy terrain. Farms thus seem to have gravitated towards clayey soils more so than villas, with a further attraction to chalkier soils in the Imperial period.

Soils Source Material Classifications	
Code	**Meaning**
1	Sand (Maritime)
2	Sand (other)
3	Swamp Deposits
4	Mixed detritus (valley deposits)
5	Alluvial (coarse)
6	Alluvial (fine)
7	Fluvial
8	Chalk
9	Conglomerates
10	Clay (marly)
11	Clay (sandy)
12	Clay (silty)
13	Terra Rossa
14	Marl
15	Limestone
16	Igneous
17	Gypsum
18	Travertine
19	Sandstone
20	Water

Table 4. Soil Codes used in analyses

Count of Soil	Column Labels												
	Farm			Farm Total	Villa			Villa Total	Village			Village Total	Grand Total
Row Labels	1	2	3		1	2	3		1	2	3		
2	1	1	1	3		1	2	3					6
4		1	1	2									2
5	3	6	1	10		2	2	4					14
6	7	12	4	23	1	4	5	10					33
7	1	2	2	5									5
8	4	14	9	27		2	3	5		1		1	33
9	1	8	3	12		4	5	9	1	1		2	23
10		1	1	2									2
11	3	9	6	18		2	2	4	2	2	2	6	28
12	2	7	3	12					1	1	1	3	15
14		1	1	2	1	1	1	3		1	1	2	7
19	4	9	5	18						1	1	2	20
Grand Total	**26**	**71**	**37**	**134**	**2**	**16**	**20**	**38**	**4**	**7**	**5**	**16**	**188**

Table 5. Soil types for farms, villas and villages in the Pre-/ early-Roman period (1), Republican period (2) and Imperial period (3).

5.3 Waterways

The measured distance to the nearest waterway contains a marked difference between farms and villas. While the average distance from farms to the nearest water source lies around 680-725 metres for all periods, this value is about 530-660 metres for villas. Median values for both types are slightly lower, but show a likewise trend. Villages lie at the greatest distance from water, but this was to be expected, since they are not directly involved in agriculture. The difference between farms and villas is also not surprising and aligns with the hypothesis set before. For both types, water was important, but wealthy estate owners simply had more means to ensure direct access to a stream. It should be noted that the water sources used for the measurements are based on more recent times, as it is not known exactly where streams and lakes were situated during the Roman period. However, the valley terrain and the location of sources mean that it is unlikely that much has changed compared to the Roman period. Therefore, the measurements are reliable enough to consider the hypothesis valid.

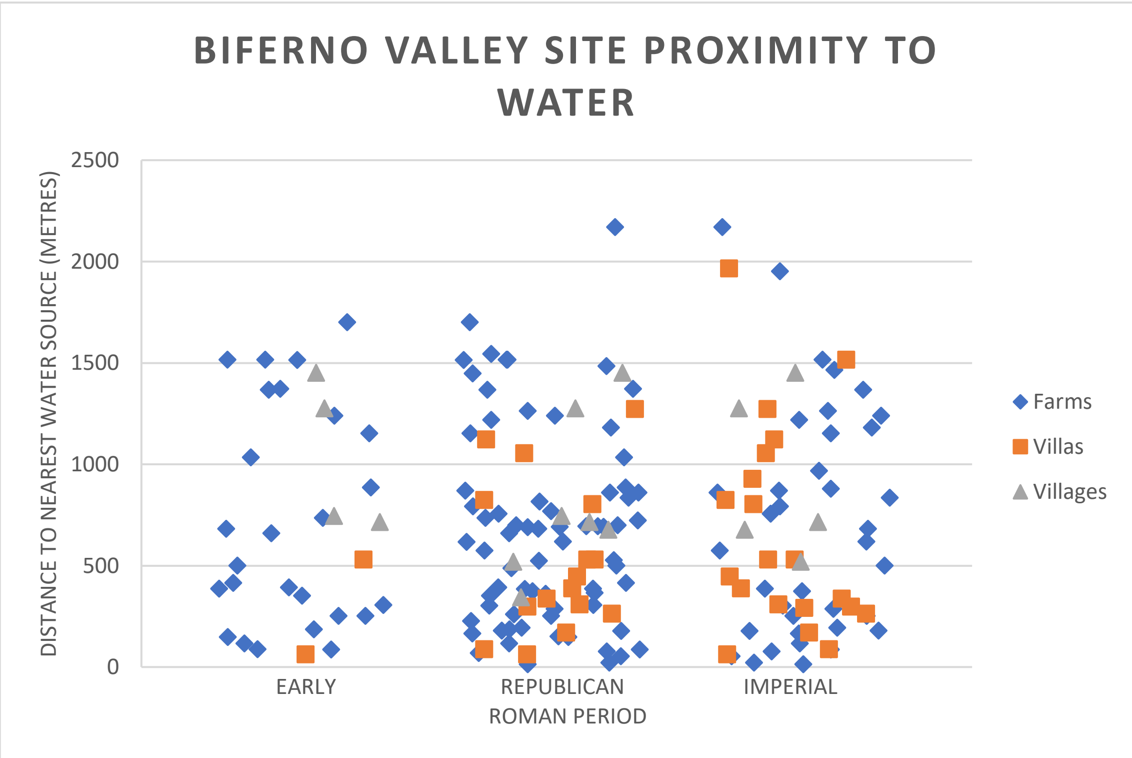


Figure 28. Graphic displaying the distance to water of farms, villas and villages throughout the Roman period

5.4 Infrastructure

5.4.1 Urban Centres

In chapter 4, the expectation of rural sites in relation to urban centres was set. It was explained that a moderate influence of towns on the location of all types of rural sites was likely. This influence seemingly increased somewhat in the Roman Imperial period. Based on the measurements, it seems that this presumption was correct, except for villages. On average, villages were at a distance of 2900 metres from the nearest urban centre, although the sample pool is quite small. This number decreases to 1900 metres in the Republican Period. However, it increases to 2300 metres again for the Imperial period, although the median remains similar for the last two periods. Once again, the significant continuity in this type of site is likely to blame for this trend, outweighing the increased attraction to towns.

Villas on the other hand show a clear difference in these numbers between Republican and Imperial times. Whereas the average distance in the former of these is about 4800 metres, it goes down to 4400 metres in the latter period. The median shows an even stronger decline in distance, moving from 5500 metres to 4200 metres. The significance of this decline can be debated upon, but it does indicate that villas in later Roman times were generally found closer to urban centres, confirming the assumptions set earlier.

The theory that farms followed suit and should also display a lower average distance to larger towns also seems to be correct. The greatest distances can be seen in the early Roman period, with an average measurement of 5900 metres and a median value of 5400 metres. There is a strong decline moving to the Republican period, with the mean and median values being 5200 metres and 4500 metres respectively. A further, although slightly weaker, decrease is seen towards the late Roman period, with an average distance of 4900 metres and a median value of 4200 metres. It has been shown in previous research that there is a statistically significant spatial correlation between towns and rural sites in the Biferno Valley (Hijzen, 2021, p.35).

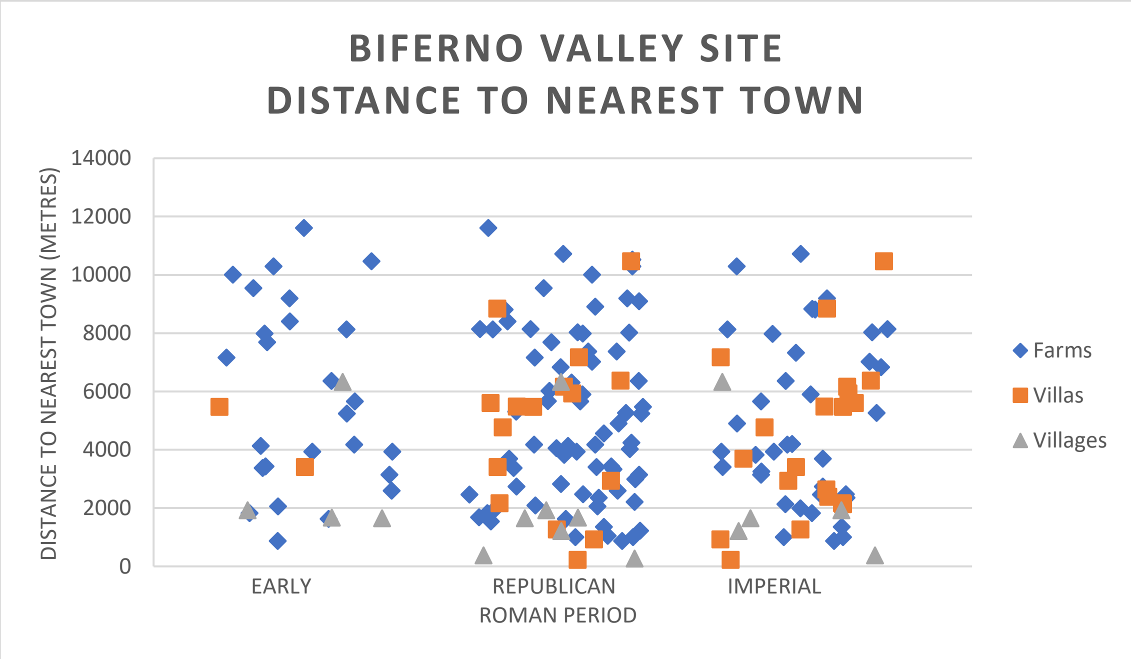


Figure 29. Graphic displaying the distance to the nearest town of farms, villas and villages throughout the Roman period

5.4.2 Roads

As mentioned, it is difficult to measure precise correlations between roads and archaeological sites. This is a result of the low traceability of these roads. In the Biferno Valley, a few major long-distance roads are known and mapped. However, little is known beyond this point. Therefore it is only possible to measure correlation to these largest roads. Own previous research in the region has shown that there is a correlation between the location of rural sites and roads, up to a significance of 5% (Hijzen, 2021, p.34). Somewhat expectedly, there is no clear measurable difference for the distance between roads and farms and villas, respectively. A significant portion of the sites lies within a few hundred metres of the mapped roads; a pattern that does not change throughout Roman times. On average, villas were found up to 500 metres closer to roads than farms. For villages, a different pattern is observed. For these sites, the distance to a major road generally declines in the Imperial period. Nevertheless, this is likely a result of road construction rather than a drastic change in village locations. In previous sections it was illustrated that there was a notable continuity in the habitation of such centres. Taking these things into consideration, the hypothesis that roads formed an important feature in dictating the location of rural sites seems to ring true. The presumption that roads exerted the largest influence on villas is also reflected in the measurements.

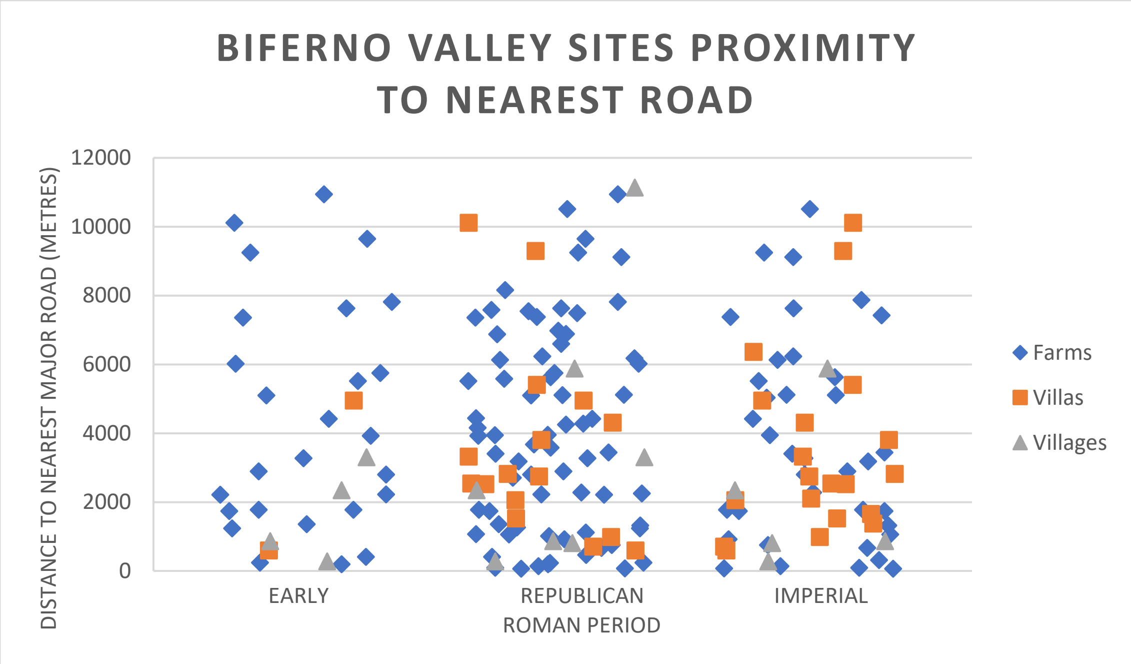


Figure 30. Graphic displaying the distance to the nearest major road of farms, villas and villages throughout the Roman period

5.5 Taphonomy

Previous research already indicated that the distribution of sites in the Biferno Valley was not random (Hijzen, 2021, p.32). In this chapter, it has been further demonstrated that there are clear correlations between these sites and natural and human variables. However, the aspect of taphonomy has not yet been addressed. Whilst all analyses thus far have been crucial in understanding the relationships between various elements in the landscape, they have not considered what has happened to archaeological remains over the past centuries.

As mentioned in the previous chapter, locations where detritus accumulates and where rivers erode and deposit sediments most heavily influence site visibility. In section 5.2, an account of all soils on which sites have been found was provided. Detritus, or slope deposits (soil type 4), shows an incredibly low number of sites, whilst accounting for a significant portion of the terrain. Furthermore, the location of many of these sections of detritus, near waterways and on flatter regions below slopes, would suggest a larger site presence.

A similar observation can be made for the present coastal and alluvial plains. Whilst these locations are expected to be quite well-suited to agriculture, a low number of sites have been identified here compared to the total surveyed area. The map below illustrates this pattern, especially towards the lower valley. As explained in the previous chapter, modern land use in this area also contributed to this pattern. Due to the high degree of modern agriculture and construction, many sites may not have been visible in archaeological surveys. These factors will be taken into account when building and testing the predictive model.

6. Model Creation

6.1 Model Building

With all the assessments made above, it is now possible to incorporate all variables into the creation of the predictive model. Initially, a Geographic Weighted Regression model (GWR) was chosen to be the main method of model creation. This type of model allows for an analysis of the effect of multiple variables. It does so by adjusting coefficients of linear regression of several variables in comparison to a points dataset (Alvarez et al., 2024, p.2). However, this type of modelling appeared not suitable, since the relation between rural sites and the chosen variables proved to be non-linear. Furthermore, computing such a model in Rstudio turned out to be circuitous, without yielding the desired results.

For these reasons, a different method of model creation was chosen: the Generalized Additive Model (GAM). This type of model allows for the incorporation of complex non-linear variables. The end result incorporates these variables by adding them together for each coordinate (Alvarez et al., 2024, p.2). This method was shown to be much more suitable to the type of research carried out here. In order to further streamline the process, the model was entirely created in QGIS. In this software, the raster calculator tool was used to specify the weight of each variable and create a raster layer based of it.

