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**Urban heritage endangerment at the  
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A spatial vulnerability assessment**

**Research Memorandum 2011-36**

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# URBAN HERITAGE ENDANGERMENT AT THE INTERFACE OF FUTURE CITIES AND PAST HERITAGE: A SPATIAL VULNERABILITY ASSESSMENT

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## Abstract

Uncontrolled urban growth has been an increasing concern in many regions in Europe and elsewhere. Brought forth by a natural tendency of population growth in relation to unsustainable land use, city sprawl has led to complex spatial developments that are creating both benefits and challenges to decision makers. A major problem inherent in uncontrolled growth of cities is the threat to fragile cultural and ecological heritage, which may escalate to permanent and irreversible damage due to factors such as environmental depletion and landscape decay. Using modern geosciences and spatial information technologies as predictive tools to analyse and forecast urban growth, a regional spatial decision system may be useful in order to offer seemly and timely information on the risk of overburdening the carrying capacity regarding historico-cultural heritage at local levels.

The present paper will develop a predictive toolkit for urban heritage in relation to urban cultural endangerment for the region of the Algarve in Portugal. The use of the Algarve as a laboratory for testing this novel methodology relies on a combined analysis of urban growth potentials and threats to the abundant presence of archaeological heritage in the area. Our approach supports the paradigm of city growth in the context of the European agenda emerging from the Valetta Treaty, in which archaeological heritage is recognized as a key element for sustainable development. The present study offers novel empirical results from the above mentioned modelling approach. This paper proposes an integrative spatial analysis methodology on the issue of historico-cultural endangerment, proposing a novel approach of comparative spatial analysis for decision making at regional scale on urban heritage endangerment. The discussion extends further on to a more conceptual level of urban planning: is urban sprawl influencing the way we perceive cities? If so, are there positive advantages in the paradigm of urban growth and urban sprawl which might help us to protect past heritage while offering sustainable and modern cities?

Keywords: Geographic Information Systems; Urban Growth; Heritage Endangerment; Spatial Decision- making; Spatial Vulnerability

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## **1. Introduction**

### ***1.1. On urban growth and urban sprawl in Europe***

Changes in the landscape of cities and regions have increasingly occurred in the last decades. Most of these changes have had a crescent relation to humans' socio-economic activity regarding the environment. With the increasing growth of cities, irreversible land use change has become an important fact for planning (EEA Report, 2006). The structural changes of city landscapes have mainly been influenced by the rapid population increase as well as the concentration of economic activities in urban regions. While cities represent often a positive externality, leading to a better management of commuting costs and may significantly contribute to sustainable development, urban areas must be treated with special care, as mismanagement may result in irrecoverable landscapes and severe imbalances in urban areas. As cities grow on their supporting infrastructures, and population density augments due to job concentration from the service sector, territorial occupation becomes often overburdened, and consecutively market failure is common. Congestion, pollution and loss of landscape aesthetics are but a fragment of the different downsides of urban change. However, these consequences are not a result of growth by itself, but rather from the excessive (Brueckner, 2000) and scattered concentration of urban areas into rural lands (Harvey and Clark, 1965), which defy the spatial agenda of urban planners. By definition, such type of urban growth is defined as *urban sprawl*. This type of growth depicts a chaotic essence, and is becoming an increasing concern especially in coastal regions where Europe has grown increasingly over the last decades. Predominantly, this growth has been a result of economic activity related to the service sectors: tourist areas, for instance, have witnessed with the increase of mobility an astonishing growth in urban perimeters. Within a Schumpeterian vision, the concentration of urban regions has been a result of increase of the

demand of specific factors (such as - in the case of tourism-leisure activities and natural landscapes in marine regions), while supply of those goods have been produced excessively without enough flows of innovation, leading to depletion and scarcity of the available goods (natural landscape). The spatial analysis of available data on urban growth in Europe shows that the natural landscape is becoming a 'scarce resource' often unavailable to offer high-quality tourism, as important regions for tourism become lost due to increasing human pressure. While this problem has been widely studied from an ecological perspective, little work has been carried out on the consequences of the loss of landscape resource from a historical heritage perspective. In fact, historical (and archaeological) heritage, presents an important asset for tourism, and an increasingly important tool for sustainable development. Losing archaeological heritage - as vulnerable as it is due to pollution and loss due to coastal erosion - is also becoming lost through the invisible hand of urban growth. Under the European umbrella, the importance of preserving historical cities and fragile monuments has been widely recognized. But no effective solution integrating the cost of urban growth has been offered or studied. Spatial monitoring however, serves to use both types of tools to integrate the preservation of archaeological heritage as well as to monitor the increasing consequences of urban growth. The European Spatial Development Perspective (ESDP) had natural and cultural heritage as a major topic of discussion on the table: *"Natural and cultural heritage in the EU is endangered by economic and social modernization processes. European cultural landscapes, cities and towns, as well as a variety of natural and historic monuments are part of the European heritage. Its fostering should be an important task for modern architecture, urban and landscape planning in all regions of the EU."* (European Commission 1999).

