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Article

A Historical Analysis of Abandoned Villages in Medieval Sardinia: A Computer Aided Approach for a Sources-Linked Temporal and Spatial GIS Visualization. A Case Study on Sarrabus, Colostrai and Quirra

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Abstract: A number of research projects and a rich literature have dealt with the theme of abandoned medieval villages in Sardinia since the end of the 60s of the last century. Some more or less precise catalogues and reviews of villages in limited territories have been published. Only recently, however, this subject is being addressed in an interdisciplinary manner, combining traditional historical research with the results of archaeological surveys and excavation campaigns, geo-archaeology, toponymy, paleoclimatology. This allows us to have a picture of the landscape and human settlement evolution with its historical changes, conditioned not only by institutional superstructures but also by human and natural traumatic events. Particular attention will be given to the sudden changes that occurred between the thirteenth and fourteenth centuries. To carry out this survey, it is possible to use some very powerful IT tools which, through the aggregation, organization, correlation and management of information, allow the geo-localization of abandoned villages as proven by the documentary evidence. Thus, on this documentation, existing and acquired in the future, is founded the construction of the related information system. The most easy and suitable tools for this purpose are the CMSs (Content Management Systems) which, in association with GIS (Geographic Information Systems) engines, allow spatial and contextual analysis of the settlements, as they were inserted in their territory. This type of tools aggregates different peculiarities of the object of study, supporting a multidisciplinary reading on the argument. The computerized tools, integrated as a system, offer the possibility to implement it, feeding it and correcting it continuously, basing on new acquisitions. In this study, we will examine a historical areal, for which we have a sufficient number of sources available: Sarrabus, Colostrai and Quirra, adding to the geographical visual information, the temporal visual evolution.

Keywords: Settlement Desertion; GIS; CMS; Digital Humanities

1. Introduction

This contribution has been prepared in collaboration by the two authors; however, the second, the third and the fourth paragraphs have been written by Giovanni Serreli (G.S.), the fifth has been written by Luigi Serra (L.S.), who has edited all the maps with QGIS and Adobe® Acrobat Creative Suite® 4, except Fig. 1.

2. A general framework: the changes in the typology of the Sardinian settlement, between high and low Middle Ages

Between late antiquity and early Middle Ages, the settlement situation in Sardinia was evolving and, in a nutshell, it was polarized between the existence of a dozen medium

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and small cities and many small rural settlements linked to the landowning organization of the agro. There were, in fact, some important urban centers of Phoenician-Punic or Roman origin, located mainly along the coasts [1]: Karales [2], Nora [3], Sulki, Neapolis, Othoca, Tharros [4], Cornus, Bosa [5], Uselis, Forum Traiani [6], Turris, Olbia [7]. These cities, in different times and in different ways, underwent substantial transformations and slowly entered into crisis with the disappearance of the classical unity of the western Mediterranean [8], until finally being abandoned and ruralized.

There were also other small coastal towns that, although not real cities, had a great strategic and commercial importance until late antiquity, such as Tibula, Pheronia or Sarcapos, or those of Santa Filitica and Sant'Imbenia (the latter perhaps corresponding to the Ptolemaic *Nympheus Portus*) [9].

The rest of the population lived in small and very small rural demic nuclei scattered in the territory, inserted in the system of rustic villas, close to productive activities and the communication routes of the *cursus publicus* [10], through which, a part of the products of agriculture, breeding and fishing, flowed into the ports to enter the mercantile circuits of the Mediterranean. A part of these small settlements were intimately dependent on the coastal cities and were part of their suburb; with the crisis of the latter, instead, they assumed their autonomy and began to welcome the populations who abandoned the large coastal centers and settled in the safest and most sheltered hinterland; historiography has long debated, until today, on the transformations of the Roman rustic villa in the village between the 4th and 8th centuries [11].

Thus, since the early Middle Ages, the Sardinian rural territory was characterized by the presence of a dense and articulated network of small settlements, inserted in the large latifundia and farms of the Sardinian countryside [12]. Conversely, the ancient cities, while still maintaining for a long time their role or the mere memory of directional political centers and the venue of civil and religious authority, gradually lost their importance, being radically transformed with the construction of monumental defensive works and polarizing their importance around the first Christian places of worship; it was the beginning of those remarkable transformations that culminated with an inexorable abandonment, at the end also of the representation of power, in different times and ways for each of them.

The estates and imperial farms and, in some cases, even private ones, passed unchanged from the Roman *patrimonium Caesaris* to that of the emperors or Byzantine officials, even through the vandal domination, without major changes in their productive and social structure; instead, the patrimony of the Church was assuming greater consistency by virtue of the increasingly marked evergetism of private individuals and of the emperor himself [13].

With the large estates, also the mining areas with their settlements, by now totally of imperial property and divided into *regiones*, passed to the imperial Byzantine patrimony [14].

Beyond the institutional upheavals, after the end of the Roman control over *the Provinciae Sardiniae* and subsequently to the occupation, indeed not very incisive, of the Vandals (456-534 d.C.) [15], a certain reorganization of the human settlement in Sardinia was probably caused also by the so-called small glacial age which, starting from the VI century, upset for a few centuries the climatic conditions in Mediterranean Europe and, therefore, also in Sardinia [16]; layers of alluvial deposits that obliterated the late ancient and vandalic phases (6th-7th century AD), above which new constructions were built at a later date, were also highlighted in the excavation of the site of Santa Filitica [17].

The most striking effects of the drastic and, to read the coeval sources, dramatic climatic changes were suffered by the coastal cities of ancient origin, which were slowly abandoned, first by the inhabitants, who sought refuge in more internal areas, and subsequently also by the civil and religious authorities [18]; also because the populous coastal cities were those most exposed to the dangers coming from the sea, starting from the end of the Roman Empire and, above all, after the Arabs broke into the Mediterranean [19].

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For the rural settlements, on the other hand, the impact of the small glacial age of the 6th century and of the dangers from the sea was less intense due to the same precariousness of the material and social structures and to the lesser dependence on Mediterranean trade. There are numerous attestations of continuity of settlement between Roman villas and Vandal and Byzantine settlements, with small variations in the forms of distribution in the territory, but often maintaining the same productive regime had in previous centuries, although no longer aimed at supplying the coastal cities, but devoted to self-consumption.

Indeed, these small rural settlements, especially those located in the immediate hinterland of the ancient cities, paradoxically drew new energy and welcomed the populations that were abandoning the large coastal inhabited centers in search of less exposed places and less pressing responsibilities [20].

There are many cases in which the results of archaeological excavations have attested substantial continuity of population since the Nuragic era or, in any case, frequent reoccupations of protohistoric or ancient buildings. It is, by way of example only, the case of Byzantine frequentation in some quarters of the *Su Mulinu* in the Villanovafranca Nuragic complex; it is a territory in the historical region of Marmilla, intensely occupied by prehistoric, protohistoric, Punic, Roman and Byzantine, as well as medieval settlements; as far as the Byzantine presence is concerned, are witness to this, in addition to the numerous toponyms of clear Byzantine ancestry and archaeological discoveries made in the past [21], the recent excavation campaigns in progress, conducted by Mauro Perra in some sectors of the *Su Mulinu* Nuragic complex. It is important to point out that, just a few hundred meters from this site, the ruins of a small castrense control structure, are under study, certainly linked to the settlement of *Su Mulinu*, probably attributable to the 7th and 8th centuries and which may have been used until the dawn of the Arborèa "Judical" Kingdom [22].

Also in the Byzantine Province of Sardinia, probably, the process of «Shift to Land» was felt following the collapse of the Roman Empire of the West and its organization on a fiscal basis; but this substantial economic change, in which the management of the land became the true requisite of power, in Sardinia we can see it only with the 7th and 8th centuries, as a result of the reorganization of the Byzantine administrative apparatus that with difficulty overcame previous crises [23]. Consequently, also in Sardinia there was a crisis of the circulating currency in the centuries of the early Middle Ages [24].

Obviously, the power structures and references have changed: no longer the Empire or the great Roman landowners, but the new Vandal ruling class first and Byzantine then, without forgetting the local Church that was acquiring a substantial part of the land heritage [25].

The speech, however, becomes more complex for the inland mountainous areas of the island, for which the absence of sources, even up to the entire medieval age, and the sporadic nature of archaeological interventions, does not facilitate the proposal of descriptive hypotheses, so much so that both the articulation and the forms of human settlement are almost unknown, at least during the so-called dark ages [26]. We must imagine, in a totally hypothetical way, the persistence of the settlement articulation inherited from the Nuraghic protohistory and the reuse of the same structures [27].

In these small centres, starting from the areas close to the coasts and gradually inward, Christianity spread and took root, especially in the Vandal era thanks to the action of Christian bishops exiled from Aryan Africa, and later in the Byzantine era [28]; the spread of Christianity also in Sardinia was favoured by the ability of the new religion to overlap with old cults, sometimes incorporating its places; even the alleged strong resistance of the internal areas of Barbagia to the spread of Christianity is now denied by the most recent archaeological data [29].

Moreover, Christianity was one of the factors that most influenced the transition from the rustic villa to the medieval village in some way endowed with its own legal personality. As many of the archaeological excavations have shown, the first small churches, often

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private, were built in these settlements, thanks to the owners' evergetism, re-adapting old structures of the villa no longer in use, usually the thermal baths ones. And just with a letter addressed «*nobilibus ac possessoribus in Sardinia insula consistentibus*» Pope Gregorio Magno in May 594 invited the owners of Sardinia to take action to convert to the new religion all the rural populations who lived and worked in their lands (Gregorio Magno, Ep. IV, 23) [30].

Considering the almost absolute absence of descriptive written sources of the landscape and settlements, the existence of late ancient and early medieval villages is often attested by the survival of remains of early Christian buildings or by the permanence of the cult or the ancient toponym; to reconstruct the settlement structure, other data can also be taken into consideration, such as for example archaeological ones and, in particular, the discovery of early medieval coins in relation with other archaeological and documentary testimonies and with the existing roads [31].

These churches, with their cult, often built in sacred places or previous structures and always using divested materials, gave a first marked identity to the villages that overcame the crises (political, social, economic, climatic) of the 5th, 6th and 7th centuries; we can hypothesize – in parallel to what proposed by Paul Arthur for the Salento [32] – that during the 8th century each settlement has acquired its own identity, its own name and the settlement structure of villages (ville), farms based in public, ecclesiastical or private estates (*curtes*, *domestiae*, *domus*, *donnicaliae*, *ecclesiae*) has stabilized, as they will emerge later with the documentation of the 11th and 12th century.

Otherwise we cannot understand how – with the appearance of the first epigraphic and documentary sources [33] thanks to which we have the certainty that in the Sardinian territory, by now unhooked from the Byzantine Empire, four state entities had formed (between the end of the 10th and the middle of the 11th century), known as 'Giudicati' having the form of a Kingdom: Càlari , Torres, Arborèa and Gallura (Fig.1) [34] –, several of their institutional, social and economic aspects appear already defined; in particular, those concerning the organization of the territory and the settlement structure:

- a territorial organization in administrative districts is functioning (*curadorìas*);
- the villages with their name, well defined in their public or private essence, are attested, articulated in a network of small settlements, precisely called by the sources *ecclesiae*, *donnicalie*, *domus*, *domestìas*, *curtes* and *villas*, in symbiosis with the resources of the territory in a regime of self-sufficiency [35].

These first documents, which with the 12th and 13th centuries became more and more dense, among other news tell us therefore that in the early 'Judical' period the settlement articulation was already permanently formed. The sources precisely define the various nuclei and their economic as well as institutional role within the latifundia in the 'Judical' organization; unfortunately, however, the terminology used to define each type of settlement has not yet been fully understood.