This way of working required a fair bit of preparatory work. To begin with, each variable needed to be translated into a raster layer of its own. The ways in which this was done can be divided into two groups. The first group of variables was already represented in a raster format (elevation, steepness, aspect) or was represented in polygons that covered the research area and was then rasterized (soil type). Through the raster calculator, each variable was turned into yet another raster, in which each cell was given a value from zero to ten, based on the suitability for farms or villas respectively. The selection hereof was derived from the assessments described in the previous chapters.

A second group of variables was represented in a vector layer that did not cover the entire research area (roads, waterways, towns, the sea). These variables first required the creation of buffers around the features. The buffers were then rasterized and each cell was once again given a value from zero to ten based on suitability. The Roads and Towns were first split into two datasets, one for the Roman Republican period and one for the Roman Imperial Period. Each of these datasets only included the roads or towns that existed in the respective period. In the Imperial period, more roads and towns were constructed for example, leading to differences in rural site locations as well. This information was accessed through encyclopaedias of the Roman world (Hanson, 2016; Talbert, 2000). Again, buffers were created around the features of each layer and subsequently rasterised. Table 6 displays the suitability numbers in relation to each variable. It was initially attempted to include a layer in which areas with a strong impact of taphonomy were marked and weighted in the model. However, this approach proved unsatisfactory, owing to the unpredictable results of such processes. Therefore, taphonomy was not built into the model, but only used as a reference when validating the results. When a sampled site displayed a low predictive value, taphonomy could be a possible explanation in some cases.

After the creation of all of the raster layers, each variable had to be assigned a weight which reflected its impact on site locations. Each variable was given a weight between zero and one, with the total sum of all weights equalling 1. As a result, the ten suitability classes of each separate variable were combined into an overall suitability map with a continuous scale. The end scale also ranged from zero (minimal suitability) to ten (maximum suitability).

Suitability Classification per Variable

Variable	Classes	Suitability
Elevation (m)	<300	10
	300-600	7
	600-700	6
	700-800	4
	800-950	2
	950-1300	1
	>1300	0
Steepness (degrees)	<10	10
	10-15	8
	15-20	6
	20-25	4
	25-30	2
	30-40	1
	>40	0
Aspect (degrees from N)	0-45	6
	45-135	7
	135-225	8
	225-315	7
	315-360	6
Distance to town (km)	0-1	10
	1-2	9
	2-3	9
	3-4	8
	4-5	7
	5-6	7
	6-7	6
	7-8	5
	8-9	5
	9-10	4
	10-11	3
	11-12	2
	12-13	1
	13+	1

Suitability Classification per Variable

Variable	Classes	Suitability	
Distance to major road (km)	0-1	10	
	1-2	9	
	2-3	8	
	3-4	7	
	4-5	5	
	5-6	4	
	6-7	3	
	7-8	3	
	8-9	3	
	9-10	2	
	10-11	2	
	11-12	2	
	12+	1	
Distance to waterway (km)	0.3-0.6	10	
	0.6-0.9	8	
	0.9-1.2	7	
	1.2-1.5	5	
	1.5-1.8	4	
	1.8-2.1	4	
	2.1-2.4	3	
	2.4-2.7	2	
	2.7+	1	
Distance to coast (km)	0-5	10	
	5-7.5	8	
	7.5-10	6	
	10-15	4	
	15+	0	
Soil code		Farms	Villas
	1	1	1
	2	2	2
	3	0	0
	4	1	1
	5	5	4
	6	8	10
	7	3	2
	8	8	6
	9	6	7
	10	6	6
	11	10	9
	12	8	6
	13	4	4
	14	5	5
	15	2	2
	16	2	2
	17	2	2
	18	2	2
	19	6	4
	20	0	0

Table 6a, b. End model suitability per variable

Model Weights

	Farms		Villas	
	Republican	Imperial	Republican	Imperial
Elevation	0.09	0.07	0.09	0.05
Steepness	0.22	0.20	0.20	0.18
Aspect	0.03	0.03	0.02	0.02
Towns	0.12	0.16	0.09	0.14
Roads	0.15	0.17	0.17	0.20
Water	0.18	0.18	0.17	0.13
Coast	0.0	0.0	0.03	0.07
Soil type	0.21	0.19	0.23	0.21

Table 7. End model assigned weights per variable

6.2 Model Testing

Many predictive modelling projects in archaeology are data-driven, which means that known site locations are used to infer the role of several variables in the landscape (Verhagen & Whitley, 2020, p.232). However, this research is theory-driven, drawing not from known locations, but from theory first. In this type of research, documented sites are not used to build the model, but to validate it (Verhagen & Whitley, 2020, p.233). Therefore, the entire dataset of sites documented in the Biferno Valley Survey was first divided based on site type (farm or villa) and period (Republican or Imperial). Four subsets were thus created. Each subset was divided into five equal groups through the 'random selection' tool in QGIS. These selections were used to test the model iterations that corresponded in the represented site type and period. Each time a new version was made, a separate subset was used for validation.

The method for validation of the created models was the Kolmogorov-Smirnov test. This test is used to test the probability of a sample, by comparing it to the full possible range of data values. In other words, it tests how well a single sample fits in a certain distribution of values (Berger & Zhou, 2014). Traditionally this statistical test was used for larger datasets, with smaller samples being prone to errors. However, by proportionally correcting for a smaller sample size, as is the case in this research, a low error rate can be achieved (Vrbik, 2018, p.16-17).

To test the performance of each model version, one of the five site samples was used. As such, five model versions were made for each combination of period and site type, meaning a total of twenty maps were created. Each new version was slightly adapted from the testing results, leading to a higher significance for each cycle. For the sites in the test samples, the raster value that the model calculated for their position was gathered. The entire range of possible values in the model was then collected. This was done by carrying out a unique values report for the created raster map, within the extents of the originally surveyed transects. The values were then saved as csv-files and a script was written in Rstudio to carry out a Kolmogorov-Smirnov test through the basic Rstudio statistics package. This process was repeated several times until each model showed a p-value below 0,05, the threshold for a statistical significance of 5%. If the p-value was above this threshold, the model was reassessed and variables and their weights were readjusted. During the testing of the last two model iterations, the p-value already fell within the threshold. However, slight adjustments were still made in order to reach even higher degrees of significance. In the end, p-values ranged from 0,002 for farms in the Republican period to 0,04 for villas in both the Republican and the Imperial period.

6.3 Results

The workflow outlined above resulted in the creation of four predictive maps that cover the entire Biferno Valley (figure 31 a through d). The maps display predictions in relation to the two studied site types, farms and villas, in two main time frames, the Roman Republican and Imperial periods. They indicate the likelihood of a site having been located on each location based on the specified variables and their weights. Site probability values are displayed on a continuous scale, with red and orange demonstrating high values, and shades of blue standing for low values. Chapter 7 elaborates on the significance of these maps. Here, several areas of high interest are regarded in more detail as well.

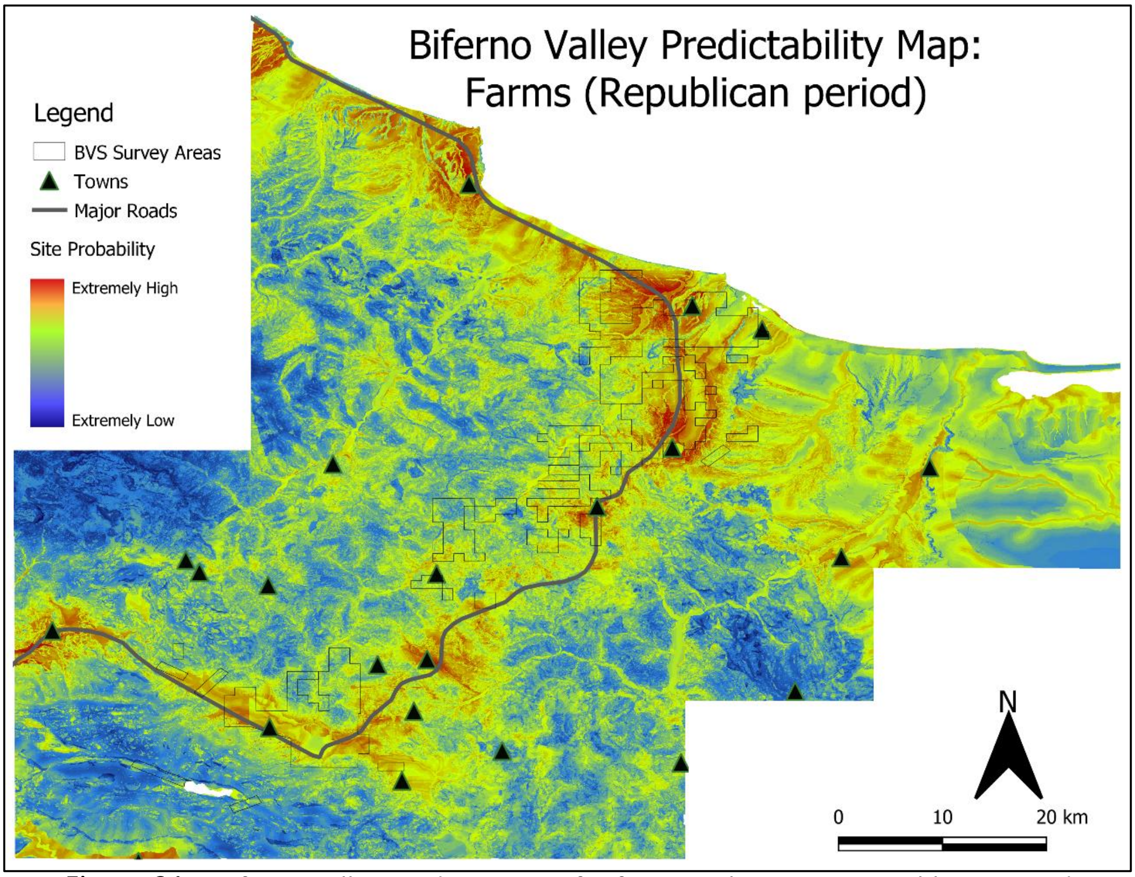


Figure 31a. Biferno Valley predictive map for farms in the Roman Republican Period

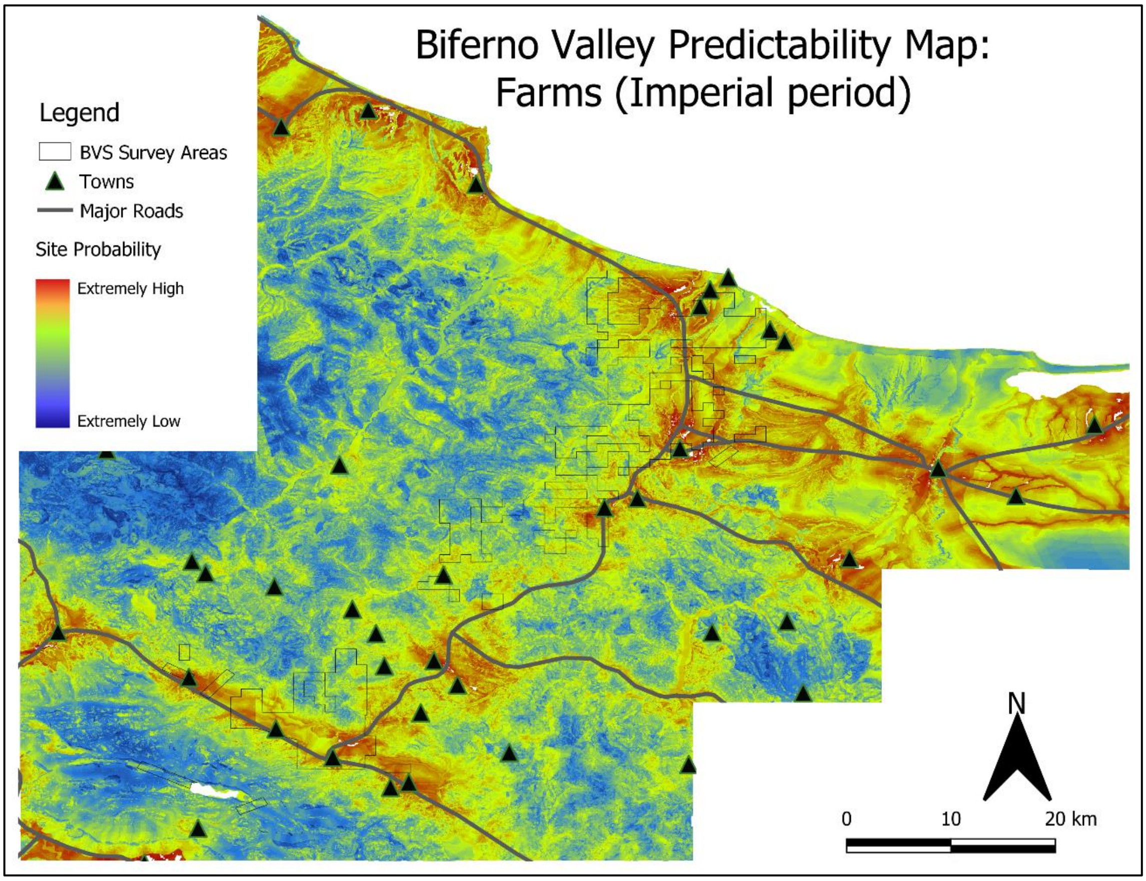


Figure 31b. Biferno Valley predictive map for farms in the Roman Republican Period

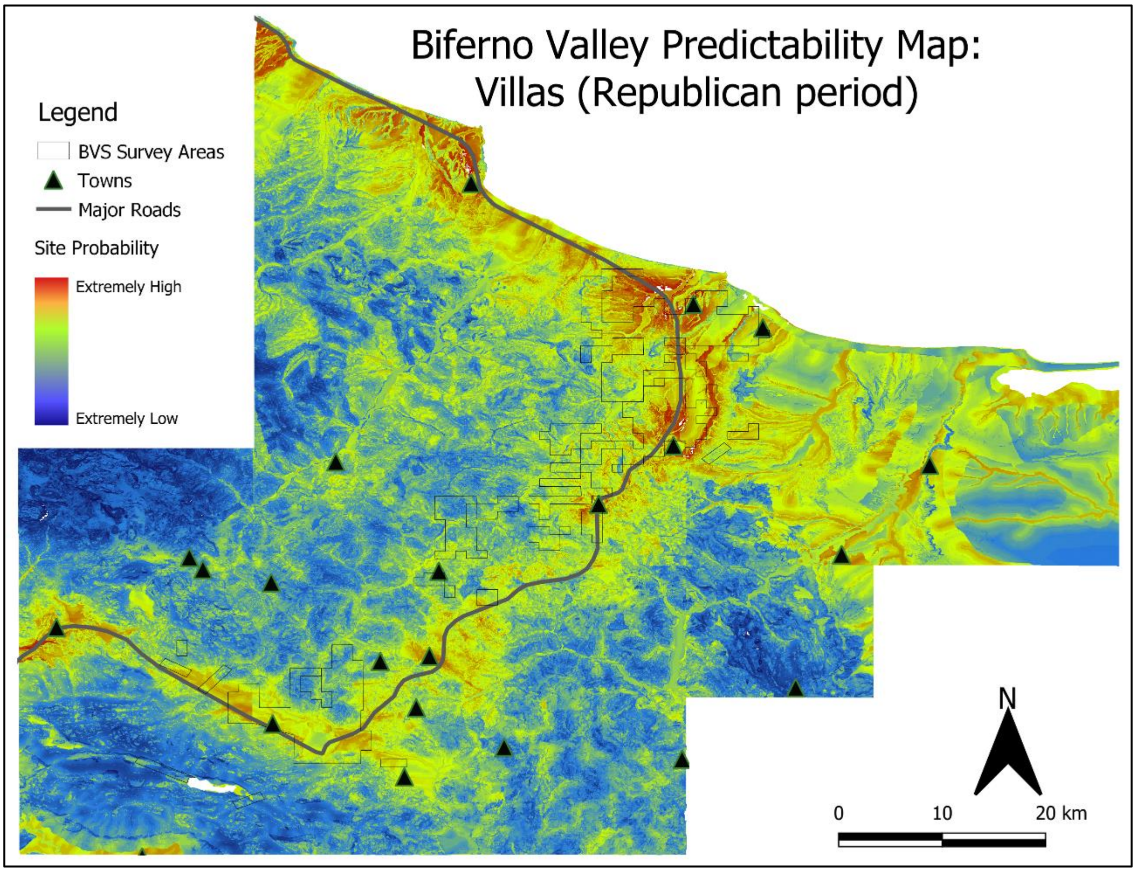


Figure 31c. Biferno Valley predictive map for farms in the Roman Republican Period