Coping with urban change is a prerequisite to maintain our quality of life at present. While in the short term local sustainability plays a major relevance, in the long term common structural changes must be considered (Capello 2001). This observation clearly exemplifies the relevance of conservation of our heritage, in which archaeological heritage preservation has a vital role in the sustainable development of cities.

### ***1.2. The cities' nexus: past archaeology and modern infrastructures***

Aesthetics of the natural landscape are strongly linked to the preservation of open spaces and maintenance of natural and cultural heritage. Heritage has enjoyed in recent years an increasing attention from policymakers, as they often represent an important resource for economic growth. It is thus plausible that preservation of those resources is an essential ingredient for sustainable development and also for sustainable tourism (Vaz et al., 2010). Over time, landscapes have changed rapidly and constantly due to human impact since pre-18th century (Antorp, 2005). Antorp's definition of post-modern landscapes recognizes that *“visible break in the continuity with the past is created. However, all these changes are made with the same concern of importing the living environment to the new needs of a growing population, which is mainly urban. People become increasingly mobile and the ecological footprint of the urbanity now stretches beyond their city”*. In the case of the Algarve, the spatial movements of the extending cities converge towards archaeological sites, which could be an important resource for tourism alternatives to rebalance the asymmetries of the urban and rural fringes (Vaz et al., 2010). Urban sprawl in the cities' nexus has as a consequence the inclusion in the area of various jeopardized archaeological sites and historical buildings. The local identity of the place becomes increasingly

lost and the costs of losing local identity in a region such of the Algarve may yield to a mass tourism industry which overburdens the fragile marine ecosystems. The re-equilibration of a sustainable tourism industry has intrinsically an impact on the stability of the environment. Increasing change and construction on the landscape is leading to an unprecedented fast pace of landscape changes.

Monitoring urban growth and heritage tourism offers an alternative to the process of centralization of tourist activities and tracking those changes. Centralization of tourism attractions is a result of lack of efforts regarding heritage preservation and exploration of neglected historico-cultural landscapes. As a consequence, overburdening tourism in certain heritage sites not only affect will the challenging carrying capacity of local areas in a vicious negative cycle (Russo 2002), but may also, lead to permanent loss of fragile archaeological sites in the long run.

Application of landscape strategies can reverse these negative impacts: (1) in the short-run (local measures): protection of existing urban patrimony often endangered due to air pollution - a consequence of human activity within an urban area due to gas emissions – through the creation of a diversified cultural heritage supply. (ii) long-run (regional measures): promotion of the design of a future urban growth that leads to a balanced choice for future urban development which may benefit directly urban planning by reducing negative impacts of urbanization.

The solution to avoid negative externalities in the long-run should take into account the usage of predictive modelling approaches, regarding both - urban growth and archaeological heritage. Both of these models should be spatially explicit, and are of crucial importance for sustainable development. The possible integration of Stonehenge in UNESCO's endangered sites list

(Webster 2007) is a clear example of the importance of understanding the future impacts of urban planning.

### ***1.3. Predicting urban change and protecting archaeological heritage***

The notion of urban sustainability and “living cities” is characterized by their exclusivity with unique historic patrimony. The impact of growing cities should not jeopardize the continuum of secular memories of urban areas, but should rather articulate the secular presence in the modern conception of the urban preservation agenda. This can only be accomplished through a transversal effort of different areas in which planners contribute to understanding the synergistic dimension of economic positive externalities and the carrying capacity of vulnerable areas.