In each of the Medieval Sardinian Kingdoms, these demic nuclei appear to us to be well organized, perfectly integrated in the institutions and in perfect symbiosis with the resources of the territory in a regime of self-sufficiency and literature has now registered the known attestations of these numerous medieval settlements, at least in the current state of our knowledge [36]. Which means that a certain organizational and settlement continuity has been maintained at least since the 8th century and up to the fully medieval age, with minor modifications or translations of the site; those that had been the imperial estates belonging to Byzantium – now too far away – had passed to the availability of the families who had inherited the power and now governed the territory in a sovereign manner. Land tenure became the main requirement of power.

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Figure 1. The four Medieval Kingdoms of Sardinia (Casula, F. C. *La storia di Sardegna*, Carlo Delfino Editore: Sassari, Italy, 1994, vol II 444)

This long-lasting vision, where a substantial continuity emerges, with small and imperceptible changes, must however take into account also the contingent events of the *histoire événementielle* that could cause sudden or catastrophic changes in the slow evolution of the settlement structure; such important phenomena cannot be explained by relying only on the analysis of the phenomena and developments of the long term history, underestimating or even not considering the incidence of particular events, capable of giving meaningful and lasting turns to the ordered course of events. In our case, according to the great medievalist, it is necessary to consider the importance of the eventual or con-

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junctural history, of micro-history, paying attention to «the great geographical and temporal differences» with which these events affected the history of the island, creating continuity solutions in the development of its events [37].

One of these events, at the dawn of the 11th century, was the enterprise and the temporary invasion – between 1015 and 1016 – of the army led by the famous Mujāhid ibn Abd Allāh al Āmiri, prince of Denia and lord of the Balearics, in some parts not yet specified of Sardinia. It is very probable that, in the places where these events took place, dramatic destruction occurred in the small villages involved, probably also affecting the settlement dynamics of those places and causing more or less long abandonments. Unfortunately, however, the already scarce documentation on the feat does not provide us with any details on the territories involved, on the dynamics and impact of this conquest on the settlement framework [38].

Beyond these unspecified and traumatic contingencies, in each Medieval Kingdom the settlement system appears already well defined in the second half of the 11th century in forms certainly suitable and functional to the type of economy of self-sufficiency. The organization of these rural settlements has been defined as a '*domus* system', that is a complex system of vast properties founded on small and large farms with a servile base [39]. «One is mistaken if one thinks of a merged and centralized organization: in reality, the *curtis* is a theoretical and managerial unit in which, especially from the 8th to the 11th century, dispersed land presences are organized» [40].

These properties were of the State (*Rennu*), of the Church, or of the families (*pegugiare*) of the richest and most influential in society and of the same reigning families in the four Kingdoms of Càlari, Torres, Arborèa and Gallura [41]. They were side by side with a series of settlements (*villas*) having a sort of legal personality and their own representatives in State institutions.

The inhabitants of these demic nuclei produced the bare essentials for their feeding, integrating the products of the land and of the breeding with what could be obtained from the resources of the *saltus*, of the woods (wood, fruits, game). How much surplus was produced, was destined by the landowner owners – whether they were the Church, the wealthy elders, the reigning House itself or the State heritage – to the construction and maintenance of public buildings such as castles and, above all, churches; those splendid buildings Romanesque, some of which the Sardinian territories still preserve and that we find scattered in the countryside: they were nothing more than the parish churches of numerous rural inhabited nucleuses today disappeared.

This articulated system, in equilibrium with the natural resources and the economy of the territories, was gradually rationalized also thanks to a certain planning initiative of the settlement or, at least, of promotion of the population even in almost uninhabited areas, sporadically carried on by the sovereigns of each of the four Kingdoms, both with the foundation of *villenove*, and with donations to Benedictine monastic bodies or, through religious foundations, to the main mercantile powers of the western Mediterranean [42].

The opening of the Sardinian Medieval Kingdoms to the markets of Pisa and Genoa, between the 12th and 13th centuries, however, it caused a sort of trauma, an upheaval in the by now established settlement system that developed in the institutional and economic channel of the 'Judical' States, which was the reflection of a consolidated economic and above all social organization, inherited from previous centuries. This subversion manifested itself slowly, as the countryside gradually repopulated; in the beginning, without substantial institutional changes, the Republics of Genoa and Pisa, together with the most influential families of these municipalities, got their hands on the productive centers and the raw materials of the judicial campaigns [43].

With the inclusion of products from the Sardinian countryside in the large Mediterranean markets, every effort was made to increase the production and therefore the earnings of the merchants [44]; with this system, Pisa unhinged the '*domus* system', breaking that delicate balance in which the various settlements (*ecclesiae*, *curtes*, *domus*, *domestias*, *donnicalias*, *ville*) were articulated, each with its own role and its own peculiarities within

the larger land and State system. Consequently, the delicate socio-economic mechanisms between population and territory that had been in force for centuries, were also upset [45].

The effects of this trauma in the natural evolution of the settlement framework, multiplied starting from the second half of the 13th century when, with the end of three of the ancient and autochthonous Kingdoms – Càlari in 1258, Torres in 1272 and Gallura in 1288 – the Municipal Republic of Pisa directly controlled these territories and incorporated them among its domains overseas [46]; to keep the ancient 'Judical' civilization alive, only the Kingdom of Arborèa remained, until 1409-1420.

The increase in the production of agriculture and livestock and, consequently, of the population in rural villages, led to the crisis and the breakdown of the social system and, therefore, to the servile emancipation [47]. Furthermore, the attraction capacity of the new cities, born or developed in the 13th century thanks to the increase of the mercantile activity and to the founding will of the Pisan lords, sometimes at the sites of the ancient cities abandoned in the high Middle Ages, should not be overlooked. The people who, attracted by the new opportunities for enrichment and emancipation, went to live in the new urban centers of *Castel di Castro* of Cagliari [48], Oristano [49], Sassari [50] or *Villa di Chiesa* [51], or in their appendices, abandoned or left depopulated the most fragile and distant villages from the new directional, institutional or economic centers.

This new social mobility, activated by the Mediterranean opening of the markets and by new industrial activities, such as extractive and mining in the *ex curadorìa* of Cixerri, is well documented in the periodic fiscal censuses that the municipal Republic of Pisa carried out in its Sardinian domains [52].

From these fiscal censuses another aspect of primary importance emerges: Pisa and its officials considered in the same way all the settlements that were subjected to the fiscal levy: it is no longer existing or, at least, perceptible in these sources the distinction between *ecclesiae*, *curtes*, *domus*, *domestias*, *donnicalias*, *ville*; it is very clear, instead, in the previous documentation of the four Medieval Kingdoms (11th-13th centuries). The destructuring of the previous settlement economic system, evident in the documentation of Pisa that attests the villages almost exclusively as *villas*, is now a done thing; there was no longer that complex and articulated '*domus* system' in which the role of each settlement, small or large, in the context of an economy devoted to self-subsistence within the latifundium was well defined. This new and simpler settlement framework was functional to a more careful control of the productive potential of the territory and therefore of the collection of taxes; it allowed a wider circulation of resources and men; led to the formation of more substantial inhabited centers to the detriment of those weaker and peripheral with respect to the lines of commerce. Ceased three of the four Medieval Kingdoms in the second half of the 13th century, the Pisan rulers in their territories had imposed new economic models and a new social structure that led to more or less profound changes in the settlement structure.

Furthermore, the urban centers of Castel di Castro of Cagliari, Sassari, Villa di Chiesa, Alghero, Castelgenovese, Bosa and, of course, Oristano (capital of the ancient Kingdom of Arborèa) had developed and acquired a leading attraction.

This is the panorama that the Infante Alfonso troops faced in 1323 when they began the conquest of the Pisan territories on the island; the Catalans, moreover, were in broad terms already aware of this articulation, thanks to the news of the spies and diplomatic activity.

This knowledge allowed the Aragonese ruler James II, through the Infante Alfonso, to outline, even before the military operations, the organization to be given to the territories he was about to conquer, which was based on the Royal Cities, on a State administrative apparatus and, for the rural areas, on the feudal assignment of the revenues of the various villages to those who, directly or indirectly, had participated in the conquest of the Pisan territories on the island [53], transformed from June 19, 1324 in the Kingdom of 'Sardinia and Corsica' pertaining to the Crown of Aragon [54].

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In fact, it was expected that the fiefs would be assigned to those who, with men, means and money, had helped the Crown in the war operations and in the realization of the Kingdom of 'Sardinia and Corsica'. Far from the values and function of feudalism of the origins in the rest of Europe, at first these fiefdoms were nothing more than the granting of rents to one or more villages with the territory of their relevance (*beneficio*) to reward those who had contributed to the conquest. The *beneficio*, combined with the other classical elements of feudalism, made these concessions a sort of division of the territory between various lords who, in exchange, would have had to guarantee a certain stability and military garrison to the newly conquered Kingdom [55].

However, the foreseen feudalization of the territory proved to be very difficult and the problems were considerable, above all because they were made without taking into account the territorial realities of belonging and the old medieval districts. If until then, even under Pisan control, in fact, the administrative districts of 'Judical' origin, which reflected geomorphological and productive differences, the Sardinian feudal cases of the Crown of Aragon were made without taking into account these realities that were systematically dismembered.

In other words, the territorial organization which for centuries had kept together the villages in the various and different sub regions of every single medieval Kingdom, in an economic and social balance that had lasted for centuries, came to be definitively disarticulated; this brought devastating social consequences to the rural populations that manifested themselves with the drastic and to some extent violent depopulation and with the abandonment of numerous villages in the territories just conquered.

What highlighted above could only trigger dramatic consequences from an economic and settlement point of view [56]: the high fiscal pressure and the immutability of the fiscal contingents established for each village, unchangeable even in spite of the economic crisis and the demographic decrease caused by the wave of plague in 1348 and the state of precariousness and war between Kingdom of Arborèa and of 'Sardinia and Corsica', caused the depopulation and, therefore, the disappearance of numerous small villages, the last inhabitants of which preferred to move to the more populous ones to divide the burden of taxes with their inhabitants [57]. Actually, it was also the war strategies of the contenders in the field - who in the second half of the 14th century were openly contending for total control of all of Sardinia - which in many cases modified the settlement structure in some areas of the island, devastating some settlements or imposing the forced displacement of entire communities to other villages for their military strategies [58].

But, in addition to the institutional and, therefore, also economic and social causes, brought by the Pisan influence first and by the Catalan occupation subsequently, with the birth of the Kingdom of 'Sardinia and Corsica' and the imposition of the feudal regime in the conquered rural territories, and in addition to the contingent causes of wars and epidemics, recently the role played by geoarchaeological and paleoclimatic factors is also taken into consideration as contributing factors to rural depopulation and the abandonment of numerous villages [59]. It is known that the last years of the 13th century were characterized by a very high rainfall, ascertained at least in the area of the Balearic Islands [60]; but it is very probable that this rainfall outside the norm has also affected neighboring Sardinia at the same time, contributing to create those negative conditions which, together with the effects of feudalisation, the continual state of belligerence and epidemics, caused the abandonment of the most fragile villages until the disappearance of more than half of the settlements in the territories belonging to the Kingdom of 'Sardinia and Corsica'.

In summary we can affirm that the retrograde and anachronistic feudal regime imposed by the Catalans in a completely unprepared reality to absorb it, perhaps accentuated by negative climate changes for the rural economy, caused so many upheavals and dramas to the rural populations and gave the coup de grace to the socio-economic system and to the type of settlement organization intimately linked to it, that had arrived almost unchanged from the high Middle Ages, causing the abandonment of over 50% of the villages in the territories of the former Medieval Kingdoms of Càlari, Torres and Gallura

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[61]. In the Kingdom of Arborèa, which survived until the first decade of the 15th century, however, the 'Judical' organization resisted the first impact of feudalism, so much so that the settlement network made up of small villages scattered throughout the territory and close to each other, survived the crisis of the 14th and 15th centuries and has come almost unchanged up to the present day [62].