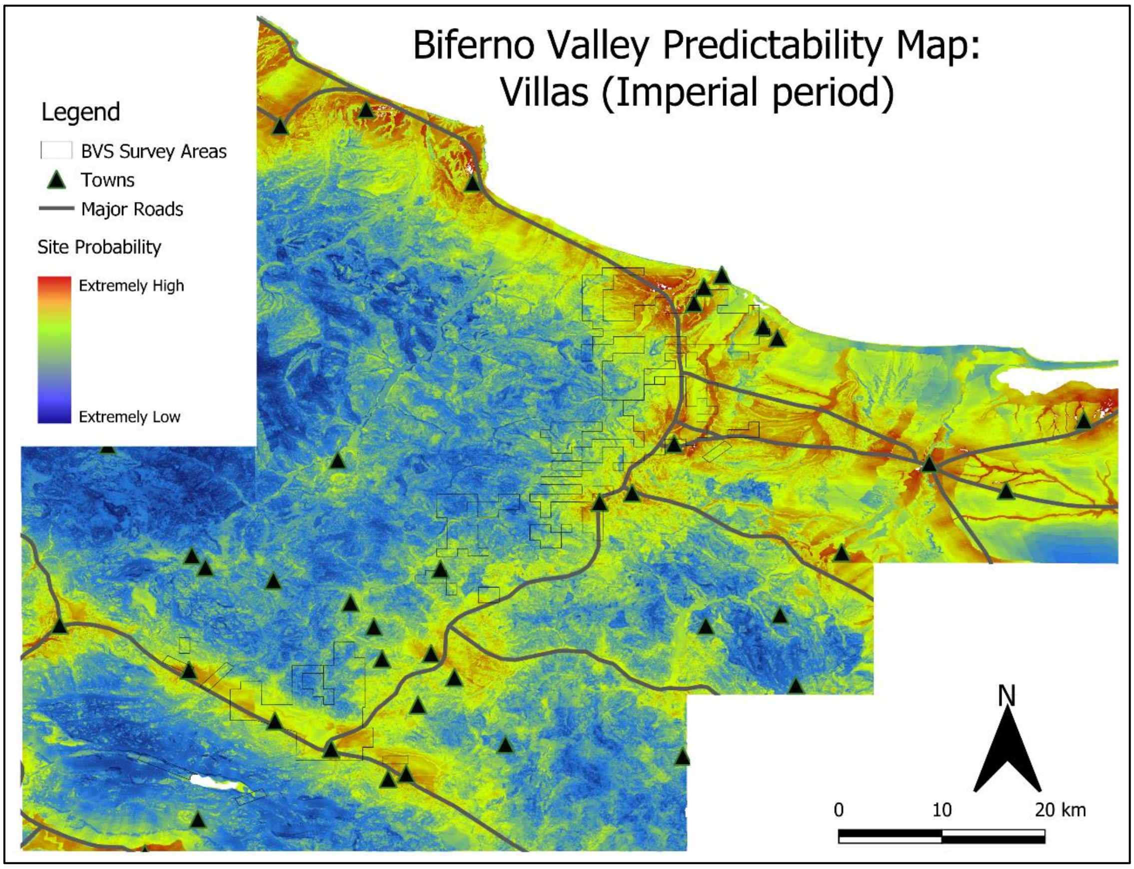


Figure 31d. Biferno Valley predictive map for farms in the Roman Republican Period

7. Discussion

This chapter builds on the maps presented in chapter 6. Firstly, a broad interpretation will be given, followed by a more in depth description of various areas of interest. Here, the terms ‘predictability’ and ‘suitability’ are used interchangeably. The maps display values that are calculated based on how suitable multiple variables made a location to farms or villas. Since the maps visualise where sites were likely to be in the past, and not where they are visible in the present, a higher suitability directly correlates to a higher site predictability value. The results are compared to the expectations set in the conceptual phase of this research. The findings are subsequently placed in a broader context. The end of this chapter summarises the insights on Roman agriculture that were gained in this thesis.

7.1 Map interpretation

7.1.1 General observations

Unsurprisingly, patterns in site predictability differ minimally in some parts of the Biferno Valley. Most notably, the mountainous regions in the eastern and western sections of the research area display low values of site suitability for both site types and in both study periods. Given the challenges imposed on agriculture by steep slopes and rocky surfaces, this falls within expectations. Looser criteria for farms result in more sections of terrain being at least moderately suitable. This is most clearly visible along the slopes of the middle Biferno Valley, where much larger sections of suitable terrain exist for farms than for villas. Nevertheless, the high mountains display similarly low values for both types.

In contrast, the Lower Biferno Valley displays a high likelihood of farms and villas in both the Republican and the Imperial period. In this region, large sections of looser alluvial deposits exist, making the land quite well suited to agriculture (Dipertimento per il Servizio Geologico d’Italia, 1976; Van Joolen, 2003, p.127). Furthermore, the presence of a major arterial road and multiple towns made this area an attractive location. In the north-eastern part of the research area, the influence of such features can be clearly observed. In the Republican period, little infrastructure existed here, leading to only moderate suitability for agricultural sites. After the construction of major roads and the appearance of several larger towns in the Imperial period, the area shows to have been much more attractive to farmers and estate owners. A more detailed analysis is presented in the following sections.

In the central and coastal plains of the Biferno Valley, the significant role of waterways also becomes evident when observing the maps. Here, strips of very suitable land follow the course of the many rivers and streams. This is a result of the high importance of water, but also of the types of sediments they deposit. Fertile clays and silts are abundant in the small alluvial plains. This stands in contrast to the otherwise quite sandy terrain. Interestingly, some streams along the eastern coast display an adverse pattern. Here, a generally quite suitable area is intersected by strips of land with very low predictability values. Presumably, these zones saw much deposition of coarser, less fertile sediments. In combination with somewhat steep slopes along the river banks, this made these segments in the landscape badly suited for agriculture.

Lastly, the south-western part of the research area shows quite varied suitability. South of the main roads, a substantial part of the terrain indicates low predictability values. This is not surprising, given the quite steep slopes and limited infrastructure and water sources that exist here. Nevertheless, spots of moderately high suitability appear throughout this region, most notably for farms. Likely, these sections highlight soils of high quality on slopes that are quite mild for the area. However, it can be argued that it is unlikely that these parts of the terrain saw many sites in actuality, given the high degree of isolation in an otherwise quite unsuitable environment. Still, it is possible that some pastoralist sites were present here, taking control over upland summer pastures. Unfortunately, this cannot be said with certainty until further fieldwork is carried out. This highlights one of the limitations of predictive modelling, in that it cannot give definitive conclusions on the actual presence of sites.

7.1.2 Southern valley

The first area to be assessed in more detail consists of the southern reaches of the central Biferno Valley. Here, a major road and several large towns, most notably

Campobasso and Saepinum were present (see figure 32). The maps displaying the predictability of farms in the two study periods are displayed here to highlight the differences and similarities between the Republican and Imperial periods. In general, the maps show similar patterns. Logically, terrain around roads and rivers were more likely to contain farms. As a consequence, the construction of new roads in the Imperial period means that the sections surrounding these transport arteries increased in suitability.

Even though this part of the Biferno Valley contains Apennine foothills, flat fluvial terraces are abundant (Margaritis, 2009). Therefore, the land was quite well suited to agriculture, as is demonstrated in the maps. Locations not near infrastructure show very similar predictive values between both study periods. This is the result of minimal changes in agricultural practices in relation to terrain. It was explained that the introduction of ploughs, for example, meant that more dense clay could be worked. However, similarly loose clayey and sandy soils remained ideal for farm owners. This is the cause of the pattern described above. The southern valley thus demonstrates the great impact of the expansion of the road network and of the urban landscape in the Roman Imperial period. This impact was far greater than the impact of natural factors.

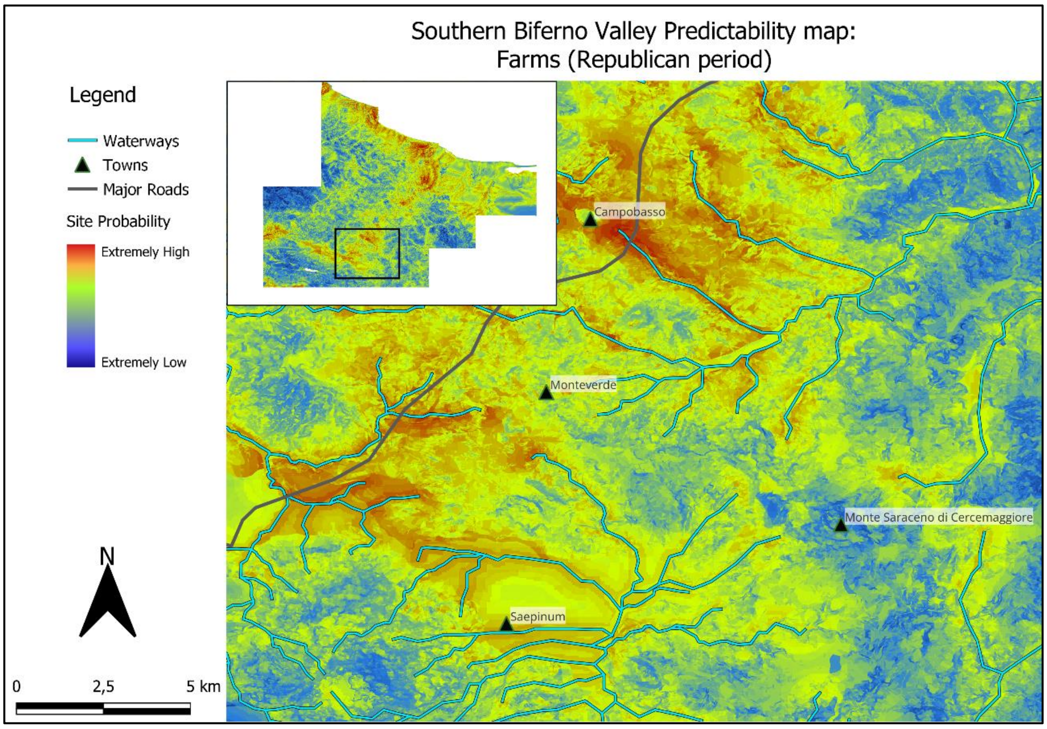


Figure 32a. Southern Biferno Valley predictability map for farms in the Roman Republican period.

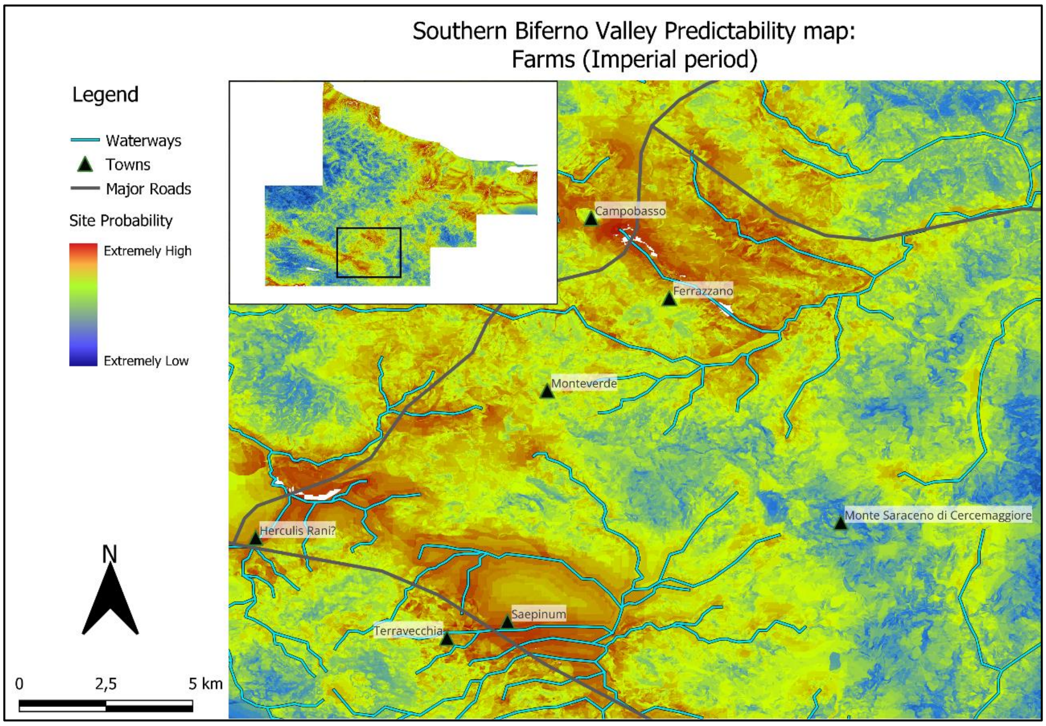


Figure 32b. Southern Biferno Valley predictability map for farms in the Roman Imperial period.

7.1.3 Eastern coast

The eastern part of the coast, in the north-eastern section of the research area (figure 33), further attests to the influence of roads. Large sections of the coastal plains show low levels of site suitability. In the Republican period, some segments along rivers and in the vicinity of Teanum Apulum, the only larger town in the region, were quite likely to contain farms. However, the surrounding landscape rarely shows above average suitability. This image is completely different from what is observed for the Imperial period. Just like the southern valley, new roads and towns appeared here in this period. As a result, the predictability values of the area increased drastically. In the north-east and south-east of this segment, further away from this infrastructure, both maps display very similar values. Interestingly, a long and thin north-south oriented strip of land, near Teanum Apulum, displays very low chances of site presence. This seems to have been the remnants of a gulley with relatively steep slopes and a very coarse underground.

Logically, this would not have been suitable to agriculture, but it remains fascinating that such zones exist in an otherwise well suited landscape.