Understanding the dynamics of spatial land use change is of vital importance to equilibrate the aesthetics of the landscape and to avoid further loss to marine environments. The objective of this paper is to address a two-fold approach based on location awareness of the urban growth continuum as well as a probable location of archaeological heritage. The city is seen as a complex and non-linear system, which is extending into archaeological heritage sites that may have an important role for avoiding continuous pressure on the coastal regions of the Algarve. Thus, the logical organization of this paper follows a systematic understanding of the urban changes felt over the last decades in the Algarve and to predict future urban change at a spatial level. Furthermore, a spatial Archaeological Predictive Model based on a known site location of archaeological sites will be assembled to link the spatial location of important vestiges of archaeological cultural heritage. These vestiges - the Algarve is one of the most important regions of Roman activity in Portugal - are important as an alternative tourist-asset which could



redefine the patterns of urban growth brought by economic pressures of tourism. It is in the convergence of both models – the Urban Growth Model (UGM) which informs of the spatial distribution of current and future urban sprawl and the Archaeological Predictive Model (APM) that shows the propensity of finding archaeological sites along the Algarve - that a strategy may be defined at the level of municipalities, to enhance the local value of cultural heritage and the existing cities concerned

## **2. Research Methodology**

### ***2.1. The study area***

With a total area of 5412 km<sup>2</sup> and a population of 458734 inhabitants, the Algarve offers a vast and rich historical and ethnographical background. Allied to a moderate Atlantic climate following short winters and agreeable summers, the Algarve has long been a region of tourism. With a total of 16 municipalities, the Algarve is famous for its sandy beaches, which since the sixties have led to the development of large and one of Europe's most important tourist industries. While the region itself has benefited from an economic perspective from the growth brought by the tourism sector, nowadays, the Algarve is suffering from some of the consequences for the carrying capacity of the coastal regions, due to excessive concentration in coastal areas of the Algarve. Nevertheless, in the vein of the definition of sustainable tourism, the exploration of the Algarve in a wider sense than sun and beach, might avoid this excessive concentration and reshape the asymmetries of the rural Algarve and the littoral fringe.

The Algarve represents a very interesting region of study, as the region is suffering from an increasing friction between natural ecosystems and urban growth. The historico-cultural richness of the Algarve as well as the ecological diversity and available land-use inventories of European interest (Painho and Caetano 2006), frame this region as a relevant case of consequences of unmonitored urban growth (see Figure 1). The coastal fringe in the Algarve has significantly changed over the last 20 years. Accompanied by a population increase and the demand for new infrastructures to cope with the tourism sector, the Algarve has predominantly expanded along the coastal shores, putting at risk fragile ecosystems part of the NATURA network, such as the *Reserva Natural da Ria Formosa*.

Cities in the Algarve represent a very diverse cultural legacy, brought forth from the Moorish influence combined with the Roman and traditional Portuguese styles. It is therefore a cradle of different civilizations, which shared the region since the Neolithic age (Calado and Rocha, 2006).