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3. A case study: the south-eastern coast of Sardinia (Quirra, Sarrabus and Colostrai)

3.1 Case study, methods and sources

By way of example we can consider the territories of Quirra, Sarrabus and Colostrai, in essence, the south-eastern coast of Sardinia (Fig. 3), which offer considerable insights and interesting historical information and allow us to draw a picture that, broadly, allows a glimpse of the evolution of settlement realities in Sardinia during the Middle Ages, as well as the social and economic frameworks that animated them.

Our analysis is based on documentary sources, sometimes from a later period, on archaeological finds and on toponymy. The goal is to verify whether the abandonment of most of the villages in these territories occurred due to Ottoman raids and from North Africa in the 15th and 16th centuries [63] or for natural or contingent causes before the 15th century.

3.2 The chronological evolution of the settlement in the south-eastern coast of Sardinia (Quirra, Sarrabus and Colostrai)

Intensely populated in Roman times, the south-eastern coast of Sardinia was crossed by the important artery that from the port of Tibula led to Caralis [64]; these territories were animated by an intense economic activity that found an outlet in the port center of Sarcapos, at the mouth of the Flumendosa. The demic nucleus of Sarcapos, to be located near Santa Maria di Villaputzu, was the most important and survived – at least in the collective memory of the populations that inhabited these places – even after the end of Roman control in Sardinia and until the Middle Ages, so much to give its name to the same *curadorìa* of Sarrabus, in the 'Judical' Kingdom of Càlari, and therefore to the geographical subregion [65].

Unfortunately, little we know about the organization of these territories and the people who populated them during the centuries of the early Middle Ages; the archaeological interventions in the territory, mostly of an urgent nature, have highlighted some early medieval settlements such as, for example, the one referable to the 8th century in *Cirredis*, at the foot of the Quirra hill [66] and an early medieval *castra* [67]. These demic centers made reference and still found the commercial outlet in the port of Sarcapos, *Sarpach* in the *Cosmographia* of the Anonymous of Ravenna [68], despite the geopolitical and economic upheavals and the ever increasing difficulties for trade and navigation.

When, in the second half of the 11th century, the historical documentation began to shed light on the Medieval Age in Sardinia, the territories examined were already fully included in the organization of the 'Judical' Kingdom of Càlari [69]; in the 11th and 12th centuries the districts (*curadorìas*) of Colostrai and Ogliastra are already attested; in the following documents will be attested the *curadorìas* of Sarrabus, Colostrai and Quirra [70]. But what were the settlements in these territories in the first decades after the year 1000?

Some information is found in two documents from the second half of the 11th century. In a donation of the king of Càlari Orzocco-Torchitorio III (1058-1081) [71] in 1066/1074, some *villae* with *sus liberus de paniliu* are granted to the Archbishopric; among these is the *villa de Archiepiscopo de Tolostrai*. This attestation allows us to know that in 1066 there was a village inhabited by *liberus de paniliu* called *de Archiepiscopo* in the *curadorìa* of

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Colostrai, probably located behind the homonymous pond in the countryside of Muravera; the *liberos de paniliu* were semi-free men bound to certain services or corvées in favor of the *Rennu* (State) or, in this case, of the Archbishop to whom they had been granted; it seems evident that the toponym of the *villa* recalls some connection with the Archbishop who perhaps founded it or, in any case, already held some rights there [72].

It was certainly not the only settlement because in the well-known Calaritan vellum in Greek characters of 1089, with which the King of Càlari Costantino-Salusio III (1081-1098) confirmed the ample donations made by his father to the church of San Saturno, were also donate the «*partzones mias ... in Platages*»; we believe that the portions of the possessions in Platages are to be placed in the *villa Platais de Castiadas*, otherwise attested only in the 14th century and located at a short distance from the Castiadas prison, 5.5 km from the sea [73].

From these documents we can deduce that in the 11th century, on the south-eastern coast of the Kingdom of Càlari, there were at least two villages, linked to the court and located near the coast: *Archiepiscobu*, near the Pond of Colostrai, and *Platages* (*Platais*) at about 5 kilometers from the sea, in areas that lent themselves to productive exploitation. Contrary to what is wearily repeating too much literature, the coasts were still populated and scattered with small settlements with free inhabitants who lived on agriculture, pastoralism or fishing, semi-free, such as the *liberus de paniliu*, and in the servile state (Fig. 4).

As can be deduced, there were vast possessions belonging to the *Rennu*, to the State, so much so that in 1104 the regent Torbeno de Lacon-Gunale donated four *donnicalìas* «*quarum una est in Ogliastro, altera est in Tolostra, et tertia in Treche, et quarta in Tamari*» to the Opera of Santa Maria of Pisa, with all their appurtenances of servants, handmaids, animals and vineyards [74].

At present it is impossible to specify the location of these four benefits; however, two *donnicalìas* were located in the *curadorìas* of Ogliastra and Colostrai, while the other two toponyms are otherwise unknown.

Another document from 1114-1120 could refer to our territories; the document is one of the so-called vernacular vellums of Cagliari, preserved in the Archiepiscopal Archive of Cagliari. It is a large donation of King Mariano-Torchitorio IV to the church of San Saturno of Càlari; the boundaries of the donated possessions passed for «*su pizzariu de Murabera*» and for «*jenna de Listincu*» [75]. If they referred to Muravera and *villa Lustincho*, located under the Castle of Quirra, they would be the first attestations of these two villages in the *curadorìas* of Sarrabus and Quirra, otherwise documented only from 1316.

A document of 1120 mentions, instead, for the first time Villaputzu: it is the exchange with which the King of Càlari Mariano-Torchitorio IV – in exchange for some *domus* previously donated to the Chapter of the church of San Lorenzo in Genoa – donated other possessions, including the domus of «*Sancta Victoria de Villa Pupia cum servos et ancillas et cum mansiones et saltus et semitas et omnia cantu bi pertinet*» [76].

Another villa was probably built, around the 13th century, near the sanctuary of San Priamo on a prehistoric and punic sanctuary dedicated to the cult of waters and still incorporated therein; most probably it was *villa Major*, attested since 1316 and located between the sanctuary and the Pond of Colostrai [77].

Also from the Pisan fiscal register of 1316 we learn of the existence of *Plassas Dabis* «*quod olim fuit ville et nunc est orrina vocatum Plassas Dabis*» (a plowing land that had once been a village); evidently this settlement, located along the Piccocca river to the southwest of San Priamo, had been vital in the 'Judical' period and now deserted in 1316 [78]; about the location of the villa, in addition to the documentation contained in the envelopes relating to the Quirra fiefdom in the State Archives of Cagliari (A.S.C.), we also find the toponym (*Pranu is Abis* and *sa Conca de is Abis*) [79]. Its toponym clearly refers to the breeding of bees, a further source of economy and nutrition for these villages, testifying to the variety of productive activities in the 'Judical' Middle Ages.

But there were certainly other settlements that some documents of the beginning of the 13th century indirectly let us know: among the witnesses of a donation to the bishop

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of Suelli – authorized by King Barisone-Torchitorio VI (1214-1218) and by his wife Benedetta of Lacon-Massa in another vellum preserved in the Archiepiscopal Archive of Cagliari – dated Friday 6 November 1215 «*Comida Anastasi, preidi de Sancta Aleni de Tolostrai et Jorgi de Calagonis, preidi de Santu Arcangelu*», are quoted [80]: it was the priest of *Sancta Aleni* in the *curadorìa* of *Tolostrai* located in the locality of *Su Reu*, currently in the countryside of Maracalagonis, where the ruins of a nuraghe and church dedicated to Sant'Elena are still attested; and of the priest of the church of Sant'Arcangelo, in the aforementioned *Villa Archiepiscopi*. The first was a village pertinent to an ancient mining area perhaps still cultivated at that time.

These priests found themselves congregated in the church of San Saturno of Calari for the feast of the Saint which is still celebrated on October 30th. In fact, in a document of the same tenor of the following day, Saturday 7 November 1215, other important figures are mentioned again who, indirectly, attest to or confirm the existence of other villages: «*donnu Mariani de Quartu, preidi de billa de Pubuççi … donnu Turbini de Lacon, curadori de Colostrai … Bera Orrunkina, filia de Mariani Orrunkina, serbu suu de da billa de Kirra*» [81].

From this document of 1215, we have the confirmation of the existence of a village called *Pubuççi*, to be identified with the current Villaputzu in the *curadorìa* of Sarrabus; the *curadorìa* of Colostrai is also remembered with the mention of its *curadore* (district administrator), *Turbini de Lacon*, an important figure of the Calaritan court. Moreover, the village of *Kirra* or Quirra is mentioned for the first time, in the homonymous *curadorìa* of which it was, probably, the capital; located near the church of San Nicola – Romanesque building dating back to the last quarter of the 12th century [82] – its territory extended up to the churches of Santa Maria su Claru, Santa Barbara, Sant'Adi, Sant'Elena and San Michele. The village was dominated by the impervious hill (*Mount Cudinas*, 296 m a.s.l.) on which stood the castle of Quirra, a fortified fortress probably built to defend the eastern border of the Kingdom of Càlari, to watch over the important road that ran along the coast and to control the fertile territory of Quirra and its outlets to the sea; it is first mentioned in an act written in the *curia* of Queen Benedetta in the castle of Quirra 1218 [83]. In 1217 a certain «*Arççocu Loki, preidi de Kirra*» [84] is mentioned among the witnesses of a transaction of servants «*in Sarrabus*» carried out by the bishop of Suelli (Fig. 5).

Another castle, that of Malvicino, controlled the Sarrabus plains and the road along the east coast; it is remembered only in 1316 as already destroyed [85], perhaps in 1309 when the Pisans reorganized the defenses of their Calaritan domains, breaking down what was no longer defendable. It was located in the territory of the medieval *villa Pupussi*, south-west of the present town, in a place still called *Su Casteddu*; the site would deserve careful archaeological investigation to verify the possible pre-existence of 'Judical' fortifications.

Another document dating back to 1215 dates back the attestation – among the witnesses of a donation by Queen Benedetta to the Diocese of Suelli – of a certain «*Comida de Serrabura portus*» [86]; it could be a royal officier responsible for the management of the port of Sarrabus, the ancient *Sarcapos*, still operational as evidence of the commercial traffic that continued to link the Kingdom of Càlari with the Mediterranean.

In the *curadorìas* of Quirra, Sarrabus and Colostrai there were, certainly, other villages, recalled from the sources of the 14th and 15th centuries. Among these, perhaps the *oppidum Tronae* mentioned in the 16th century and of which we know nothing else; if existed, it was located in the countryside of San Vito near the *Trona* nuraghe, almost on the border with the *curadorìa* of Quirra [87]; a certain Leonardo Quartana of the *villa* of Turne attended the first Parliament of the Kingdom of 'Sardinia and Corsica' (1355); if it were the same *oppidum Tronae*, it would be the only *villa* of the former *curadorìa* of Sarrabus represented in this assembly [88].

Perhaps, he had to suffer directly the dramatic consequences of the sieges to the castle of Quirra during the wars between the Republic of Pisa and the Kingdom of 'Sardinia and Corsica' and between the latter and the Kingdom of Arborèa.

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In any case, this vast territory, which today may seem poor in populated centers and in some places almost abandoned, in the Middle Ages was constellate by numerous small settlements, populated by a few dozen inhabitants, which based their economy on the cultivation of the land, breeding, mining activities, fishing and, probably salt. It was the type of settlement that best suited the territory and the economy of the 'Judical' Calaritan society: small villages that lived in symbiosis with the resources of the territory in a regime of self-sufficiency. Even considering the recurrent natural catastrophes, droughts, floods, epidemic crises and famines, common throughout the known world, we can say this territory offered the necessary to live, even at the price of the hard work in relation to the archaic means of production (Fig. 6).