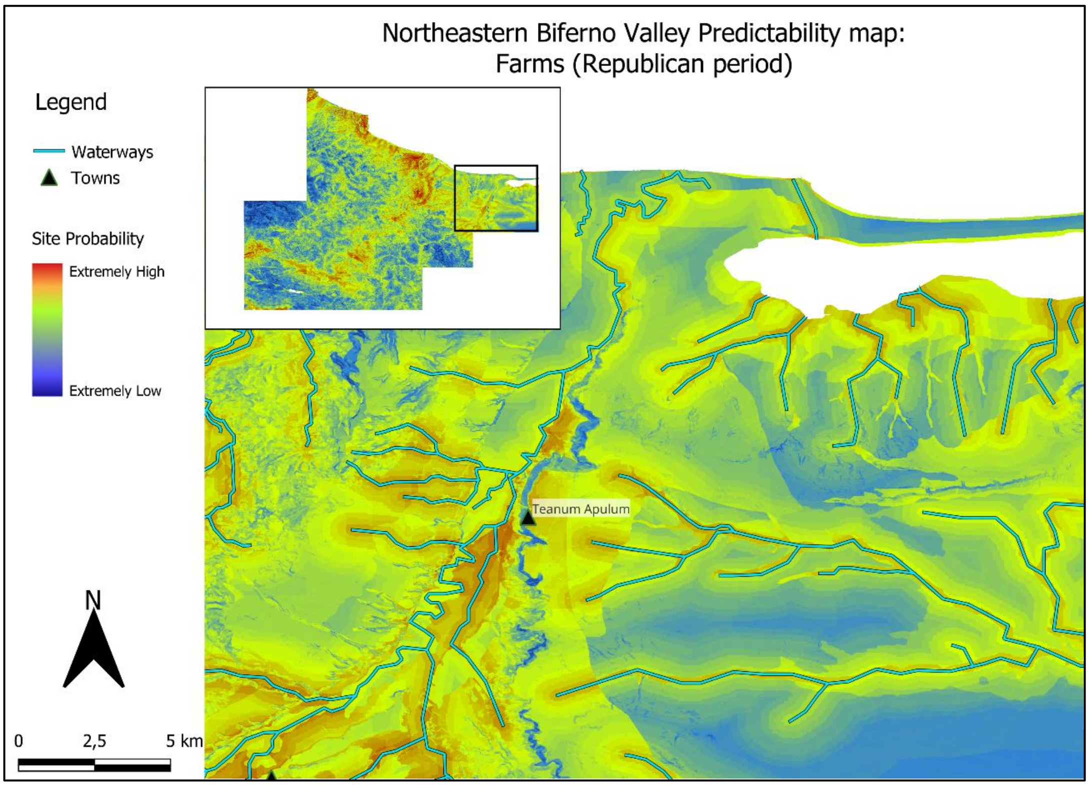


Figure 33a. North-Eastern Biferno region predictability map for farms in the Roman Republican period.

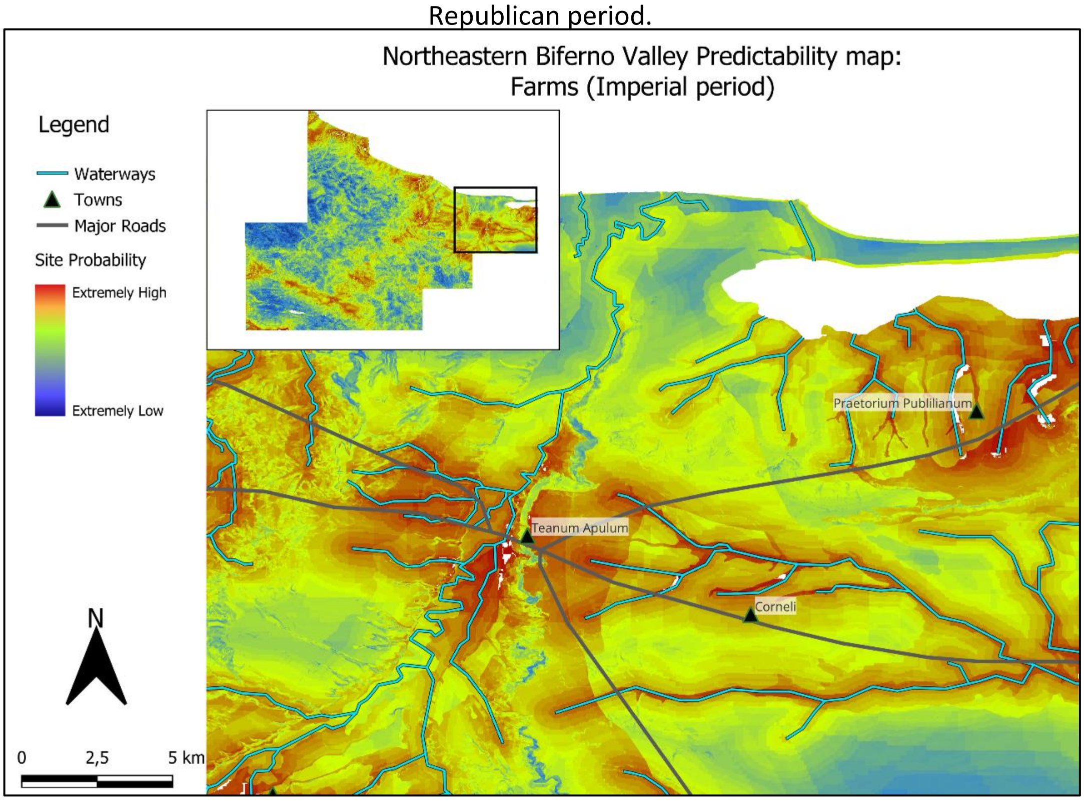


Figure 33b. North-Eastern Biferno region predictability map for farms in the Roman Imperial period.

7.1.4 Northern valley and central coast

In order to examine patterns in relation to villas, the example of the Northern portions of the research area is given (figure 34). Here, the Lower Biferno Valley meets the plains on the Adriatic coast. In the Republican period, this region displayed the greatest likelihood of villa presence in the entire research area. With the existence of some major towns, Uscosium and Larinum, and the presence of a road, this region offered great prospects to estate owners. Furthermore, the abundant waterways, slight slopes and fertile soils made for excellent farmland.

Moving from the Republican into the Imperial period, a shift in focus can be seen. Initially, large sections of moderately suitable land could be found in the western parts of this region, where moderate hills were predominant. In the east, moderate to high values were observed on the coastal flatlands. This pattern changed over time. In the Imperial period, the predictive values of land in the west increased, whereas the values in the west decreased. The central parts of this area, around the larger towns, display minimal change. This attests to the increasing priority of trade in Imperial times. The coastal plains where intersected by large roads. This meant that trade via land, but also via the sea was well facilitated. In the western hills however, exchange was more difficult. Even though the land was still of high agricultural quality, it was simply more difficult to reach. In the central valley, where roads and towns were continuously present, much less variation occurred.

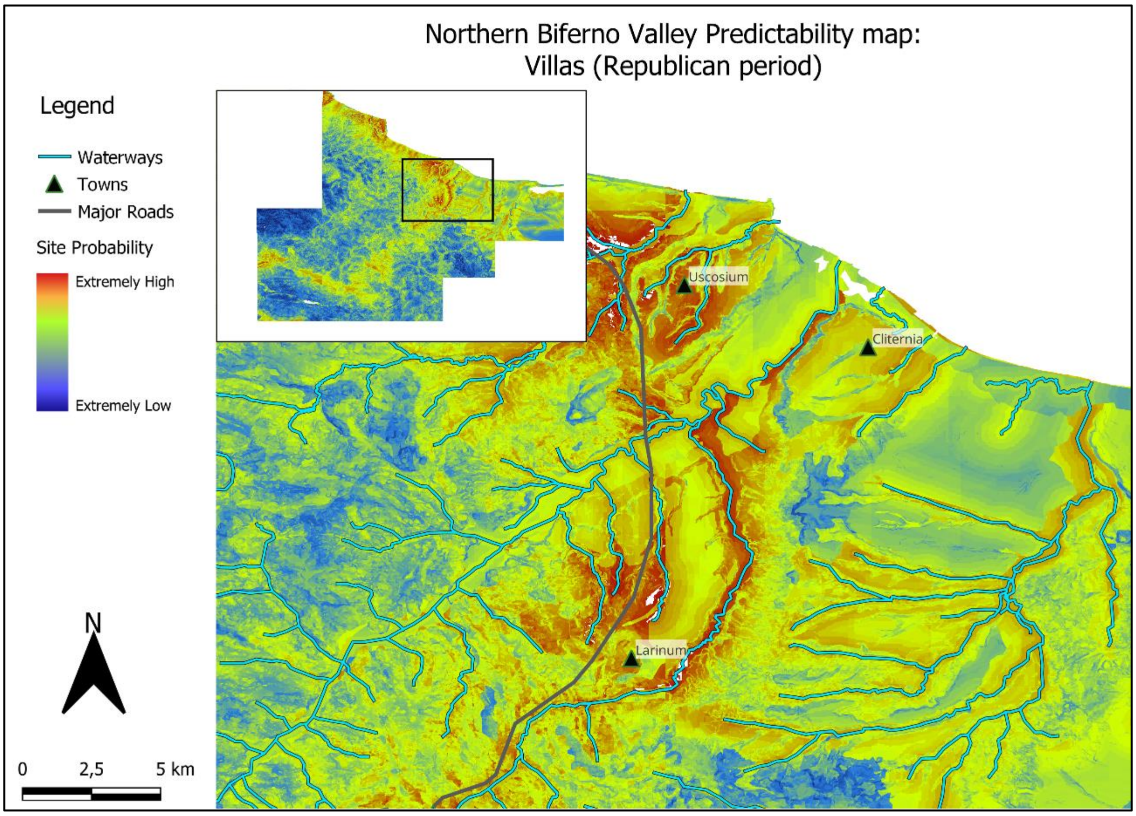


Figure 34a. Northern Biferno region predictability map for villas in the Roman Republican period.

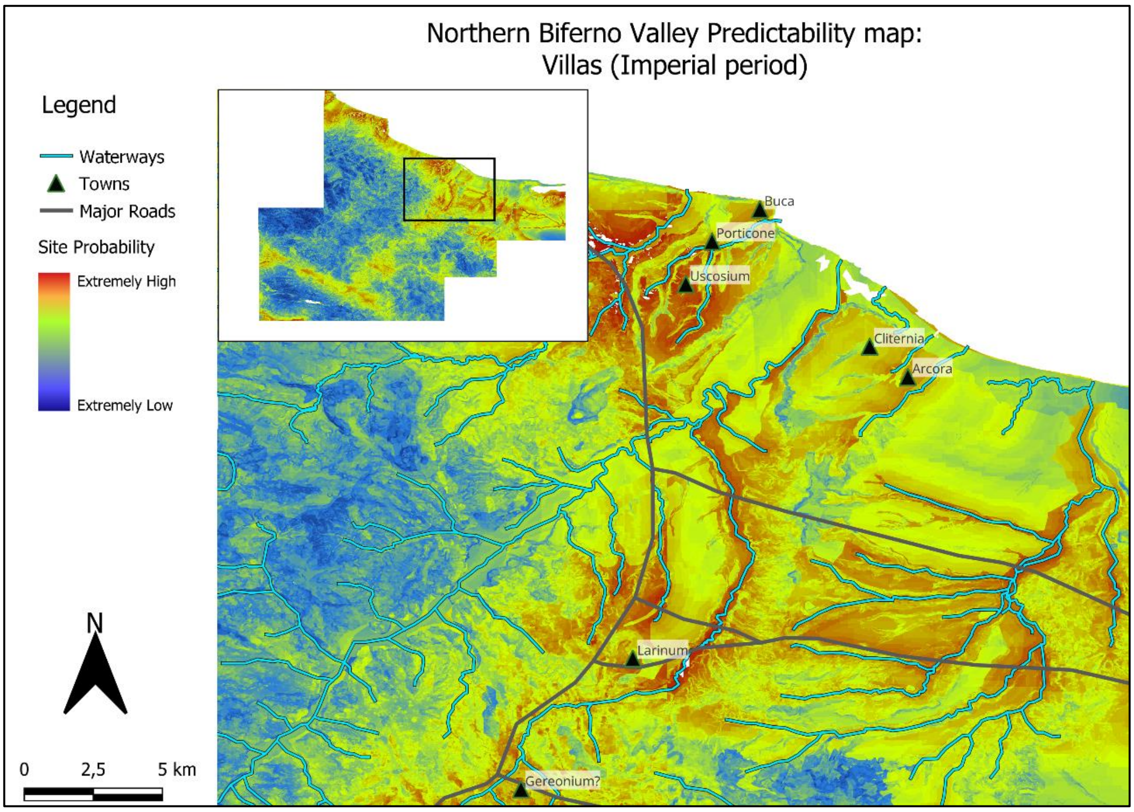


Figure 34b. Northern Biferno region predictability map for villas in the Roman Imperial period.

7.1.5 Western mountains

In the mountainous areas in the western parts of the research area, where no major roads were located, the more strict terrain requirements for villas can be seen clearly (figure 35b). Because of the more rugged nature of this area, vast sections of the landscape appear unsuitable to villa-farming. Despite the presence of several larger towns, villa owners in the Imperial period would have had little prospect of exchanging goods out of this region. Therefore, only limited sections of the landscape, mostly around the larger town of Terventum, show a moderate suitability.

This stands in contrast to the map displaying the predictability values for Imperial farms (figure 35a). In this case, much more of the landscape displays average predictability values. This can be attributed to the presence of waterways and clayey soils. This means that much of this landscape was reasonably well suited to small-scale farming. However, the steepest mountain slopes, in the west of this section, remain completely unsuitable. This region therefore indicates that farms were more dispersed in the landscape and that the presence of transport networks was not absolutely necessary. For villas on the other hand, a lack of roads meant that there was little incentive to occupy such locations, especially when the soils were not of optimal quality. This applied to the Imperial period more so than the Republican period.

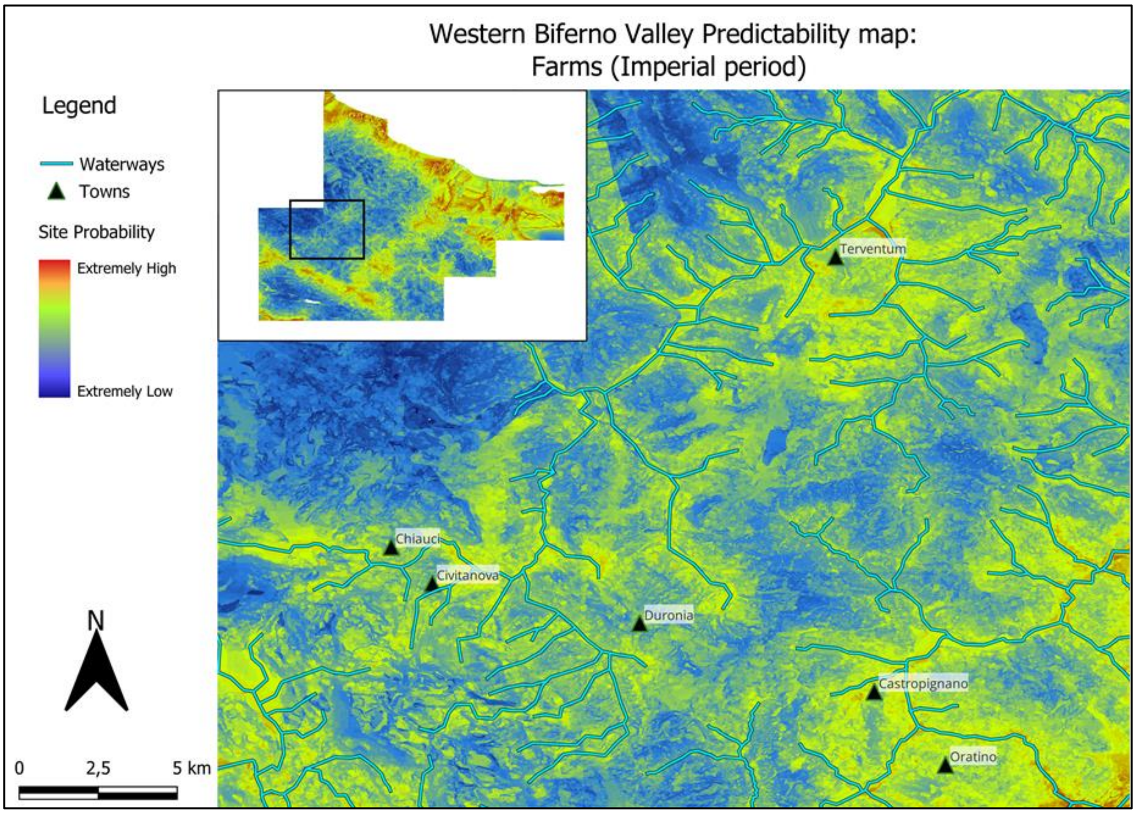


Figure 35a. Western Biferno region predictability map for farms in the Roman Imperial period.