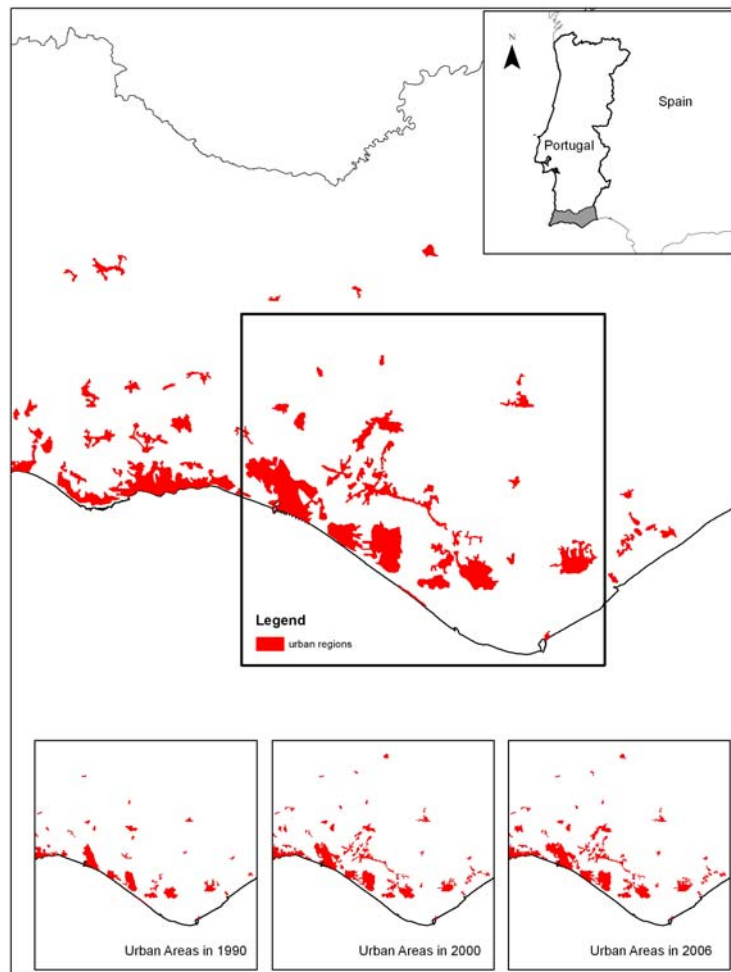


Figure 1 – Change in urban regions in the Algarve

## ***2.2. Data types and sources***

The approach in this study draws forth from a comparative assessment of areas with higher propensity for urban sprawl with regions showing more probability of becoming archaeological landscapes. While urban sprawl is unavoidable, segmentation of regions of city growth may help to protect areas of archaeological interest. The major reason of this protection is a result of the Valletta treaty, justifying the importance of preservation of a collective Archaeological memory.

Several data types are adjusted to allow the following research efforts: (1) creation of an urban growth model (UGM) based on socio-economic and environmental variables to assess the propensity for urban growth, and (2) integration of a predictive model showing the regions with a high probability for important archaeological sites. To allow the generation of the UGM, the data types used were assessed from the CORINE Land Cover data over a period of 1990 to 2006. The major classes related to artificial land use were filtered through the spatial inventory, as to allow an assessment of land use change.

### **3. Urban Growth Models**

The urban growth model (UGM) follows a classical SLEUTH modelling approach, encapsulating socio-economic and geophysical variables that respond to the most plausible outcome of urban sprawl in the Algarve in the forthcoming years. These variables explore the tendency for urban growth up until 2020, based on Markov transition probabilities, and are then compared to the spatial location of most probable archaeological sites. The integration of both spatial information systems, allowed us to elaborate on a spatial model which reported the location of probable archaeological sites and valued historico-cultural places in the vicinities of existent urban fringes.

Cell-based models allow an accurate interpretation of urban growth dynamics and changes facing land use as well as its resulting impacts (Oguz et al. 2007). The importance of such models is intrinsically related to the need to monitor sustainable urbanization and is closely linked to global sustainable development (Camhis 2006). Urban Growth Models (UGM) follow a long tradition

in the spatial sciences (Wilson 1974) and have been for decades considered of great interest in simulating future growth patterns (Tobler 1970).

The cell-based model approach, due to their similarity to urban growth behaviours, is an optimal choice for tracking urban change (Batty 2005). As such, these models may have an important role in the decision-making process regarding future urban growth and regional planning strategies (Piyathamrongchai and Batty 2007). The change is conditioned by the distinct states adopted by urban or non-urban, represented as  $\mathbf{S}$ . These states,  $\mathbf{S}$ , are influenced by the subsequent propensity derived from the Markov transition matrix ( $f$ ). Thus, the state of the cells ( $Sc$ ) may be defined as:

$$Sc^{t+1} = f(Sc^t, Sn(c)^t) \quad (1)$$

The transition rule takes into account the previous time ( $t$ ) within the propensity of the surrounding neighbourhood ( $Sn$ ) moving then forward to the state in  $t+1$ .

The Markov transition matrix ( $f$ ) is calculated by the relationship of the existing change from one land-cover to another and may be represented as:

$$P_t = \begin{pmatrix} p_{11} & \cdots & p_{1Nw} \\ \vdots & \ddots & \vdots \\ p_{Nw1} & \cdots & p_{NwNw} \end{pmatrix} \quad (2)$$

$P_t$  is the probability of transition for  $x_i$  to  $x_j$  in  $t$  steps, given the weights:

$$P_{ij}(x_i, x_j) = \frac{x_{ij}(x_i, x_j)}{d_i} \quad (3)$$

and

$$d_i = \sum_{j=1}^{N_w} w_{ij} \quad (4)$$

Due to the capacity to create a transition matrix based on conditional probabilities of  $P_{ij}$ , land use change probabilities may be assessed underpinned by multi-temporal land use covers. Thus, a resulting matrix will necessarily evoke the changes occurring within a defined timespan. The mechanisms of change between  $t$  and  $t+1$  are thus detected and repeated as to allow an accurate perception of the next moment  $t+2$ , in which every pixel changes based on a transition rule as a function of the neighbouring pixels so as to form the  $t+2$  moment expressed as a land use map.

The importance of this known time reference is that of a validation that allows a future projection of urban growth for 2020. As we see, the coastal areas of the Algarve have shown the largest increase in urban growth in the last decades and tend to grow even thus becoming most probably continuous artificial areas.