A more definite picture of the settlement in the *curadorìas* of Quirra, Sarrabus and Colostrai can be obtained from the more numerous and detailed documents dating back to the 14th century, when the 'Judical' Kingdom of Càlari was no longer in existence and its territories were already confiscated by Pisa that from here drew most of the wealths; in fact, in 1258, a pro-Pisan coalition destroyed the capital Santa Ilia and ended the Calaritan Kingdom, whose territory was dismembered: the curadorìas of Quirra, Sarrabus and Colostrai were occupied by the Visconti, at the head of the neighboring Kingdom of Gallura [89]. The export to the Mediterranean markets took place from the ports of *Ogliastra*, active until the late 15th century and perhaps corresponding to today's Arbatax, of *Sarcapos*, and of Quirra – not far from the homonymous castle, as the sources of the middle of the 14th century affirm, ships stopped over coming from the ports of the peninsula directed to Castel di Castro [90] – as well as from other coves accessible to the mercantile wooden boats of the Middle Ages.

To reconstruct the settlement situation in these territories at the beginning of the 14th century, we can count on a Pisan fiscal census of 1316 referring to the *ex curadorìas* of Sarrabus, Colostrai, Quirra and Ogliastra [91]. A preliminary consideration that can be made from the reading of this fundamental document is that the economy of the villages of the south-eastern coast of the Calaritan was naturally based on the products of breeding and cereal production (wheat and barley), but also, and above all, on the exploitation of the resources of the Colostrai and Ogliastra ponds, on the cultivation of the vine and on the wine production and trade. There were many vegetable gardens and vineyards, many of which also include fruit trees; moreover, there are numerous references to the taxes that fall on the production and sale of wine that show us how widespread viticulture was. Another activity subjected to taxation was that of fishponds which, during the direct rule of Pisa, was contracted to entrepreneurs usually living in Cagliari; if this activity, as it is likely, was practiced also in the previous centuries, the inhabitants of *curadorìa* of Sarrabus near the coast had had the possibility to exploit also the products of fishing, in the open sea or in the ponds along the coasts.

The *curia Sarabi*, that is the former *curadorìa* of Sarrabus, from 1288 incorporated in the overseas possessions of the Municipal Republic of Pisa, was roughly formed by the territories, north of *Rio Picocca*, of the current Municipalities of Muravera, San Vito and Villaputzu. The villages that made it up were: the four villages of Cortinia, Ygali, Orrea, Ulmus, united in the *Scolca* of Orrea, and then Muravera, Petrera, Carruti, Sorrui and Villapùtzu, the most important center of the district.

The *villa* of Muravera (the toponym consists of Sardinian *mura* = 'tree and fruit of the mulberry tree', and *vera* = 'cultivated, edible') extended between the churches of Sant'Anna and San Nicola, his parish [92]. If we do not want to consider the uncertain references of 1089 and 1114-1120, mentioned above, it is attested with certainty for the first time in 1316, in the *Murahera* form, when this village was united, in the payment of taxes due to Pisa, to that of Petrera, located at a short distance to the east. The document also gives us the unique list of the inhabitants of the two villages, without distinguishing their origin, the amount of taxes due and, indirectly, also the activities carried out [93]; it was a small village with no more than forty inhabitants. The two villages of Muravera and Perdera were very close, connected by a road, but not yet joined together, so much so that

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in the inventory of the revenues of the Mensa Arcivescovile of Cagliari, dating back to 1365, they are still separated [94]. They joined certainly around the beginning of 15th century, when the devastating effects of the recurrent plague epidemics, of the climate worsening and of the state of continuous war between the Kingdom of Arborèa and the Catalan-Aragonese Kingdom of 'Sardinia and Corsica' were felt, but above all the effects of the fiscal pressure in the feud of Quirra, belonging to the Carròs, to whom the Sarrabus villages were given in fief in the first half of the 14th century.

The *villa* of Petrera, instead, it extended around the south-eastern outskirts of present-day Muravera, between the churches of Santa Lucia (built in the 13th century) and the Vergine d'Itria; another church of the *villa*, perhaps more ancient, was dedicated to Santa Cecilia. The toponym refers to the abundance of stones, being close to the banks of the Flumendosa river.

The territory of Muravera and Petrera should not have been very extensive, suffocated by that of Sorrui in the south-east and those of Villaputzu and the *scolca* of Orrea in the north; in fact, in the Pisan composition of 1316 many gardens, vineyards or arable land, as in the other villages, are not remembered.

The *scolca* of Orrea, in fact, was formed by the *ville* of Cortinia, Ygali, Orrea and Ulmus, physically separated but administratively united [95]; the institution of the *scolca* – here also handed down from the toponym *Nuraghe Scrocca* just north of San Vito – was a relic of the 'Judical' *scolca*: the lands of each Calaritan village were protected by an armed guard of men from small groups of aggregate ville, generally in number of four, commanded by a *majore de scolca* with tasks of police and control over minor officials [96]. The *scolca* of Orrea were located around today's village of San Vito. Among their churches are cited San Lussorio and Santa Maria, which still exist.

Among these *ville* the most important was Orrea; it owes its name to the Latin *horreum*, that is a grain store: in it, perhaps, the wheat harvested in the territory was piled up. Its name is perpetuated by a district of San Vito, near the church of *Santa Maria Orrea*; Ulmus, on the other hand, was to be located near the church of San Vito. Orrea named the *scolca*, and had a longer life. Indeed, the 18th century (1784) copy of the feudal concession to donna Violante Carròs of 1505, listing the *ville* of the Sarrabus, identifies *Villa Putzu* with the ancient *Orrea* and *San Vitto* with the ancient *Perdedo* [97]. Instead, a document dated 1606, drawn up during the pastoral visit desired by Archbishop Desquivel, lists the *ville* of Muravera and *Santo Vitto y Horri* [98], belonging to the Archdiocese of Cagliari.

However, these four villages were inhabited, in total by about seventy inhabitants; the territory, on the other hand, was very extensive and, from the *Nuraghe Scrocca* and from the locality *Gennadorria*, in the north, reached the locality of *Sant'Antioco*, very close to Muravera.

The *villa* of Carruti, instead, was located in *Terrudi*, about 2 km SSW away from San Vito. It was very populated, compared to the other villages mentioned so far; in fact, in the 1316 census no less than seventy inhabitants are attested. Being close to the banks of the Flumendosa river, its territory was also suitable for the cultivation of vines, often associated with fruit trees, especially figs and quinces [99].

The village of Sorrui was instead located in the place of the same name, near *the Torre della Porta* or *dei Dieci Cavalli* (Tower of the Door or of the Ten Horses) and near the church of San Giovanni – of which the ruins are barely visible today – and in the vicinity of those of Santa Maria, Santa Marta and San Giorgio [100]. The high number of churches should not be surprising, because in 1316 Sorrui appears to be a very populated village: between one hundred and one hundred and fifty inhabitants. One of the *ville* closest to the sea in this district was also among the most populated and economically viable, thus in stark contrast to the reconstructions of those who argue that the Sardinians abandoned the coasts after the fall of the Roman Empire.

Also the territory of Sorrui was very vast and, besides having numerous plowing lands and vineyards with fruit trees, it was suitable for activities related to fishing, in the open sea or in the ponds near the *Torre dei Dieci Cavalli*. In the register of 1316 a land is

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surveyed «*in loco dicto Muro inter Aquas*»: it is a reference to the wall constructions that started from the carriage door, above which, in the 16th century, the *Torre dei Dieci Cavalli* was built [101], and that perhaps served to contain the waters of the pond but also to protect the activities that took place there. In the village also resided *Meuccius de Vico* and *Gomita Spanus*, *burgenses* of Castel di Castro, who had obtained the contract for the collection of taxes related to any trade or activity in all the former *curadorìa*: on the sale of animals, wheat, barley, wine or timber, of which the woods of the hinterland were very rich. Among the levy, there was also the one to pay for the boats loaded in the ports of the district [102].

The town of Villaputzu, called *Villa Pupussi*, is also recorded in the register of 1316; during the 'Judical' period this village inherited the function of *curadorìa* capital from the ancient *Sarcopos*. In fact, in the 1316 census the *villa Pupussi or Pupputhi*, appears to be the most populated in the *curia* with about two hundred inhabitants. The role and importance assumed by the *villa* were due not only to its strategic position, but also to the profitable and varied productive activities – from specialized agriculture with several vegetable gardens and orchards, to breeding, trade and river fishing – which gave considerable incomes; in its extensive territory there were vineyards, wheat and barley fields, as well as vegetable gardens with fruit trees, including orange groves. The production of wine had to be copious and traded both in the *tabernae* and in the individual houses. Formerly protected by *Castrum Malvicini* («*…montis in quo erat castrum Malvicini…*»), its churches were Santa Vittoria – named after and mentioned as early as 1120 and whose cult is still celebrated today – San Giorgio («*…ecclesia Sancti Georgii de villa Pupussi…*»), Santa Caterina e Santa Mariedda which has given its name to a neighbourhood in the village [103].

The revenue register of the Municipality of Pisa, dated 1316, with the same wealth of details, also records the *ville* of the *curie* of *Tholostra* (Colostrai) and Quirra; a picture emerges that testifies to an extraordinary productive vitality and a consistent commercial flow: it talks about the fishponds in the Stagno of Colostrai, the production and trade of wine, as well as the traditional agricultural and livestock production (Fig. 7) [104].

But, already from the second half of the 14th century, this happy conjuncture failed due to – as already seen above – the difficult political moment, the climate change, the plague epidemics, the wars, but above all the imposition of the feudal regime wanted by the sovereigns of the newborn Kingdom of 'Sardinia and Corsica' [105]. In fact, since 1324 all the villages and rural territories, having become part of the new institutional reality, were granted in fief to the Iberians who helped the Crown in the conquest [106].

In our territories all villages were granted in feud to various Iberian nobles and soldiers, without taking into account the administrative articulations that had resisted until then; when the Carròs – the admiral Francesco Carròs, in fact, had been the captain of operations for the conquest of the south-eastern coast – succeeded in creating a great territorial fiefdom, uniting the surviving villages of that territory [107], the process of deconstruction and abandonment of the most fragile villages in favor of the larger ones (such as Muravera, Villaputzu, Orrea and Ulmus replaced in 1485 by San Vito), had by now begun and perhaps it was also favored by the feudal lord to better control his vassals.

The introduction of the feudal regime and the long and bloody war that, from 1353 to 1420, contrasted the indigenous Kingdom of Arborèa with the Kingdom of 'Sardinia and Corsica' [108], caused a drastic demographic decline that manifested itself in the restructuring of the settlement framework in these territories. The effects of the crisis are clearly visible in the retail sales of salt from the Cagliari salt pans to the villages of Sarrabus, Chirra and Ogliastra between 1347 and 1414: purchases of salt in our districts were absent until 1389, resumed from 1390 to 1393 and then ceased again [109]. We could hypothesize that, until the war of 1353, the ponds of Colostrai and Ogliastra guaranteed the quantities of salt needed for these villages; the war interrupted connections with Cagliari because of the Arborean conquest. Purchases resumed after the peace of 1388 and then ceased again, in a context of destruction and abandonment (Fig. 8).

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By now the depopulation of the smaller villages of the *curadorìa* was started and was further accentuated by the dramatic effects of the second war between the Kingdom of Arborèa and the Kingdom of 'Sardinia and Corsica', between 1365 and 1409 [110]. Only in 1485 we have the first attestation of a new village, San Vito, which had covered the gaps left by the many abandoned villages (Fig. 9).