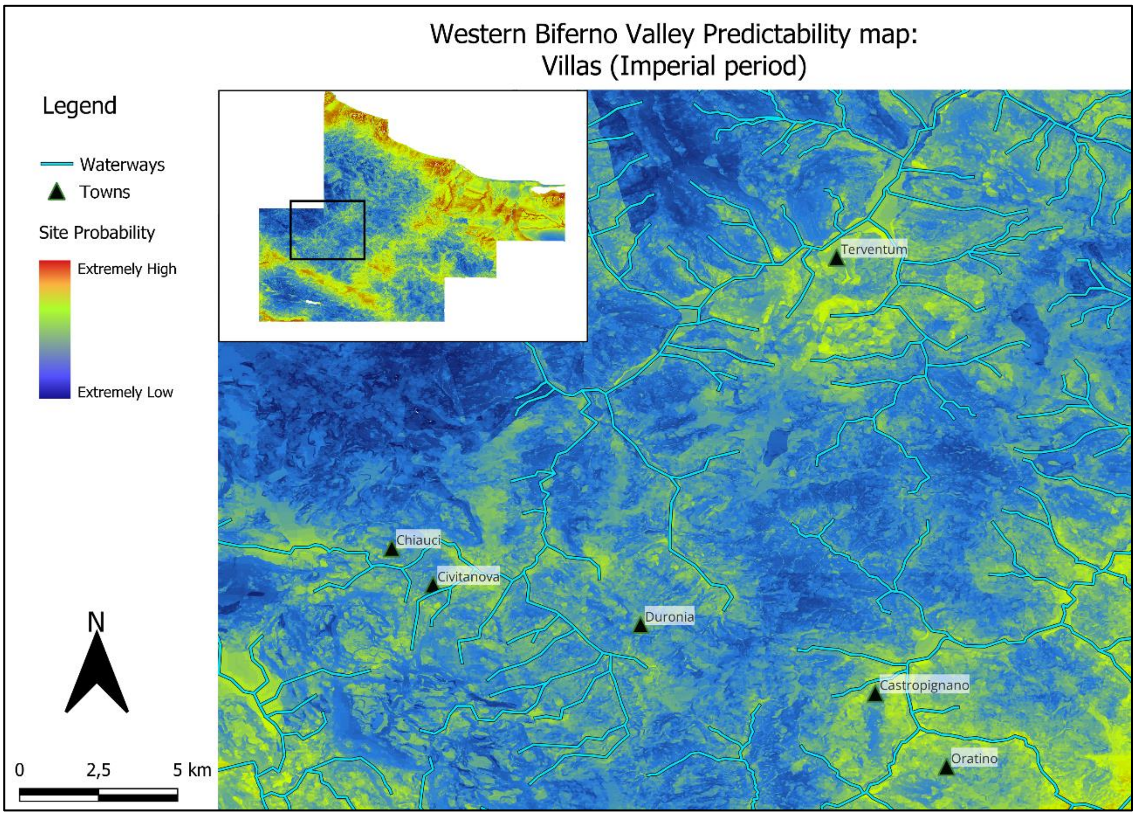


Figure 35b. Western Biferno region predictability map for villas in the Roman Imperial period.

7.1.6 Western coast

The last area of interest to be discussed in this chapter is the north-western section of the research area (figure 36). This region shows remarkably similar results for both types of site in both the Roman Republican and Imperial periods. For all four maps, a large portion of the coastal landscape near Histonium displays high predictability values. The presence of sandy and clayey soils, minimal slopes and the an arterial road made this an area in high demand. Interestingly, many locations in very near vicinity of waterways show to have been less suitable that areas somewhat further away. This is the result of coarser fluvial material being deposited next to the present rivers, leading to the creation of steeper embankments.

The most substantial difference between these maps can be found in the hills in the southern part of this area. Here, distinctly lower predictability values are observed for Imperial villas. This can be attributed to the increasing production scale and export of such sites in this period. Smaller sections of suitable land simply no longer met the desires of estate-owners. In the Republican period, this seems not to have been the case to the same extent. In this period, suitability patterns for villas and farms are almost identical. Furthermore, the situation is not much different for farms in the Imperial period. This all is indicative of the unique role villas began to play in Roman Imperial times. As demand for agricultural goods increased, large production landscapes of villas must have appeared near roads and towns along the coast. This will have changed the rural landscape quite drastically, as a more dispersed network of agricultural sites was in place during the centuries prior.

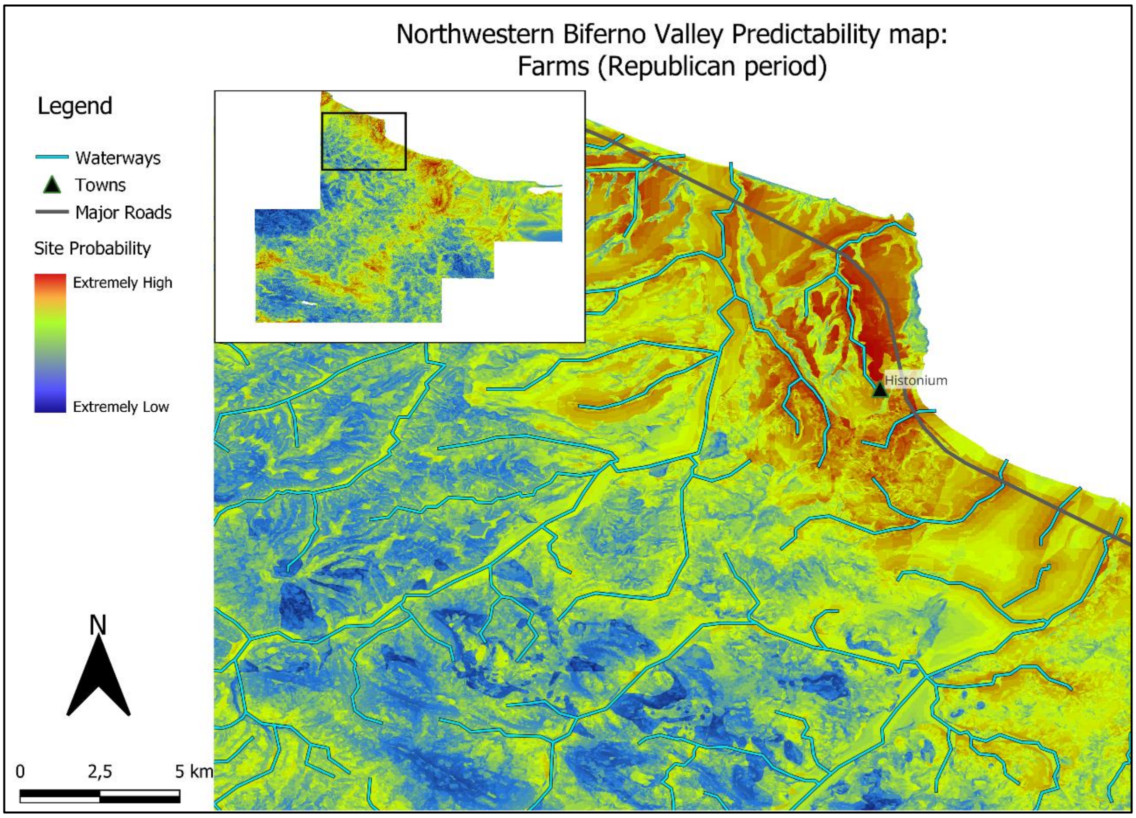


Figure 36a. North-Western Biferno region predictability map for farms in the Roman Republican period.

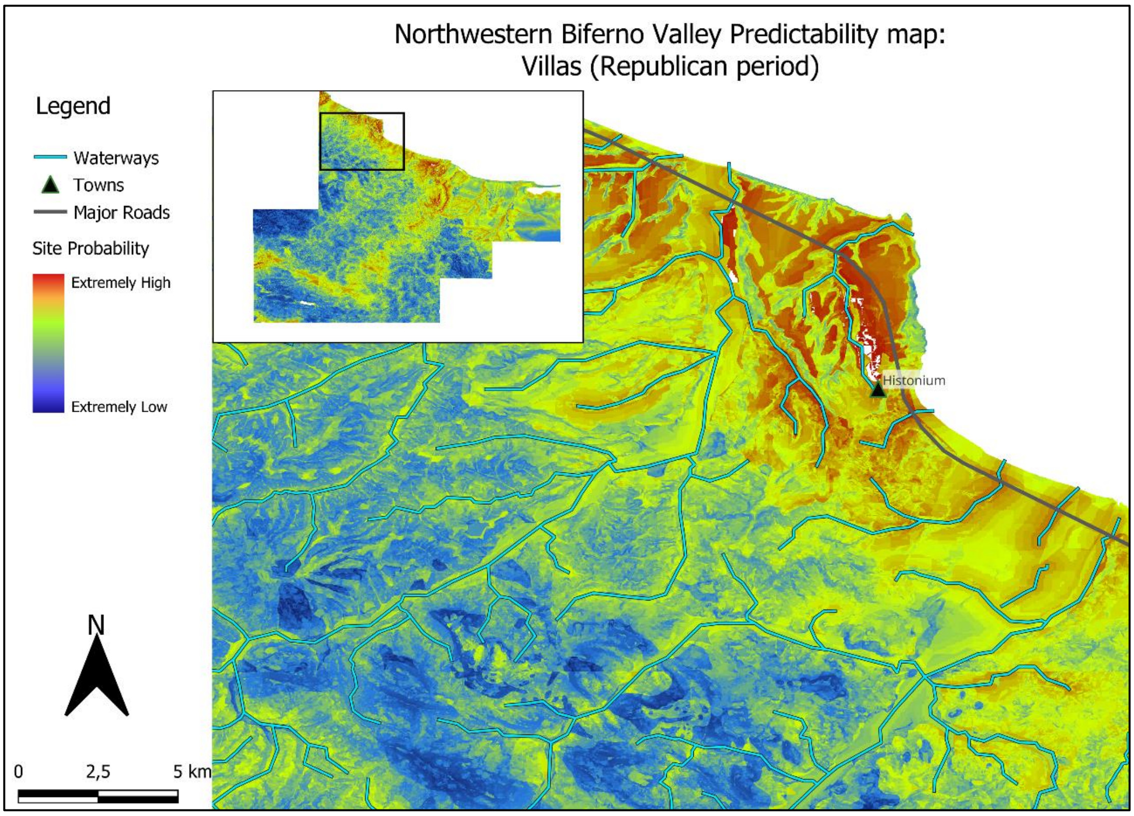


Figure 36b. North-Western Biferno region predictability map for villas in the Roman Republican period.

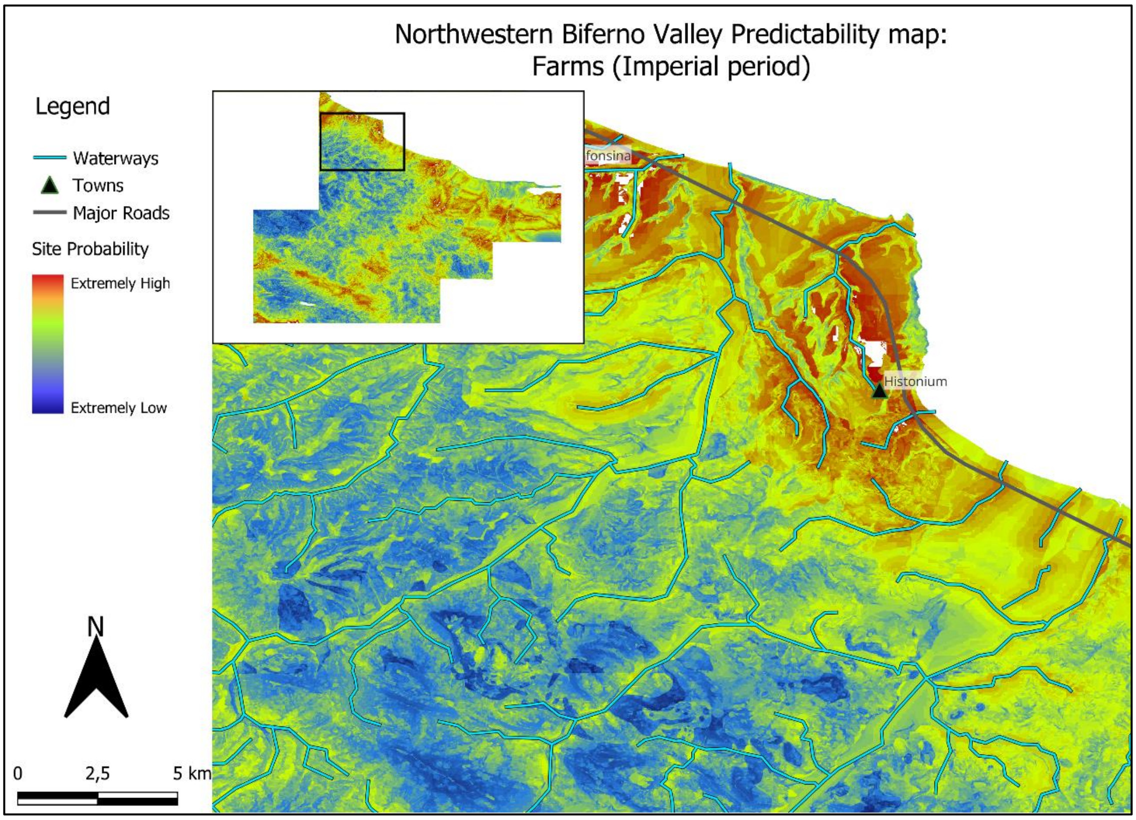


Figure 36c. North-Western Biferno region predictability map for farms in the Roman Imperial period.

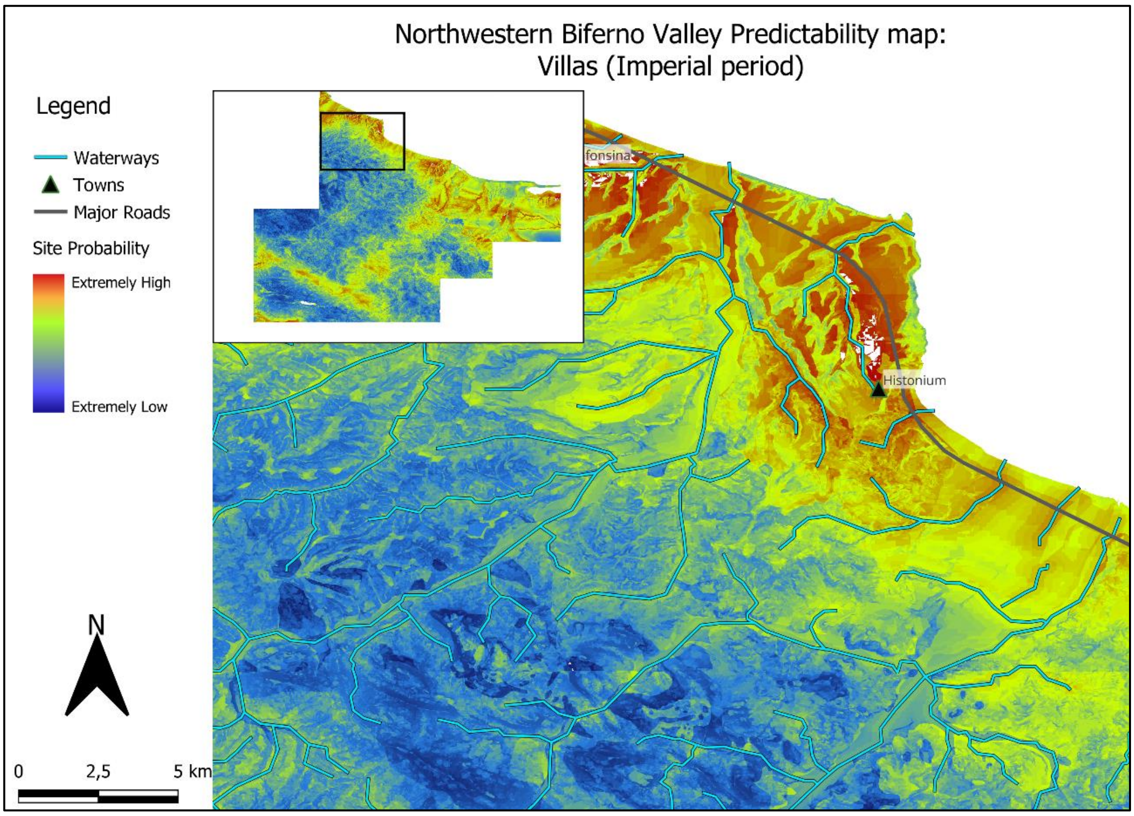


Figure 36d. North-Western Biferno region predictability map for villas in the Roman Imperial period.

7.2 Expectations versus results

Many observations made on the basis of the predictive maps align with the expectations set in this research's conceptual phase. The significant role of roads and towns in determining the location of agricultural sites is reflected clearly in the created maps. Most zones with high predictive values lie around these features. It could be argued that construction of towns and roads would have been more common in easily accessible terrain and that the type of terrain is also responsible for a high presence of rural sites. However, examples from the coastal plains indicate that large sections of land increased significantly in appeal after the construction of new roads and towns in the Imperial period. This change is most notable for villas, which benefitted most from the presence of dense infrastructure.

Similarly, the expectations regarding the role of water are met in the model. In most of the Biferno Valley, sections of land around rivers and streams display larger suitability values than the surrounding landscape. This rings true for both types of site in both study periods. Nevertheless, the situation on much of the coastal plains is somewhat different. Here, locations in very close proximity to waterways often appear to be less suitable than sections further away. This can be attributed to the presence of coarse, not very fertile alluvial material and of slightly steeper slopes due to river activity. In the Adriatic plains, where abundant clayey and sandy soils exist, these areas were in low demand. Generally, waterways were thus important for agricultural practices, but other factors could be weighted more heavily in certain scenarios. Proximity to the Adriatic Sea shows a similar trend. Generally, more villas should have been found near the coast in the Imperial period, which is visualised in the predictive maps. Still, some areas containing poor soils or featuring limited accessibility remained in low demand. It also needs to be noted that this area is heavily influenced by taphonomic processes. This means that, while there were likely many sites present here in Roman Antiquity, it will be difficult to detect them through archaeological fieldwork.

In relation to the steepness of the terrain, no surprises occur either. The most mountainous areas, with the steepest slopes, display the lowest suitability values in the entire research area. The central valley and areas near the coast, where slopes are much milder, generally display much higher suitability. This is related strongly to elevation as well. Zones in the research area with steep slopes are usually at higher elevations as well. As mentioned, high altitudes are unsuited to the cultivation of many types of crops. Therefore, the observed pattern completely falls within expectations.

For the third variable related to the shape of the terrain, slope aspect, observations differed from what was initially expected. It was presumed that south-facing slopes would be heavily sought after, as these should be the best suited to the growth of several types of grain (Van Joolen, 2003, p.127). However, analyses demonstrated in chapter 5 showed that both farms and villas were found mostly on north and east-facing slopes. Even though the differences were not too large, this is still a remarkable observation, which is also reflected in the end model. Interestingly, the steepness of these slopes was of no effect either. When disregarding slopes below certain thresholds (2, 5 and 10 degrees), the same pattern occurred. The image also deviated from the general variance in slope aspect in the surveyed areas, meaning that the observations were significant.

It is suspected that there are two main reasons for the observed differences. The first one is that other factors simply weighed more heavily than the direction of a slope. The second possible reason is related to the type of agriculture that was carried out in the Biferno Valley. It was explained that this region saw polycultural agriculture, in which pastoralism and the cultivation of a large variety of crops was present (Carrer, 2015, p.4). Based on this discussion, it seems likely that pastoralism and the cultivation of olives was more common than other types of agriculture. Again, slope aspect matters most when cultivating grain (Van Joolen, 2003, p.127). Therefore, a stronger focus on transhumance and on the cultivation of cash crops, mostly olives, would mean that the direction of a slope mattered less.

The role of the last variable to be discussed, soil type, also deviated from expectations. It is true that the observations in relation to farms are not entirely surprising, as many areas with high suitability are situated on clayey soils. This is different for villas. It was mentioned that sandy-clayey and loamy soils appeared to be ideal agricultural ground for the purposes of an estate. However, results show that chalky terrain and gravelly soils were most abundantly used instead. Once again, this could point to a larger prevalence of olive cultivation, as this crop thrives in such soils (Van Joolen, 2003, p.113). The cultivation of olives therefore seems to have played a much larger role in the Biferno Valley than previously expected. This would have been at the cost of grain cultivation. This revelation would not disprove the remaining theories outlined above. On the contrary, it further attests to the importance of trade in this region, which explains the strong relation between rural sites and roads and towns. The large amounts of suitable land near the sea also indicate that sea-based transport was common, especially in the Imperial period.

7.3 Organisation of agriculture

Through the findings outlined above, a broad view on the organisation of Roman agriculture can be provided. Throughout this research, one prominent distinction has been the one between 'farms' and 'villas'. As mentioned, a more complex typology was at place in Roman Antiquity, but the terms were here used to highlight differences between smaller sites that focused on subsistence and larger ones with a focus on market exchange. Developments in the location of these types of sites were similar, but not entirely the same. Small farms already existed in the Biferno Valley when the Romans took control of the area. Villas only appeared in the Late Republican, as a result of the increasing demand for olives and wine (Erdkamp, 2005, p.14). This process only increased going into the Imperial period, leading to a much larger number of villas in the landscape (Van Joolen, 2003, p.120). Due to these developments, smaller farms focused less on the production of cash crops, in favour of a diverse type of agriculture that provided subsistence to the families of farmers (Solonakis, 2017, p.26-28). Despite villas having control over large sections of farmland, the number of small farms remained high. This can be attributed to the mutual benefits of villa owners and smallholders. The latter often worked on the former's land in exchange for money and/or food (Van Oyen, 2020, p.22). The results of this research reflect these tendencies. Sections of land around roads and near the coast were most suitable to villa-based agriculture, owing to the ease of transport out of these areas. Farms could be found on a broader range of terrain types. Nevertheless, similar predictability patterns demonstrate the strong relations between the two types of sites.

In terms of labour employed by villa owners, it is logical that the cheapest solution was usually sought. In general, this meant the use of slaves to work their lands (Marzano, 2020, p.7). However, the strong spatial relation between farms and villas has been linked to connections in the form of labour. Despite the substantial use of slaves on villas, cheap labour from nearby farms continued to be an important aspect of villa based agriculture (Marzano, 2020, p.9). Since the price of slaves remained relatively high throughout the Roman period, cheap seasonal labour was often a good solution. Paying local farmers the usual price of about four sesterces per day, labour intensive periods of farming could be carried out by these workers with more profit in comparison to a slave that was straight up bought (Marzano, 2020, p.8). For most of Roman Italy, similar relations can be seen. Seasonally, many farmers moved from the countryside to urban centres and villas to work. Because working their own land was often not as profitable as working elsewhere and because of the differences between available land and labour, this became a usual thing (Erdkamp, 2016, p.2). In a region such as the Biferno Valley, with limited farmland and a strong clustering of agricultural sites, it is fair to assume that this process of seasonal labour was significant. This is likely a major reason why farms and villas occupied similar areas of this landscape.

Even though differences in soil preferences existed between the two types of sites, infrastructure seems to have played a larger role in determining site locations. Road access especially was incredibly important to rural sites, most of all for villas (Erdkamp, 2005, p.111;p.172). Many other research projects have highlighted the important role of Roman roads in attributing to the Roman economy. As roads were built, production centres appeared, leading to economic growth (Dalgaard et al., 2018, p.22). This process is observed throughout the Roman Empire, with the most significant increase happening during the early empire, under the rule of emperor Augustus (Hitchner, 2012, p.224). All of this falls in line with what the predictive model indicates.

The substantial role of urban centres can also be seen through the model results. They offered a selling market to estate owners and a place to buy necessary goods for smallholders (Witcher, 2017, p.42; Hollander, 2018). Therefore, towns formed a great point of attraction for all agricultural sites. However, wealthier farm owners were often not confined in this way, meaning that spaces further away from cities could occasionally be occupied as well. Similar situations occurred when old farmsteads showed continuous occupation (Marzano, 2007, p.36). This still means that agricultural sites were generally attracted to locations near cities, but that this was a relatively flexible concept. Whilst these patterns changed minimally over time, the construction of new infrastructure meant that rural sites went on to occupy new parts of the landscape that were previously less suited (Van Oyen, 2020, p.59). It is important to note however, that there seems to have been a large degree of continuity. Farms that were in use in the early Iron Age and the Roman Republican period often remained occupied for longer periods of time (Van Joolen, 2003, p.14). It appears simply that large amounts of villas and farms were constructed in the Imperial period in these newly exploited parts of the landscape.

However, there is a seeming lack of agricultural activity near multiple larger settlements in the research area (see section 7.1.5). In much of the Roman world, especially on the Italian peninsula, cities and towns drew from their surrounding hinterlands to provide their populations with food. In these cases, grain was the predominant crop cultivated in these areas (Van Oyen, 2020, p.123). Figure 37 illustrates the expected area of influence of such urban centres. To exert control over the large amounts of farms that would exist in these cases, landscapes were transformed and roads were built. However, no evidence of such practices occurs for many towns in the Biferno region. Furthermore, there is a notably low suitability score for the surroundings of several towns, especially in the Imperial period. Therefore, it seems that there was limited local production of foodstuffs, i.e. cereals. This means that there must have been a substantial import of grains, in order to feed the growing urban population of the region.

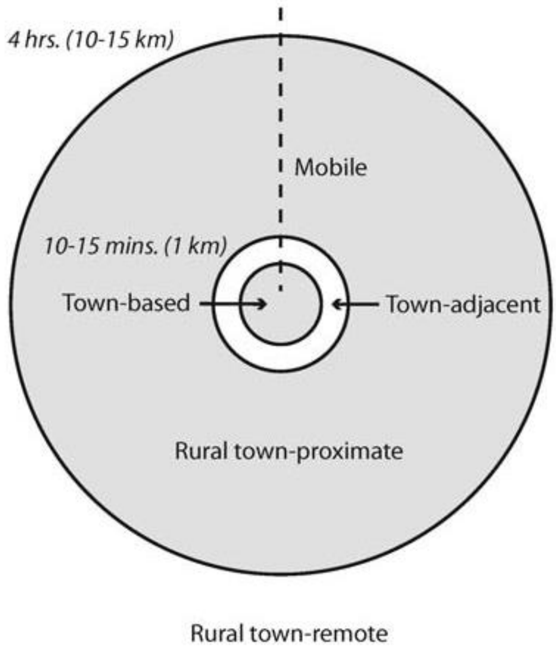


Figure 37. Craft production zones in relation to a town (Kron, 2017, p.205)

No fixed characteristics existed that determined the suitability of a location to agriculture in Roman times. Instead, qualitative assessments were made on a case-to-case basis (Saller, 2022, p.85). Still, general patterns occur in relation to natural factors as well. The types of soils that were worked and the apparent lack of preference for south-facing slopes meant that olives were likely produced in large quantities in the Biferno Valley. This hypothesis is further validated through the relation of villas and farms to roads. The lacking intensive agricultural activity in the hinterlands of numerous towns also fits within this theory. Suitability patterns near the coast (see sections 7.1.3 and 7.1.4) imply large numbers of sites on the coastal plains and a slight aversion to locations right besides waterways. A location near the coast meant that crops could be easily transported over large distances. The lack of suitability of locations next to rivers could point again to a substantial olive cultivation, as this crop did not fare well in very wet soils (Van Joolen, 2003, p.120). This aversion to terrain in very close proximity to waterways was most prevalent during the Imperial period. Whereas water sources were of high importance in Early Republican Rome, the introduction of new kinds of farming and of methods for irrigation meant that proximity to rivers gradually became more variable and less important (Bruun, 2015, p.133).

The preference for sandy and gravelly soils in the Biferno Valley in combination with a strong reliance on the road network seem to point to a significant production of cash crops. It is true that in much of the Roman world, villas saw a wide range of cultivated crops. Some examples show that villas could focus heavily on the production of cereals, whereas others relied almost entirely on the cultivation of cash crops (Purcell, 2005, p.158). In the case of the latter, crops that were fundamental to large-scale food production would have to be imported (Purcell, 2005, p.159). This contrast between styles of farming was also visible on a chronological scale. As time went on, new ways of increasing the production of agricultural land were applied. This lead to an increased specialization and commercialisation of villa owners. It also meant that systems of crop rotation became increasingly employed, reducing the time fields were fallow. With this came a larger production of fodder crops and the prevalence of complex agrarian systems (see figure 38) (Bowes, 2021, p.124; Bowman & Wilson, 2013, p.5). It is possible that a similar thing occurred in the Biferno Valley, which would also partially explain the observations outlined above in relation to preferred soil type and terrain.