4. Partial conclusions

As emerges from the general context in Sardinia and from the particular case study, the coastal depopulation and the abandonment of most of the villages of the *curadorìas* of Colostrai Sarrabus and Quirra took place between the 14th and the beginning of the 15th century for a series of external, internal and contingent causes:

- the war between the Aragonese and the Pisans first (1323-1326), and later that between the Kingdom of 'Sardinia and Corsica' and the native kingdom of Arborèa (1353-1420);
- a worsening of the climate starting from the end of the 13th century;
- the Black Plague of 1348;
- the imposition of the feudal regime in the rural areas of the Kingdom of 'Sardinia and Corsica'.

When, starting from the end of the 15th century, the effects of the expansion of the Ottoman Empire and the incursions of the Muslims of North Africa became insistent and devastating, the coasts of these territories were already depopulated and the few surviving inhabitants were concentrated in the villages more inland (Muravera, Villaputzu and San Vito). The reports, descriptions and geographic maps of the 16th century represent in this way the settlement organization of these territories, which has survived to the last century.

(GS)

5. A computer aided approach for a sources-linked temporal and spatial GIS visualization. A case study applied to Sarrabus, Colostrai and Quirra.

5.1. Overview on current IT tools

As we have seen, it could be very useful to visualize the location of the demic nuclei in a mid and long-term timeline. Once dated, through the evidences and different sources related to them, the more accurate the dating is, the more precise could be the representation in a map. Due to the fragmentation of the sources it is a tricky task, anyway, we can try to apply the model with little areas, with few nuclei and for specific time windows. Little by little, we can easily extend the procedural approach to wider collections and regions every time we will find additional data.

IT tools that permit us to handle such kind of heterogeneous data in an easy way, could be the Content Management Systems. Usually called CMS, they are integrated software engines that allow collecting and manipulating hybrid data collections through a unique platform. At the beginning of the early 90s of the last century the CMSs were mainly used to manage e-commerce sites, programmed in high-level programming languages, but still complex principally like C and C ++ besides other procedural languages. They mainly interfaced with very expensive proprietary Data Base Management Systems (DBMS), like Oracle®, in the order of millions of dollars. In March 1995 the first «Open-Source» CMS was released, with freely redistributable open source code, and this contribution is due to Ward Cunningham. He developed the «Portland Pattern Repository» called «Wiki Wiki» which in the Hawaiian language means "fast and easy". His first commercial release took place via Apple's Hypercard. In the same year CNET.com published

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its own studios with the «Vignette» label, giving users the possibility to create their own website in a simpler and more personalized way.

Recent applications of Plug and Play CMSs are very useful to embed any kind of data into a website, so it is easy to exploit them to input historical and geographical information as well. There are many solutions, proprietary and open source, to reach this goal we have defined Plug and Play (PnP). Formerly used for any kind of hardware pluggable into a computing system, PnP means «connect and use». This expression is used in different contexts of computer science: when an object is ready to use; when a device is connected to the system and can be used immediately without any user intervention, because it is automatically recognized by the system; when a software is installed and immediately usable without any configuration by the user. Anyway, we will tend not to focus on a particular solution, except for the reference to one of the most widespread and simple solutions currently available: WordPress. We won't approach this topic going in deep with any solution, because what seems to be apparently easy to use, it hides many complexities behind, that we leave out of our treatment. It is important to remember that too specialized CMS applications, would force us to make heavy changes to these ready-made platforms intervening on the source code, an operation that is not for everyone.

To install and use CMSs, is not necessary to have particular skills in programming, such as PHP, PERL or other programming languages. Since PHP was born 1997, it has been a derivation of the dynamic HTML (Hyper Text Markup Language), created only two years before, and it has been immediately acclaimed for its versatility, stability and ease of use. The acronym originally meant Personal Home Page, but has been soon renamed in the recursive acronym PHP: Hypertext Preprocessor. Someone attribute to the acronym PERL the following meaning: "Practical Extraction and Report Language", although this is a backronym or acronym assigned after the creation of the name itself. We must instead refer to the language itself with the name of «Perl» and to the specific implementations of the programming as «perl».

The architectures today available use LAMP, ready-to-use platforms for the most, and Open Source. LAMP is an acronym that stands for "Linux Apache MySQL PHP" which is a platform that includes a server operating system (L), an application server for web pages (A), a backend database (M), a programming language to create web pages (P). Similar systems for Windows and Apple environments are called in turn WAMP and MAMP. Then there is another multi-platform package called for this reason XAMPP where X stands for «cross platform» and the last P stands for «Perl». We can easily follow a guided wizard to install the packages and we can find a plenty of documentation and How-To guides on the Net. WordPress, for its simplicity is also known as "five minutes install", to find further useful documentation, see [111]. As anticipated, without going in deep, we can embed maps or other geographical tools into a CMS website, choosing among several plugins today available [112].

5.2. GIS and databases

Other important and powerful tools, that in the last decades have become irreplaceable for the geospatial analysis of data, are the GIS. What literally have made thematic maps take off, has certainly been the Information Technology. In 1963 Roger F. Tomlinson, coordinator of the data processing center of the Canadian land inventory of the Agricultural and Rural Development Administration, began to design a computerized geographic system which, implemented in 1965, became operational in 1967. The system was designed to manage problems related to land, water management and human resources in Canada, thus starting the first functioning GIS system. To see his first presentation, see [113]. During those same years, the university world was experimenting with numerous approaches to this new methodology. Many scholars and professors have made an important contribution to strengthening the GIS tools. These include Prof. Howard Fisher, who in 1964 founded the first computer graphics laboratory (and spatial analysis) at Har-

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vard University. In 1966 he developed the SYMAP (SYnagraphic MAPping System) software, capable of printing maps, isolines and coropletics on generic dot matrix printers. The research group, formed by Carl Steinitz as landscape architect, regional and urban planning, the urban planner Allan Schmidt, the hydraulic engineer and economist Peter Rogers and the architect Allan Bernholtz, has been the first to use this new software. Together, they began experimenting new ways of temporally and spatially distributed representation through the help of the newly formed Computer Graphics, focusing on regional design, architecture and landscape architecture, analyzing the role of computers in programming, design, evaluation and simulation. For a version of the history by Prof. Steinitz, see also [114].

As we have anticipated, the recurrent characteristic of villages' settlement is that someone reports about them in some document, while no other have mentioned this or that village, before. Therefore, we have to trust in reliable sources, crossed or overlapped with other evidences, to estimate the effective date of appearance and the exact position of a settlement. This last feature is often possible by the direct observation of the landscape, the ruins, the vegetation and the orographic conformation of the sites.

With the help of relational databases, it is possible to reconstruct the network of references for a correlation of the sources with the object of interest observed. For a complete overview of the origins of such kind of databases, see [115], while for an alternative method to represent and model a reality using relational model, see [116].
In this relational model, through the registration of the sources referencing them with foreign keys, it is possible to display snapshots of the target objects through appropriate queries resulting in materialized views. These views will show only the required information, joining different tables, based on the current query over the original data.

Even if there is quite data dispersion in the time range considered, because of the lack of precise time and data about each demic nucleus, we have tried to animate the evolution of a very limited region, entering the temporal information for each nucleus mentioned in some source.

For simplicity, we did not use a shape file containing the accurate topographic surveys, we have instead placed map points, using georeferencing tools, in the places where we had documentary evidence, or where those still exist today, or in other presumed places deduced from descriptions taken from those fragmentary sources that have come to the present day.

5.3. Proprietary commercial and Open Source solutions

This experimental test has been conducted with different types of solutions, both proprietary and Open Source, but it is possible to conduct it all with free software. For a definition of Open Source see [117].
Even if are available other solutions like ESRI ArchGIS, which is currently the market leader with over the half of the whole market, is it possible to achieve good results with non-commercial solutions as well.

The establishment of the Environmental Systems Research Institute (ESRI) in 1969, by Jack and Laura Dangermond, would have changed forever the GIS history, bringing this wonderful tool from the mainframes to desktops, web and Cloud now become ESRI ArchGIS. As we can read in the ESRI website [118]: «GIS Goes Commercial: As computing became more powerful, Esri improved its software tools. Working on projects that solved real-world problems led the company to innovate and develop robust GIS tools and approaches that could be broadly used. Esri's work gained recognition from the academic community as a new way of doing spatial analysis and planning. In need of analyzing an increasing number of projects more effectively, Esri developed ARC/INFO—the first commercial GIS product. The technology was released in 1981 and began the evolution of ESRI into a software company».

The one we have used to carry out this simulation and to handle geographic data, is the open source Long Term Release QGIS version 3.4.5-Madeira available at [119]. To

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download the latest version visit [120]. As we can read from an official guide of a previous version [121]: «QGIS is an Open Source Geographic Information System. The project was born in May of 2002 and was established as a project on SourceForge in June of the same year. We've worked hard to make GIS software (which is traditionally expensive proprietary software) a viable prospect for anyone with basic access to a personal computer. QGIS currently runs on most Unix platforms, Windows, and macOS. QGIS is developed using the Qt toolkit https://www.qt.io and C++. This means that QGIS feels snappy and has a pleasing, easy-to-use graphical user interface (GUI). QGIS aims to be a user-friendly GIS, providing common functions and features. The initial goal of the project was to provide a GIS data viewer. QGIS has reached the point in its evolution where it is being used by many for their daily GIS data-viewing needs. QGIS supports a number of raster and vector data formats, with new format support easily added using the plugin architecture. QGIS is released under the GNU General Public License (GPL). Developing QGIS under this license means that you can inspect and modify the source code, and guarantees that you, our happy user, will always have access to a GIS program that is free of cost and can be freely modified. You should have received a full copy of the license with your copy of QGIS, and you also can find it in Appendix GNU General Public License».

This software allows installing additional plugins [122], depending on the needs of the users. One of these, helpful and fundamental for our scopes is Time Manager [123] developed by Anita Graser [124]. This module allows generating exportable moving pictures, or animations, to visualize spatial temporal data. Time Manager complements QGIS with time controls. Using these supplementary commands, we can create animations of vector features based on temporal attributes. As the developers refer in the section plugin > manage and install plugin…, «There is also an experimental raster layer support and support for interpolation between point geometries. You can create animations directly in the map window and export image series».

5.4. Materials and methods

The minimal reference database we have used, containing the wanted information in twenty-nine lines, has been populated in two separate phases, using different software and with the following information: the Progressive Number, The Name of the Nucleus, the Nucleus Longitude (X), the Nucleus Latitude (Y), the Nucleus Approximated Appearance Date, the Nucleus Approximated Disappearance Date. When a nucleus still exists today, this last date has been set as the current year. The geographic coordinates, longitude and latitude have been extracted from a precompiled .kml file obtained as output from the software Google Earth Pro freely downloadable [125]. For those who are not familiar to this file format, KML file extension stands for Keyhole Markup Language file. Such kind of file, embeds XML code to manage and store geographic information for subsequent visualization by saving locations data in a predefined way. For further documentation see Google KML Documentation: Time and Animation [126]. It could be useful to know that the Google Earth KMZ file format is instead a Keyhole Markup (Language) Zipped.

Having no pre-stored data on the nuclei, among the several methods usable to fix in a georeferenced map the coordinates of the nuclei we had available (moreover not always accurate), we used this Google powerful free tool to set the georeferenced locations. Simply picking the points on Google Earth (or on the web version Google Maps as well) and positioning a new placemark on the map, looking at its properties, we have been able to copy the longitude and the latitude as separate coordinates for future uses. Anyway, for long lists, this procedure could be annoying. As QGIS handles with easiness .kml files directly, thus it is sufficient to sort these placemarks into a folder and save the resulting file, containing the object collection, from Google Earth. Once we have saved the .kml file we can import it into QGIS passing through two conversions due that QGIS handles tabular coordinates format in decimal UTM (Universal Transverse Mercator coordinate system) notation (9,590648455 39,43286297) instead of those sexagesimal (39°25'59.56"N

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9°35'24.60"E) generated by Google Earth. Even if the importing tool asks to specify which are the coordinate fields in the CSV file records we are importing, note that the geographic coordinates are usually given in Latitude and Longitude. Thus we can incur in a mistake transposing bulk data from the tabular form, because of the reference to a Cartesian plane, which requires (x,y) format for the coordinates. Respect to the geographic coordinates, we must swap the coordinates keeping in mind that Longitude is X and Latitude is Y.