Figure 38. Reconstruction of a complex Roman agrarian system (Lepetz & Zech-Matterne, 2018, p.4)

Sea-based transport seems to have been quite important to the Biferno Valley in the Roman period. Not only does it seem that the sea facilitated the export of the substantial production of cash crops, but also would grain be imported to feed the urban population. Grain was presumably cultivated here too, but to a lesser extent than other regions on the Italian peninsula. This would have been most notable in the Imperial period, when grain production for a large part shifted to other regions of the growing Roman Empire (Van Oyen, 2020, p.59). Strong interrelations between farms and villas seem to have existed in the Roman Biferno Valley. This region was further strongly connected to other parts of the Roman world, which is evident through the large degree of exchange that characterised this region. Unfortunately, little is known about the proportion of local production to import in the Biferno Valley. As mentioned, a large proportion of the rural population was involved in production of agricultural produce. It is however uncertain how much of the production involved the creation of finished goods (Erdkamp, 2005, p.321). In the research presented in this thesis, only villas and farms were regarded, not taking into account other types of sites, such as kilns or pottery sites. Therefore, it is uncertain exactly how many finished products were exported from this region. Depending on the makeup of exported goods, a larger or lesser import of agricultural products would have been needed. In many regions in the Roman Empire, the production of high-value goods provided sufficient economic activity (Erdkamp, 205, p.321). Unfortunately, not enough is known about the agricultural production in the Biferno Valley to give a definitive answer on this topic. Nevertheless, results indicate that the region was quite exchange-oriented. Therefore, it is very likely that large quantities of goods, finished or not, were imported and exported.

8. Reflection

The previous chapter outlined the findings in interpreting the results of the predictive models. In this chapter, a reflection on the methodology employed in this research is provided. Firstly, the possibilities and challenges of working with legacy survey data are summarised. An explanation of how working with legacy survey data differs from working with modern data is given as well. Following this, the results of the predictive model will be compared to similar models in other research projects. Lastly, a retrospect on the applied workflow will conclude this chapter.

8.1 Usage of Legacy Survey Data

8.1.1 Possibilities and challenges

Through the research presented here, an idea of how legacy survey data can still contribute to our understanding of the Roman world has been formed. It should be clear that there are definitely challenges when attempting to use such data. However, this research has shown that new insights can still be gained by applying the right methodology. It was mentioned early on that the main advantage of using legacy survey data lies in the fact that there is so much of it. Over the past decades, an incredible amount of information has been gathered through archaeological surveys (de Haas & van Leusen, 2020). Many times, the resulting data has not been analysed using modern techniques, not making the most out of the available information (Verhagen, 2007, p.15). Besides, given that archaeological surface remains are very prone to degradation, using data that was gathered in the recent past may be beneficial (Witcher, 2008, p.4). Newer surveys potentially uncover fewer remains as a result, especially in areas with intensive human activity. Large legacy survey projects, such as the Biferno Valley Survey, can therefore offer valuable knowledge on large scale archaeological patterns. It is however important to be aware of the restrictions of this type of data. It has been explained that older data cannot simply be used to build analyses without delving deeper into the theory behind it all. Therefore, statistical tests alone do not suffice. The results of this research attest to the insights that can be gained when correctly applying legacy data. By going for theory-driven research, legacy survey data allows for a holistic analysis of the past, in which archaeology is intertwined with other fields of research.

Nevertheless, core challenges remain present. A main issue lies in the quantification of variables. As explained, Romans assessed possible locations for agricultural sites in a qualitative way (Saller, 2022, p.85). This stands in contrast to the quantitative manner in which a predictive model is built and statistical tests are based. As a result, no direct line can be drawn between theoretical research on the Roman rural world and the practical aspects of predictive modelling. The main challenge herein lies in the translation of subjective factors of attraction into numbers. Whilst the results of this research indicate that this was successfully achieved, it is important to note that this was not an objective process either. Large, moderate and slight influences on the rural landscape were weighted differently in the model. Which factors fell under these categories was up to the researcher's interpretation based on theoretical research. The weights in the end product were further decided by the researcher's interpretation of test results. Nevertheless, the chosen weights should not be considered random. By generalizing the desires of a smallholder or estate owner for the researched periods, an average view of these periods was achieved. Furthermore, substantial testing was in place to ensure a correct functioning of the model. Multiple times, factors proved not to be tailored correctly. When test results showed low significance numbers, results were reassessed and the weights of variables were adjusted. By following this workflow, the subjectivity was removed from the equation as much as possible.

Even though much information can be gathered from existing survey data, there are limits to what can be done. It is generally possible to make general statements, but a more in-depth analysis often requires more detail. The extent to which this is possible depends largely on the original survey project's methods. In the research described in this thesis, site dating and interpretation lacked detail. For that reason, it became unfeasible to carry out a more precise chronological analysis or to describe differences between sites in more detail than done here. This issue highlights the problems that occur because of the large variability of older survey projects. Some of these issues apply to survey archaeology in general, but are amplified in this context. Furthermore, complex processes such as taphonomy could not directly be incorporated into the model due to their unpredictable nature. This further leads to a generalisation of the created predictive models. Therefore, large-scale patterns over a long period of time can be assessed reasonably well through the usage of legacy survey data. More precise analyses are however very challenging, depending on the structure of the original dataset.

8.1.2 Legacy versus modern survey data

Section 8.1 outlined what can be gained from using legacy survey data and the challenges that arise when doing so. In this section, a discussion on how results could differ if modern survey data was used in this research instead is provided.

In broad terms, the research results would likely be quite similar if modern survey data was used. This is because of the theory-based approach that was employed. Documented sites were used simply for validation. In this sense, the outcomes of the first stages of the research would be pretty much the same. Only when assessing the validity of hypotheses would differences start to occur. Generally, the methods employed in the field have remained quite similar over the past decades. Much of the Biferno Valley Survey project was centred around systematic and intensive surveying, a method which is still in broad use (Attema et al., 2022, p.242). New technological advancements in the field have meant that larger and more rough areas can now be examined more efficiently. Lidar, for example, has proved to be a valuable asset to archaeology (Poux et al., 2017, p.372). However, even when using such techniques, a theoretical foundation is needed. Furthermore, validation through in-person fieldwork remains crucial (Guidi et al., 2017, p.352). For those reasons, it is likely that the Biferno Valley Survey yielded similar information on the location of sites as modern survey projects would have done.

The major drawback of using legacy survey data has been the lack of consistent documentation. Throughout the research, the lack of detail in the interpretation and the dating of sites has caused difficulties. As a result of the very broad dating frames that were employed, broad generalisations had to be made to produce the desired results. Therefore, two maps representing the entire Republican period and two maps representing the Imperial period were based on long-term developments. It was mentioned in the previous chapter that these results are significant, but that more precise documentation would have been preferred. Because of the lack of detailed site interpretations, generalisation had to occur here as well. Two types, farms and villas, formed the basis of all analyses, whilst these categories were much more complex in reality. Nevertheless, one could argue that this situation would be similar when using modern survey data. It is true that survey projects generally run into issues when dating and interpreting sites. This is a result of the way in which a 'site' is identified. Usually, this is done based on artefact density. With only artefact scatters to interpret, it is often challenging to provide detailed interpretations or accurate dating (Banning et al., 2017, p.468). However, the application of controlled vocabularies and a higher degree of transparency in terms of how exactly sites are identified lead to an increased understanding of site patterns (Alcock, 2016, p.13). This includes more precise chronological assessments, when possible, and a larger variation in site types. This stands in contrast with projects such as the BVS, in which there was little standardisation. As a result, interpretation of sites depended almost fully on the person documenting them (Barker, 1995, p.51).

Overall, it can be said that the use of modern survey data would likely allow for a more detailed analysis of rural developments in Roman Antiquity. This is for the most part due to the documentation methods that were employed in the Biferno Valley Survey project. However, in many cases, current survey projects still struggle with comparability and representability, because of the lacking reflection on methods and personnel (Banning et al., 2017, p.467). Furthermore, surveying still suffers from a risk for biases. Archaeological fieldwork is inherently biased as a result of differential preservation and representation of materials (Graesch, 2009; Jackes, 2011). This goes for survey archaeology too, which has a strong tendency to take place on current agricultural land. On top of this, natural processes further alter the archaeological record (Feiken, 2014, p.3). As a result, some aspects of past life are underrepresented. In this research, the example of wheeled transport against footed transport was noted. Whereas the former is reasonably well accounted for, traces of the latter are almost negligible (Kolb, 2019, p.12). Still, paths for footed transport were a large part of the rural world and undoubtedly impacted site locations (Erdkamp, 2005, p.112). Besides issues in representability, the diversity of archaeological surveying poses further challenges. The BVS project employed a range of strategies, from high-intensity, systematic field walking to very low-intensity and unsystematic reconnaissance (Barker, 1995, p.42-44). The areas in which each type occurred are well documented though, making this a minimal issue. Nevertheless, the differences between surveyed areas do need to be accounted for when using the data for research. Overall, it can be said that the usage of modern survey data would allow for more nuanced analyses of the Roman past. Nevertheless, inherent issues still exist, making the incorporation of theoretical frameworks a crucial step in research involving survey data, modern or not.

8.2 Model results in context

When comparing the results of the predictive maps generated in this research to those generated by others, the goal of the research has to be taken into account. Many predictive models attempt to convey where archaeological sites are detectable in the present. This research attempted to illustrate where sites would have been in the past, without taking into account present visibility. This difference means that models can often not be compared one-to-one. Nevertheless, a comparison to the results of other projects offers an insight in the functioning of the predictive maps generated in this research.

One project that must regarded here is the Aesernia Project. This survey project occupies an area within the Biferno Region and has led to the creation of predictability and visibility maps. The main results hereof are in a way similar to the ones provided in this thesis. Similarly, the role of soils and urban centres is acknowledged (Casarotto et al., 2018, p.179). However, the project focused more on the effects of erosion and other geomorphological processes. Furthermore, a more statistical approach was used. This is a result of the focus being put on the visibility of sites (Casarotto et al., 2018, p.178). Overall, this research indicates that similar factors were important, but the resulting visibility map (figure 39) is not quite comparable.

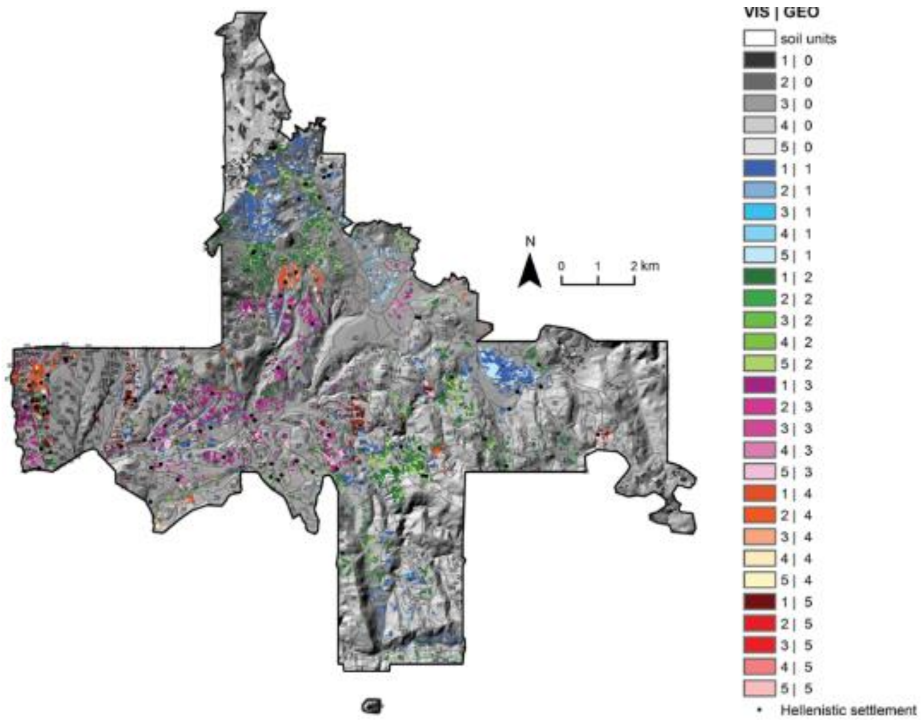


Figure 39. Cross-tabulated detectability map of the Aesernia region.
(Casarotto et al., 2018, p.189)

Similarly, other modelling projects in the area deal primarily with detectability and are often more statistics-forward. For example, the importance of current land use is stressed as well (e.g. Peters, 2019, p.94). Other research with a similar scope, though not necessarily in the same region, computed travel time along pathways to map reachability (e.g. Revert, 2017, p.83). These are all things that could be applied to the Biferno Valley as well. Nevertheless, this was out of the scope of this research and seems unnecessary in this context. Furthermore, similar factors are stressed throughout the field: urban centres, reachability, water and terrain. How exactly these factor into a model is the choice of the researcher.

As mentioned, the choice of variables and their weights varies between research projects. This means that other researchers in some cases included different variables than the ones used in this thesis project. Current landuse and viewsheds are two aspects that are often included in predictive models, but that were left out in this research. Landuse relates to current visibility. Once again, this was not incorporated into the model in this thesis because this variable does not relate directly to this resaerch's goals. Viewsheds are often argued to have played a large role in determining spatial patterns in the past (Danese et al., 2014, p.43). This aspect was not included in this research, due to the increasing complexity it would bring. Figure 40 demonstrates the impact of these variables in predictive modelling, although in the context of Neolithic sites.

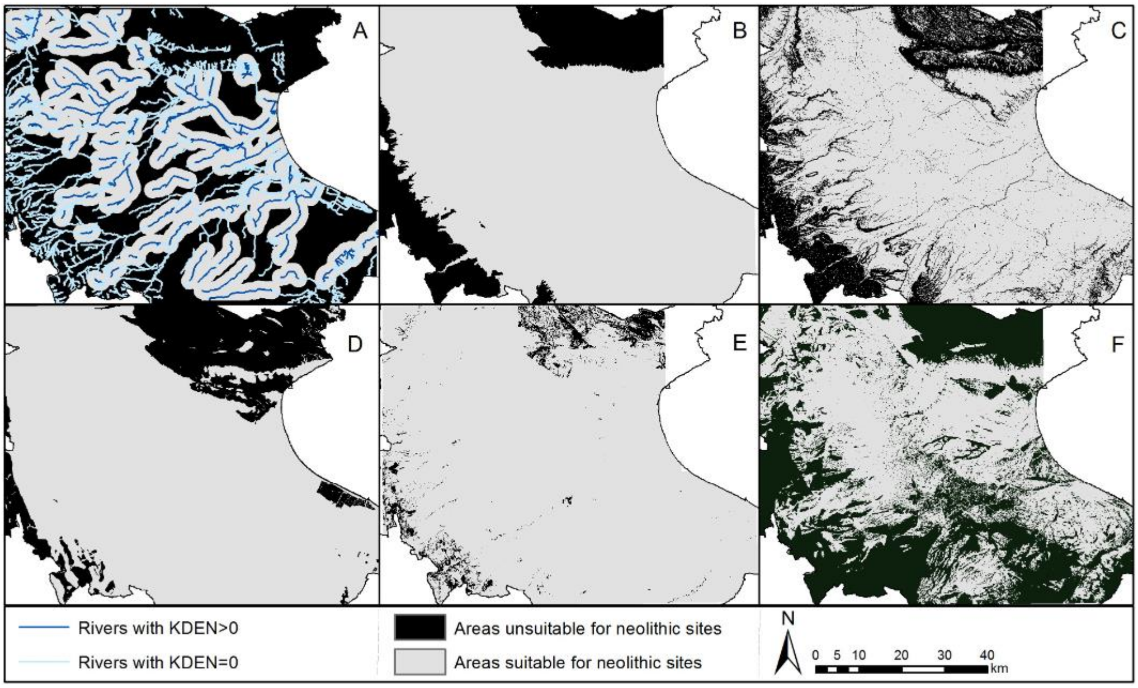


Figure 40. Visualised impact of A) distance from rivers and network kernel density estimate, B) elevation, C) slope, D) lithology, E) land use and F) viewshed . (Danese et al., 2014, p.50)

Lastly, variations occur between research projects in the way in which multiple variables are combined into a predictive model. In this research, predictability was expressed in a continuous scale, because of the way in which the Generalised Additive Model was set up. However, predictive models often express predictability through several classes, with the number of classes varying between projects. Occasionaly, binary classification of single variables are even included. The suitability of a location is then determined by wether certain variables are present or not, with little nuance. Figure 41 displays a predictive map that was created in this manner, for a region close to the Biferno Valley.