To convert a .kml file we can import it into a spreadsheet. We used MS Excel of the Microsoft Office Professional Plus 2016 suite: opening a new file and choosing the target xml file, after accepting the first alerts of the program interface about the file format mismatch, we have to choose the XML table. We must accept it even if the source schema does not refer to any XML schema. MS Excel will create it basing on the original data XML code read. We will find the longitude and latitude fields, scrolling the table just extracted.

To manage raw data, it is sufficient to input them in a datasheet. Even if the CSV is enough to manage such kind of data, as we have seen, it is easier handling them in a visual tabular form using the spreadsheet, first. We used MS Excel, but it is quite simple to use even Calc, part of the Apache OpenOffice suite available at the official repository [127]. The resulting database record, in CSV format, would be the following:

```
#; Nucleus Name; Longitude (X); Latitude (Y); Approximated Appear-
ance Date; Approximated Disappearance Date
```

Note that we have used a semicolon as separator of the records because the UTM format implies the comma in the coordinates format, ambiguous character for the machine reading and confusing for the correct acquisition of the record fields. At this point, once assembled and well formed the CSV file, we have to import it into the QGIS project. For the sake of brevity, we do not report all the preliminary steps for the creation of a project in QGIS, nor for the setting of the geometry and coordinates Reference Systems (RS) and various other customizations such as the colours and other secondary aspects. For all these notions, we refer to the reference manual [128] of the release we are using and to the several forums of the vibrant QGIS community. The vector resulting from the CSV importing has been referred to the IGNF:WGS84G - World Geodetic System 1984 RS, based on the coordinates format and related to the RS of the main project EPSG:32632 – WGS84 / UTM zone 32N. As soon as we have defined and focused the target region from a shape file (.shp), we can add the data source, previously assembled, containing the information desired for the temporal visualization. It is suggested to pay attention to the format of the fields, in particular to those containing the coordinates in decimal format and the dates in the formats allowed by the Time Manager plug-in importing tool. For this simulation we have input the %Y-%m-%d %H:%M:%S format.
The first Sardinia shape file from which we started, had the following projections parameters taken from XML descriptor source:

```
PROJCS['WGS_1984_UTM_Zone_32N',GEOGCS['GCS_WGS_1984',DA-
TUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]]
,PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PRO-
JECTION['Transverse_Mercator'],PARAMETER['False_East-
ing',500000.0],PARAMETER['False_Northing',0.0],PARAMETER['Cen-
tral_Meridian',9.0],PARAMETER['Scale_Factor',0.9996],PARAME-
TER['Latitude_Of_Origin',0.0],UNIT['Meter',1.0]]
```

It is possible to overlap as many layers we need, like boundaries shape files or civil buildings shape files, to see where the nuclei were settled, in comparison both with the former States they belonged, villages, and cities and suburbs existing today. All these files are available thanks to the Sardinian Regional Administration, which releases all the documentation in Open Access form in a thematic site where it is possible to download all the shape files of Sardinia [129]. There is also the possibility to download the files related to the current “boundaries of administrative units for statistical purposes as of 1 January

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2022" from the Italian National Institute of Statistics (ISTAT). It is an updated source, but to derive the individual regional territories, it is necessary to manipulate the original shape file, which includes the entire national territory. The updated files can be found at the proper repository [130].

After we have installed the Time Manager plug-in, we can set the toggle visibility, visualizing its commands, and opening the "Settings" button. We can now "Add a layer" choosing the same data source, previously imported. Setting the Start time and the End time from the contextual drop down menus as "Extimated Appearance Date" "Extimated Disappearance Date" respectively, we have now embedded the timing needed to animate the nuclei depending on the period. Due to a limitation in the time range offered by the current release of Time Manager, the date format must be manipulated to match the regional settings. There is an "Archaeological" mode feature, but still unstable and released as experimental. For dates prior 1970-1-1, till today, we should have used integers, unfortunately it did not worked for us. We have solved this issue with some stratagems using a plausible timing coherent with the time flow examined, approximating from the decimal subdivision of the years in a century to the sexagesimal portion of the seconds in a minute.

The list and the years resulting from the evidences and documents are the following:

Table 1. List of Nuclei, Longitude, Latitude, Appearance and Disappearance Year

#	Nucleus Name	Longitude (X)	Latitude (Y)	Appearance Period	Disappearance Period
1	Sarcapos	9,590648455	39,43286297	1	1316
2	Oppidum Tronae	9,55951652	39,47706924	1355	1400
3	Villa de Archiepiscopo de Tolostrai	9,583553825	39,35612302	1066	1450
4	Platais de Castiadas	9,505052108	39,24124793	1088	1350
5	Murabera (Muravera)	9,56655233	39,42051838	1316	2022
6	Villa Lustincho	9,60215082	39,53698635	1114	1400
7	(Villa) San Pietro	9,601329739	39,54566932	1000	1350
8	Villa Pupia (Billa de Pubucci)	9,575428049	39,44100918	1215	2022
9	Villa Major	9,565047059	39,35603627	1000	1500
10	Villa Ponti	9,560290989	39,35055939	1000	1350
11	Plassas Dabis	9,518561178	39,36410972	1000	1250
12	Sancta Aleni de Tolostrai	9,464651881	39,20169503	1000	1250
13	Billa de Kirra	9,60603908	39,51649191	1000	1500
14	Arculentu	9,55562067	39,36501529	1200	1350
15	Mamussi	9,566187288	39,36111073	1200	1350
16	Cortinia (Scolca di Orrea)	9,546839897	39,43942802	1200	1350
17	Ygali (Scolca di Orrea)	9,53434641	39,44002609	1200	1350
18	Orrea (Scolca di Orrea)	9,54016133	39,44664241	1000	1500
19	Ulmus (Scolca di Orrea)	9,545100401	39,44354736	1000	1485
20	Petrera	9,580505451	39,41643473	1000	1400
21	Carruti	9,553950409	39,43400617	1200	1350
22	Sorrui	9,606626267	39,40137023	1000	1400
23	Villa Castiadas	9,508292579	39,24619931	1000	1300
24	Villanova de Castiadas	9,499804429	39,23688421	1316	2022
25	Porto di Quirra	9,629669202	39,52279879	1250	1550

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26	Castello di Quirra	9,602753868	39,53150085	1000	1600
27	Castello di Malvicino	9,574715227	39,43887546	1250	1309
28	San Vito	9,545100401	39,44354736	1485	2022

After a qualitative approximation of one century to a minute (half minute compared to a half century, 15 seconds to 25 years, 12 seconds to 20 years), adhering to the record field format of Time Manager %H:%M:%S, the CSV has resulted as follows:

Table 2. CSV File

```
#;Nucleus Name;Longitude (X);Latitude (Y);Appearance Period;Disappearance Period;START;END
1;Sarcapos;9,590648455;39,43286297;1;1316;00:01:00;00:13:06
2;Oppidum Tronae;9,55951652;39,47706924;1355;1400;00:13:30;00:14:00
3;Villa de Archiepiscopo de Tolostrai;9,583553825;39,35612302;1066;1450;00:10:31;00:14:30
4;Platais de Castiadas;9,505052108;39,24124793;1088;1350;00:10:39;00:13:30
5;Murabera (Muravera);9,56655233;39,42051838;1316;2022;00:11:00;00:20:22
6;Villa Lustincho;9,60215082;39,53698635;1114;1400;00:11:00;00:14:00
7;(Villa) San Pietro;9,601329739;39,54566932;1000;1350;00:10:00;00:13:30
8;Villa Pupia (Billa de Pubucci);9,575428049;39,44100918;1215;2022;00:12:06;00:20:22
9;Villa Major;9,565047059;39,35603627;1000;1500;00:10:00;00:15:00
10;Villa Ponti;9,560290989;39,35055939;1000;1350;00:10:00;00:13:30
11;Plassas Dabis;9,518561178;39,36410972;1000;1250;00:10:00;00:12:30
12;Sancta Aleni de Tolostrai;9,464651881;39,20169503;1000;1250;00:10:00;00:12:30
13;Billa de Kirra;9,60603908;39,51649191;1000;1500;00:10:00;00:15:00
14;Arculentu;9,55562067;39,36501529;1200;1350;00:12:00;00:13:30
15;Mamussi;9,566187288;39,36111073;1200;1350;00:12:00;00:13:30
16;Cortinia (Scolca di Orrea);9,546839897;39,43942802;1200;1350;00:12:00;00:13:30
17;Ygali (Scolca di Orrea);9,53434641;39,44002609;1200;1350;00:12:00;00:13:30
18;Orrea (Scolca di Orrea);9,54016133;39,44664241;1000;1500;00:10:00;00:15:00
19;Ulmus (Scolca di Orrea);9,545100401;39,44354736;1000;1485;00:10:00;00:14:51
20;Petrera;9,580505451;39,41643473;1000;1400;00:10:00;00:14:00
21;Carruti;9,553950409;39,43400617;1200;1350;00:12:00;00:13:30
22;Sorrui;9,606626267;39,40137023;1000;1400;00:10:00;00:14:00
23;Villa Castiadas;9,508292579;39,24619931;1000;1300;00:10:00;00:13:00
24;Villanova de Castiadas;9,499804429;39,23688421;1316;2022;00:10:00;00:20:22
25;Porto di Quirra;9,629669202;39,52279879;1250;1550;00:12:30;00:15:30
26;Castello di Quirra;9,602753868;39,53150085;1000;1600;00:10:00;00:16:00
27;Castello di Malvicino;9,574715227;39,43887546;1250;1309;00:12:30;00:13:06
28;San Vito;9,545100401;39,44354736;1485;2022;00:14:51;00:20:22
```

5.5. Results

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The resulting visual effect is a small constellation of points that, turning on and off, while the time axis flows, gives us more indications, with an impressive visual component, about the birth and death of the demic nuclei showed by their appearance and disappearance in the map. Obviously, the effect is quite limited due to the small amount of nuclei recorded in this studied case, to the confined area and to the quite dispersion in the dating from the sources. Anyway, as anticipated before, following the same indicated procedural pattern we can extend the region, handling an indefinite amount of demic nuclei. Thus, the results turn out to be very interesting to have a visual representation of realities today disappeared or still existing, overlapped to the real map, to current regions and boundaries in greater areas, such as a province or a whole nation. In this way, it is possible to implement a correlation and view an accurate and positional fluctuation of the villages. If this behaviour is seen in correlation with micro-historical happenings, and pinpointed events around those sites, we can better understand the global course of a region's changes: synchronizing the scrolling of the time bar with other related events it can show us the evolution of the different transversal factors that have characterized the studied area and its landscapes' changes.

The area of interest in the map is the following extracted from the European coastline shape file available in the proper repository [131]:

Figure 2. Sardinia respect to the physical Europe.

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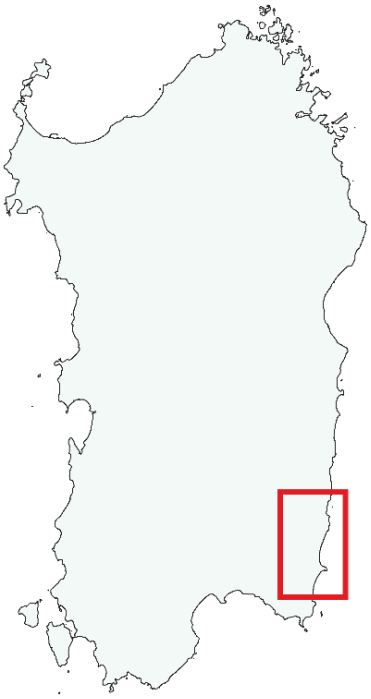

Figure 3. Southern east coast of Sardinia.