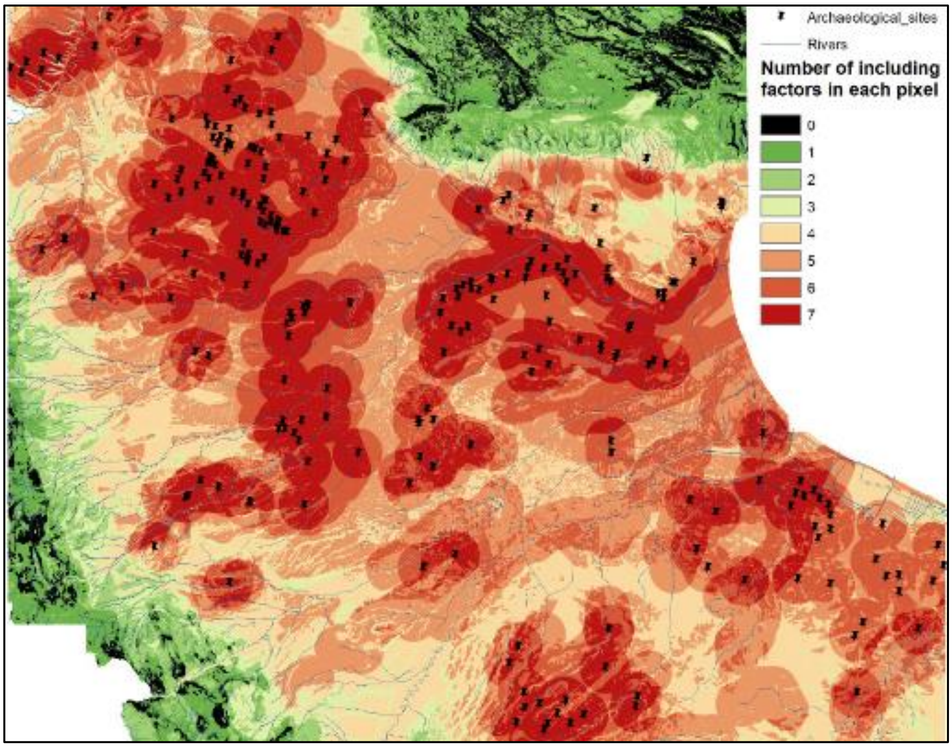


Figure 41. A predictive map of Neolithic sites in Apulian Tavoliere, Italy. (Danese et al., 2014, p.52)

Whilst generated in a different way, this map indicates the importance of several factors that were included in this thesis as well. The role of waterways, elevation and the presence of sites are the most notable aspects. Still, less detail is present in this figure than the maps created in this thesis project. Overall, an argument can be made for the inclusion or exclusion of a number of variables. Furthermore, many different ways of generating a predictive model could have been used. Nevertheless, a comparison to other research indicates that the chosen methodology lined up well with the research goals and that the chosen approach offered clear advantages on a number of levels.

8.3 Reflection on workflow

The workflow applied in this research has been demonstrated in the methodology chapter. Here, significant attention was given to the first stages, in which theoretical assumptions led to falsifiable hypotheses. These hypotheses were statistically tested on the basis of known site locations. The resulting theories were built into various suitability maps of natural and infrastructural variables. Predictive maps were created by using a weighted additive model which incorporates all of these variables. The results were tested again through random subsamples of sites. The results hereof dictated whether and how the model needed to be adjusted again. Generally, this workflow proved to function well in creating the desired results. Again, the lack of detail in interpretation and dating of sites meant that testing could only follow general developments. This is however a result of the available data, around which the workflow built a suitable methodology.

In comparison to the workflow of similar research within the field, theory received a stronger focus here. Whereas hypotheses usually follow directly after the formulation of research questions and modelling follows directly after analysing the hypothesis statistically (Revert, 2017, p.49-50; Romanowska, 2015, p.172), extra conceptual steps were applied in this research. The technical phase however seems to be mostly similar to that of many other projects, where univariate modelling and testing leads into a combination of multivariate modelling and testing. These steps were followed in this research through the creation of suitability maps for each variable. This is also something that occurs in other research (Peters, 2019, p.79).

One difference is that most projects include a form of test to validate site visibility, which is also included in the model. It has been explained that this has not been done in this research, because it deviates from the main goal of the research in determining where sites were likely located in the past. The interpretative stage of the research once again differed minimally from the same stage of others. Results were compared to the hypotheses and the model's validity was assessed on this basis. Finally, the conclusions were drawn up from the results. In general, the workflow employed here was adapted in several crucial stages to allow for the use of legacy survey data. As the last stages followed similar steps as other research, the results are comparable whilst using different source data. This attests to the great possibilities of using legacy survey data to gain new insights on the past.

9. Conclusion

9.1 Background and methodology

Understanding the rural world and agricultural practices are a crucial aspect of understanding the Roman world in its entirety. Strong connections between cities and the surrounding countryside played a determining role in the structure of the social and economic side of Roman life. In the study of the rural landscapes, archaeological surveys have been paramount in the gathering of information. Throughout the years, such projects have gathered incredible amounts of data on the location of archaeological sites. However, for a long time there was little in terms of standardisation or consistency. As a result, the use of existing survey data, also called legacy survey data, is often deemed unproductive. This research brings together both issues by using legacy survey data to gain new insights into the Roman rural world.

This has been achieved through the creation of predictive maps, which indicate the likeliness of the presence of two types of archaeological sites, farms and villas, through several Roman periods. This has been done for the Biferno Valley, a region in central-eastern Italy where significant surveying has occurred in the past. Most of this surveying has been carried out as part of the Biferno Valley Survey, which is the source of the site data used in this research. In order to use this data, which suffers from some methodological issues, a theory-driven approach to the research was chosen. A theoretical framework was built first, leaving the documented sites to play the role of validating the findings. By doing this, it is possible to use the existing data in a meaningful way, without suffering from its inconsistency.

Through the founded theory surrounding the Roman countryside in the Biferno Valley, an evaluation of variables was made. Factors that were deemed influential in determining the location of farms and villas were included in the creation of the predictive model. Firstly, it was assessed on the basis of other research and literature what the precise role of these factors was. This was then tested statistically on the basis of sites documented in the Biferno Valley Survey. The resulting variables and their suitability were translated into raster maps in QGIS. A weighted Additive Model was then created with these maps. In the model, each variable was assigned a certain weight, according to the deemed importance hereof. After this, the created maps were tested by comparing the results to the known sites in the study area. This was done on the basis of Kolmogorov-Smirnov tests, indicating the significance of the results. Depending on the outcome, adjustments were made to the model until the desired significance was achieved. Lastly, it was examined what the results indicate about Roman agriculture and life in the rural world.

9.2 Findings

During the conceptual phase, a complex image of life in the Roman world was generated. Over the centuries, many political and social changes occurred that impacted decisions. Because of the generalisation that had to be done in this research as a result of the available data, a precise impact of all of these changes could not be given. Nevertheless, a broad scheme of how the location of agricultural sites changed over time could be created. Important to note is that there was no strict template that determined whether a place was suitable to agriculture. Rather, the polycultural system of Roman agriculture meant that this assessment was made by the farmer on a case-to-case basis. Still, several factors that were the most influential were chosen to be examined further and to be included into the model.

In the end, the following factors were chosen: elevation, steepness, aspect, soil type, waterways, urban centres, roads and for villas the sea. Generally, the impact of these variables was quite straight forward. For elevation and steepness, higher values meant a lower suitability. For waterways, urban centres and roads, a closer proximity meant a higher suitability. The same thing can be said for the sea, although this variable was only really impactful in the Imperial period for villas, as the coast was deemed mostly unsafe before then. For soil type, differences occur between farms and villas. The former seems to have been found on clayey and sandy terrain mostly. The latter was located more often on alluvial materials and on gravelly terrain. The most dubious variable was slope aspect. It was expected that south-facing slopes would be considered ideal, considering their higher productivity when it comes to cereal cultivation. However, this was not reflected in the archaeological record, leading to the belief that this variable played only a minimal role.

Including these factors in varying weights into the model gave some interesting insights into the likely functioning of the rural Biferno Valley during the Roman period. It can be seen that agricultural sites, most notably villas, were likely clustered quite strongly. The cluster centres generally lay around roads and population centres. This is logical, since these features were deemed the most important in determining the location of a rural site. Based on this pattern, and the types of soils that were preferred, a significant production of olives and grapes is expected in the Biferno Valley. Still, it is possible that a large degree of crop rotation was responsible for the resulting views. Either way, it is likely that at least some grain had to be imported into the region from elsewhere to support the urban population. It is possible that this was facilitated by a high degree of finished goods production, although this is not certain. What is known is that many farmers were seasonal workers, who periodically moved to towns or nearby villas to perform labour in exchange for some money. This once again attests to the strong intertwining of urban and rural life and the strong relations between all kinds of farmers and estate owners.

These results offer clear answers to the research questions stated in chapter 1. The first research question; *How can legacy survey data contribute to our understanding of the Roman past?*, can be answered as follows. Through the application of theory-based analyses, survey data is moved into a role of validation. Therefore, a strong understanding of past processes in the research area is needed to build suitable hypotheses. By testing these hypotheses through legacy survey data, a strong link between theory and practice is constructed, whilst also accounting for the disadvantages that come with the usage of such data.

The findings indicate that the application of such a methodology is well suited to the study of the Roman rural world, giving an answer to the second research question; *How was the rural world in the Biferno Valley organised during the Roman Republican and Imperial periods?* Patterns in the location of farms and villas in the Biferno Valley attest to the great importance of trade and exchange in the region, especially during the

Roman Imperial period. A strong interlinking network of agricultural sites was in place, in which owners of farms and villas mutually benefitted from each other's presence. Relations stretched beyond the Biferno region as well, with a strong focus on the export of cash crops and the import of cereals. Agrarian systems in which the rotation of crops was employed were likely spread throughout the research area. This all points towards a complex system of entanglement between all sorts of people in the rural Roman world.

9.3 Context and future research

This research has demonstrated that legacy survey data can still be combined with more modern techniques and that it can lead to a better understanding of the Roman world. In order to do so, a firm grip on the theory behind the studied region and time period is needed. Once this is achieved, similar analyses can be carried out to many other research projects. In this case, predictive modelling was used to create new knowledge. However, other types of analyses can be carried out as well, depending on the goals of the research. Some issues still remain when following a similar approach. The most notable is the lack of consistent documentation. Because of this, generalisation has to occur, meaning that nuances can be lost. Despite these issues, this research offers a promising prospect. It opens the door to other researchers to employ a more emic and theoretical approach to an otherwise very data-driven field. By doing so, the most can be made of all the information there is. Considering all data meaningful therefore leads to a more profound understanding of the past.

A further focus on social developments would aid in our understanding of the Roman world. Whereas the research presented in this thesis revolved mostly around environmental factors, it is recommended that future research puts a stronger emphasis on the social aspects of life in the past. More attention should also be paid to providing more detailed analyses. Unfortunately, the extent to which this is possible relies on the source project. If legacy survey data is to be used, more comparative analyses might be needed to make this possible. Alternatively, more fieldwork in the region would undoubtedly offer more knowledge, but moves away from the issues and prospects offered in this research. Nevertheless, a more typology focused study of rural sites, in which differences between various kinds are highlighted would also greatly benefit the field. Lastly, an explanation of why the impact of some variables deviated in practice compared to the expectations set in theory is needed. This thesis offered several ideas on the reasons behind the observed discrepancies in relation to the impact of soils and terrain. Whilst this sufficed in the context of this research, a more profound exploration of these topics would lead to definitive answers on the organisation of the Roman world. This research has presented a great step towards a more holistic study of the Roman past, in which the most is made of all available data. It is strongly recommended that other researchers in the field build upon the results by adding more in-depth analyses on several factors that so far remain underlit. This will lead to the provision of an accurate and holistic understanding of Roman agriculture and of life in the past in general.

Abstract

The rural world and farming activities were a crucial part of Roman life. The majority of the Roman population was in some way involved in agriculture, meaning that socio-economic developments depended for a large part on what happened in the countryside, away from city life. Much of what we know about the rural world is based on information gathered during archaeological surveying. Over the years, incredible amounts of data have been gathered in this way. However, older projects suffer from issues in consistency and representability. As a result, they are often disregarded in the current academic climate. Nevertheless, much information can still be inferred from this older data, also known as legacy survey data. This research studied the organisation of the rural world through legacy survey data on the hand of the Biferno Valley. This region in central-eastern Italy saw much surveying. The Biferno Valley survey charted many sites in the period of activity, from the 1970s through the 1990s, but suffered from the same problems mentioned above. Therefore, it forms the perfect case-study for this research.

Through the application of a theory-based sequence of predictive modelling, this legacy survey data was used to gain new insights into the Roman rural world. Firstly, ancient literature and other research were used to build hypotheses on the locations of rural farms and villas. These hypotheses were subsequently tested through the archaeological data gathered in the Biferno Valley Survey. Influential variables were assessed and combined into a model which visualises the probability of site presence. Four maps were created in this way, representing two main site types, farms and villas, in two time frames, the Roman Republican and Imperial periods. Results were statistically tested through the legacy survey data. As such, this data functioned as a validation tool for the study of the Roman past. The models were adjusted until each map represented the probability of site presence with significant accuracy.

The results allowed for a reconstruction of the Roman rural world, which gives an indication as to how Roman agriculture was organised. It was found that the impact of most variables fell within expectations. Logically, steep slopes and areas of high elevation were avoided. Locations near waterways, roads and towns were preferred.

Especially in the Imperial period, roads and towns must have been a great force of attraction, especially for villas. Two variables mainly deviated in practice from what was expected. The types of soils that seem to have been preferred point towards a high degree of cash crop cultivation. Similarly, the fact that south-facing slopes were not as popular as initially hypothesised indicates the same thing. It is possible that a large degree of crop rotation was in part responsible for these findings, although this cannot be said with certainty. Regardless, results indicate that the Biferno Valley must have had a strong reliance on trade over larger distances. Cash crops could be exported, whilst imported cereals fed the region's urban population. Within the research area itself, strong spatial and social relations must have existed between owners of farms and villas. This all points towards a highly interconnected Roman rural world. These results thus show that significant gains can be made from the usage of legacy survey data in modern archaeology.

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