We will show a selection of the screenshots of the most important transition periods, in which we register, with a range more or less of a century, a variation in the numbers of nuclei.

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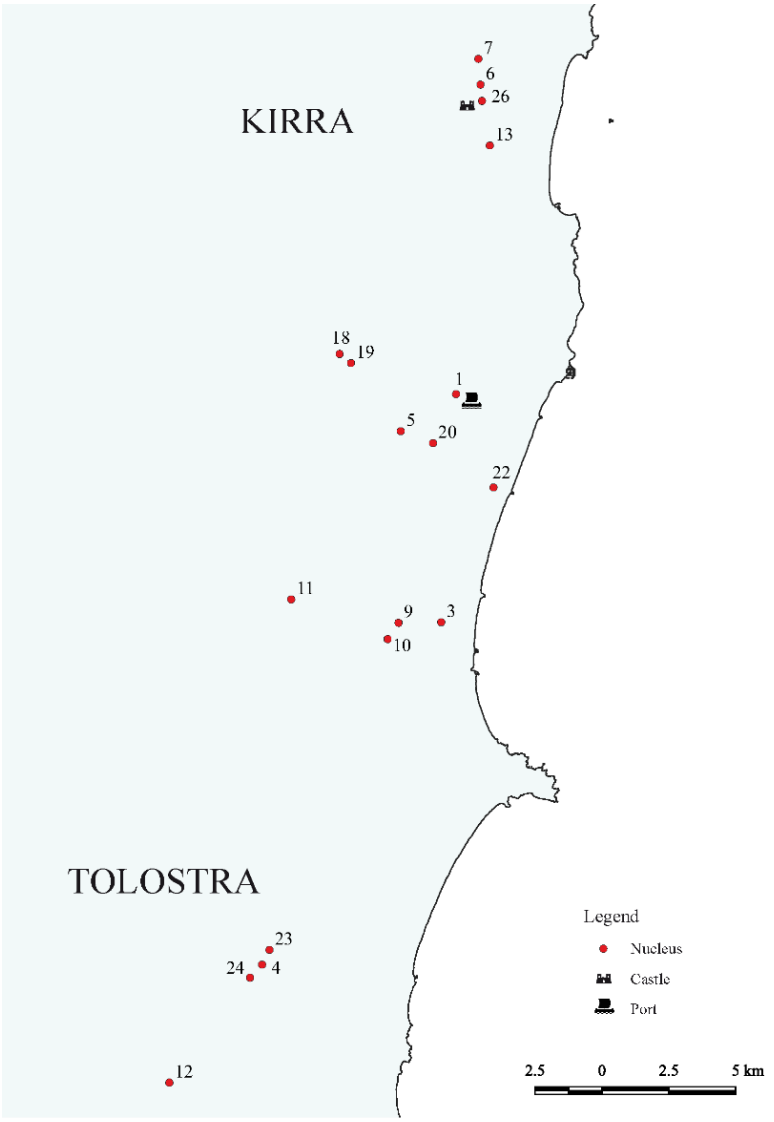

Figure 4. The settlements attested between the end of the 11th and the beginning of the 12th century (Tolostrai and Kirra in the Kingdom of Càlari).

F4	Nucleus Name
1	Sarcapos
3	Villa de Archiepiscopo de Tolostrai
4	Villa Platais de Castiadas
5	Murabera (Muravera)
6	Villa Lustincho
7	(Villa) San Pietro
9	Villa Major
10	Villa Ponti
11	Plassas Dabis
12	Sancta Aleni de Tolostrai
13	Billa de Kirra
18	Orrea (Scolca di Orrea)
19	Ulmus (Scolca di Orrea)
20	Petrera
22	Sorrui
23	Villa Castiadas
24	Villanova de Castiadas
26	Castello di Quirra

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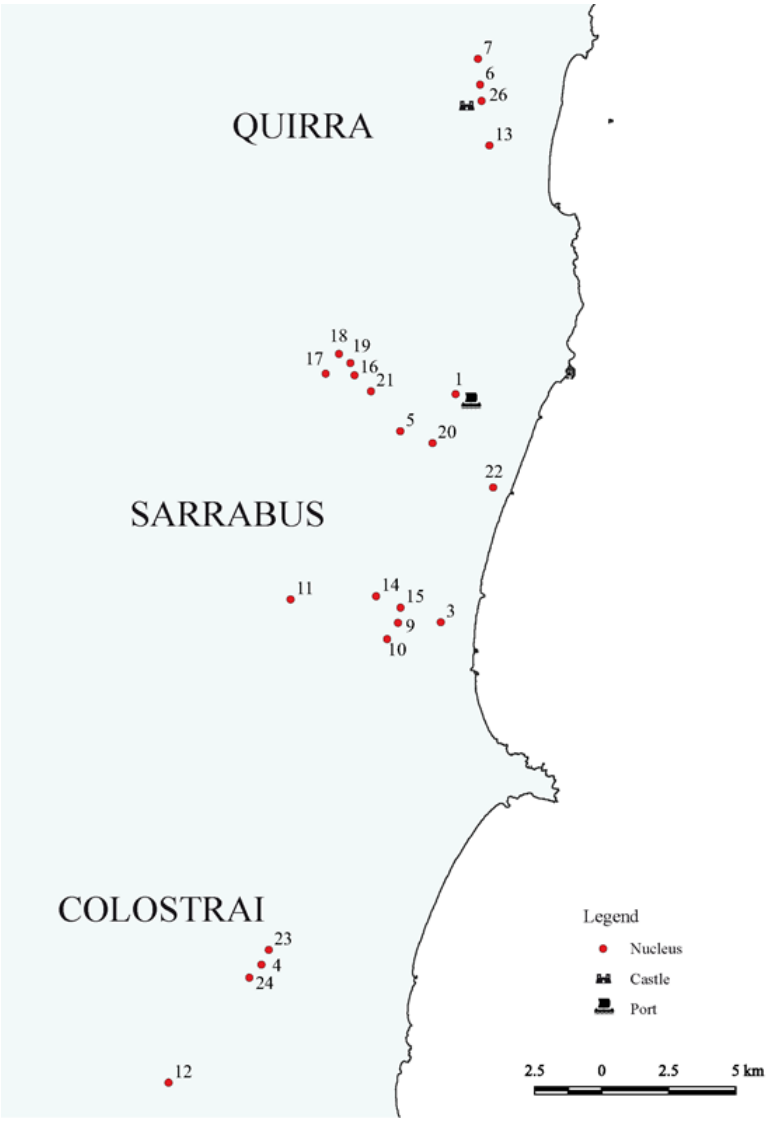

Figure 5. The settlements attested between the end of the 12th and the beginning of the 13th century (Colostrai, Sarrabus and Quirra in the Kingdom of Càlari).

F5	Nucleus Name
1	Sarcapos
3	Villa de Archiepiscopo de Tolostrai
4	Villa Platais de Castiadas
5	Murabera (Muravera)
6	Villa Lustincho
7	(Villa) San Pietro
9	Villa Major
10	Villa Ponti
11	Plassas Dabis
12	Sancta Aleni de Tolostrai
13	Billa de Kirra
14	Arculentu
15	Mamussi
16	Cortinia (Scolca di Orrea)
17	Ygali (Scolca di Orrea)
18	Orrea (Scolca di Orrea)
19	Ulmus (Scolca di Orrea)
20	Petrera
21	Carruti
22	Sorrui
23	Villa Castiadas
24	Villanova de Castiadas
26	Castello di Quirra

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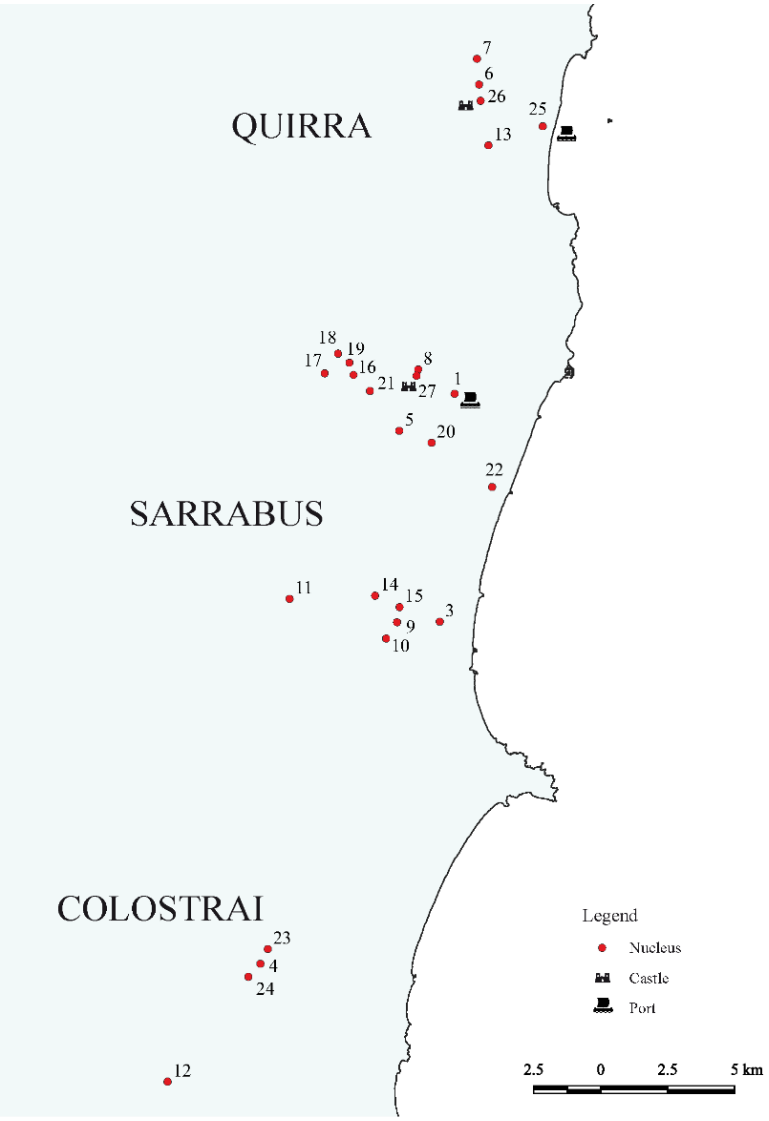

Figure 6. The settlements attested around the middle of the 13th century (Colostrai, Sarrabus and Quirra, at the end of the Kingdom of Càlari).

F6	**Nucleus Name**
1	Sarcapos
3	Villa de Archiepiscopo de Tolostrai
4	Villa Platais de Castiadas
5	Murabera (Muravera)
6	Villa Lustincho
7	(Villa) San Pietro
8	Villa Pupia/Billa de Pubuççi
9	Villa Major
10	Villa Ponti
11	Plassas Dabis
12	Sancta Aleni de Tolostrai
13	Billa de Kirra
14	Arculentu
15	Mamussi
16	Cortinia (Scolca di Orrea)
17	Ygali (Scolca di Orrea)
18	Orrea (Scolca di Orrea)
19	Ulmus (Scolca di Orrea)
20	Petrera
21	Carruti
22	Sorrui
23	Villa Castiadas
24	Villanova de Castiadas
25	Porto di Quirra
26	Castello di Quirra
27	Castello di Malvicino

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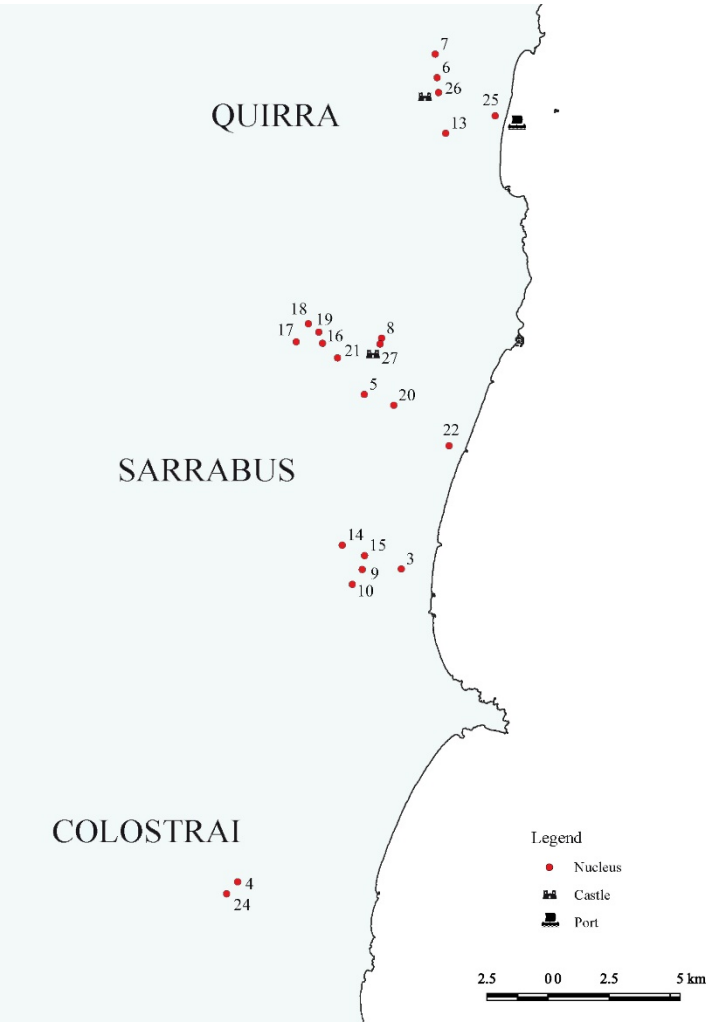

Figure 7. The settlements attested around the beginning of the 14th century (Colostrai, Sarrabus and Quirra, under the control of Pisa).

F7	**Nucleus Name**
1	Sarcapos
3	Villa de Archiepiscopo de Tolostrai
4	Villa Platais de Castiadas
5	Murabera (Muravera)
6	Villa Lustincho
7	(Villa) San Pietro
8	Villa Pupia/Billa de Pubuççi
9	Villa Major
10	Villa Ponti
13	Billa de Kirra
14	Arculentu
15	Mamussi
16	Cortinia (Scolca di Orrea)
17	Ygali (Scolca di Orrea)
18	Orrea (Scolca di Orrea)
19	Ulmus (Scolca di Orrea)
20	Petrera
21	Carruti
22	Sorrui
24	Villanova de Castiadas
25	Porto di Quirra
26	Castello di Quirra
27	Castello di Malvicino

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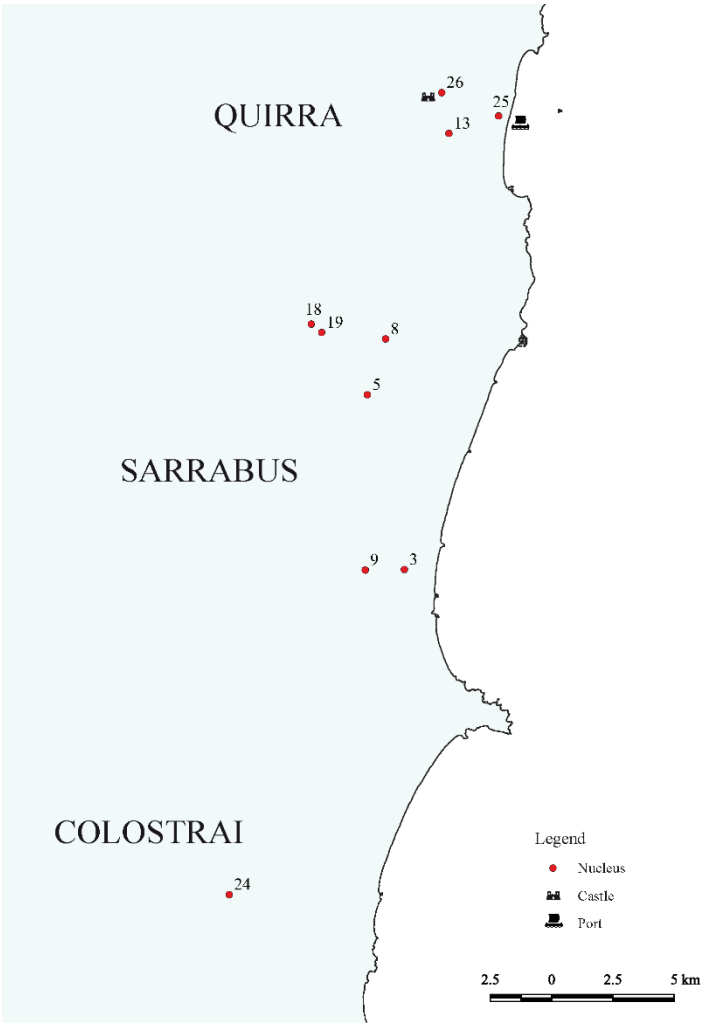

F8	Nucleus Name
3	Villa de Archiepiscopo de Tolostrai
5	Murabera (Muravera)
8	Villa Pupia/Billa de Pubuççi
9	Villa Major
13	Billa de Kirra
18	Orrea (Scolca di Orrea)
19	Ulmus (Scolca di Orrea)
24	Villanova de Castiadas
25	Porto di Quirra
26	Castello di Quirra

Figure 8. The settlements attested around the beginning of the 15th century (Colostrai, Sarrabus and Quirra, in the Kingdom of 'Sardinia and Corsica').

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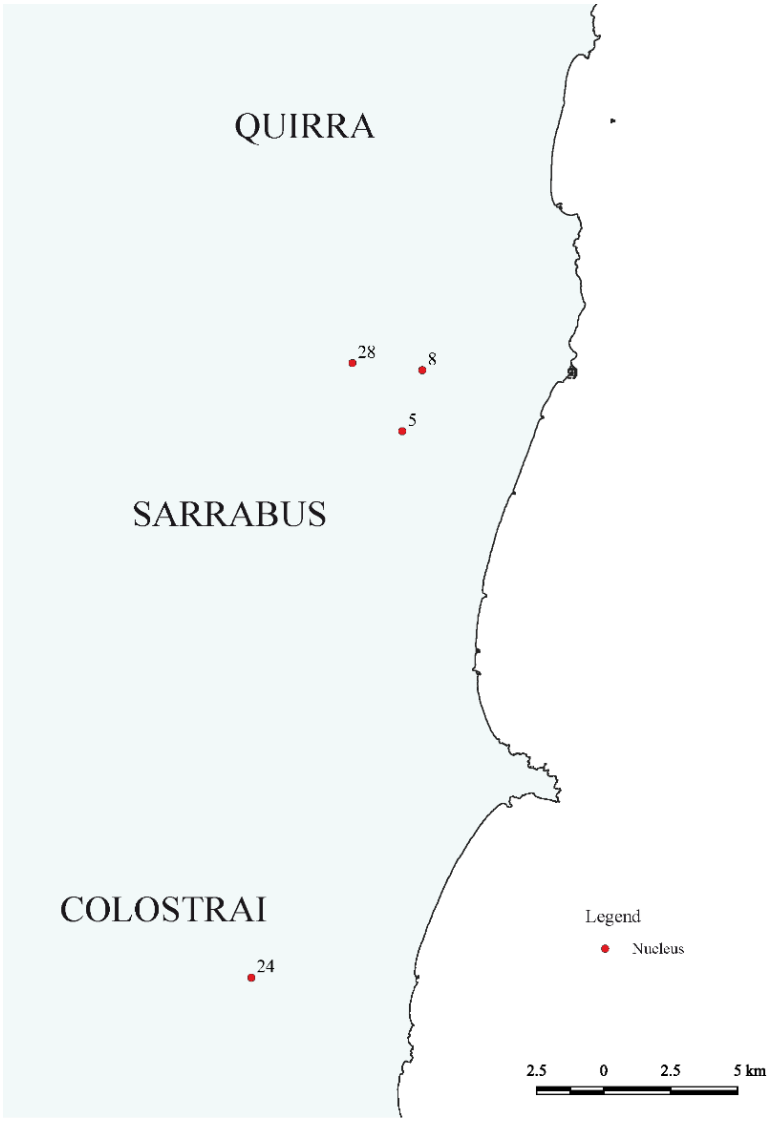

F9	Nucleus Name
5	Murabera (Muravera)
8	Villa Pupia/Billa de Pubuççi
24	Villanova de Castiadas
28	San Vito

Figure 9. The countries of the south-east coast, from the 17th century until nowadays.

To create the animation we have used the aforementioned desktop version of QGIS [120] with the Time Manager plugin. The included "Export Video" function, generates a variable number of images in .png format depending on the selected "Animation frame delay". To export a complete video of the whole animation, we have used the screen capture software OBS Studio [132]. There are some technical requirements to be observed to obtain a product that, as well as being functional, could be also useful. Some plugins can be installed to export as close as possible static maps from QGIS. Without going in deep, we limit ourselves to tell that there are several alternative tools to publish even dynamic maps on the web. If we would embed this resulting map, browsable into a web site, it could be a tricky task and a little bit overwhelming, but we can use ready plugins to facilitate the task. The implementation of CMS, WordPress for example, could allow us to embed a web based dynamic map. Web GIS is a proprietary solution even if there are many other both Open Source or commercial solutions. Among these, used alone or combined, we have [133].

To define what a Web GIS is, we can cite ESRI write in their official web site [134]: «Web GIS is a type of distributed information system, comprising at least a server and a

client, where the server is a GIS server and the client is a web browser, desktop application, or mobile application. In its simplest form, web GIS can be defined as any GIS that uses web technology to communicate between a server and a client. Here are a few key elements essential to web GIS: The server has a URL so that clients can find it on the web; The client relies on HTTP specifications to send requests to the server; The server performs the requested GIS operations and sends responses to the client via HTTP; The format of the response sent to the client can be in many formats, such as HTML, binary image, XML (Extensible Markup Language), or JSON (JavaScript Object Notation)».

5.6 Conclusions

The goal of this simulation was not to cover the entire topic, which is quite large, differentiated and complex; it has been instead to show how new IT tools can aid our investigation work connecting as much as possible with Informatics. About this aspect, another important facet that deserves attention, is the link between the sources and the objects. In this case could be very useful to trace documents and sources linking them to the geographical information of the nuclei. In this way, every time the scholars will find a new source talking about that demic nucleus, the GIS records would gradually increase, adding new information about the same object and cross references information between the static object, precisely the nucleus, and the dynamism of sources found elsewhere. So that, we will feed a collection of heterogeneous references orbiting around each village, but joined by the geographical origin of the source and the geographical destination of the same one, that is the village itself. With a GIS is possible to model new shapes including the borders of the States with different colours, gradients plus temporal information, so that the map could animate itself showing the evolution of the lands occupation and its owners pertinence, through the years and, varying the time intervals, over the centuries. Simplicity of this specific simulation apart, overlapping this information with the multi-layer approach, it shows the appearance/disappearance dynamics of the villages or simpler nuclei, with other environmental aspects. Thus regarding the States' borders, the battles, the weather conditions (see reference [60] Andrea Luca BALBO et alia), the diseases, the trading routes (see reference [31] Marco Muresu) and production sites by type of goods in a visual representation, make us visually understand how the political changes or other aspects apparently disconnected, if considered as summation or concatenation of events, can deeply transform a land and a social tissue.

(LS)

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