The propensity map (Figure 2) for urban growth used the CORINE Land Cover data information for urban areas, proximity to road networks, population density per parish and proximity to coastal areas.

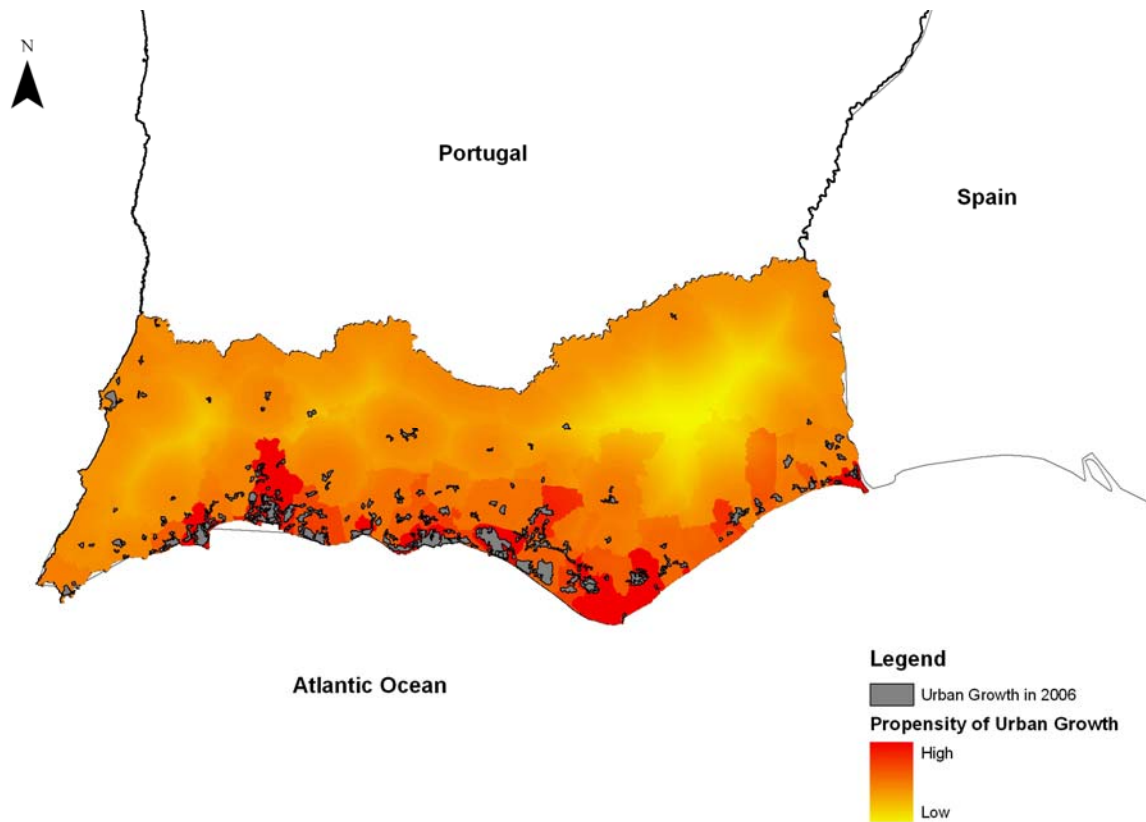


Figure 2 – Propensity of Urban Growth Map and Urban Growth by 2006

Understanding of spatial dynamic models and urban growth scenarios is important and has been studied widely in the literature (Meaille and Wald 1990; Al-kheder and Shan 2005).

Urban growth in the Algarve started suddenly in the 1960s with the exploration of the tourist industry in this region. The Algarve expanded and its littoral cities became major foci of mass tourism, especially during the summer season, due to its temperate climate and beach areas. The demand generated an increasing economic prosperity in the Algarve and took four decades later naturally its course. The Algarve has prospered due to this active industry, while the coast line of the Algarve is in fact one of the most expensive areas of Portugal for habitation, where many large and expensive investments are found.

The population in the Algarve in the winter season is a tenth of the population in the summer season. One of the problems of the hospitality industry in the Algarve has been to cope with the seasonality of the tourist industry which has far less activity during the winter time. Tourism, as such, has shown for the Algarve both, a symbiotic and antagonistic impact where antagonistic relationships are strongly linked to the rigidity of the supply in the short term compared to the elasticity of demand (Matias 2004).

The Algarve has specific fauna, flora and cultural characteristics, that make this region worthwhile of and an alternative for tourism opportunities that generate more symbiotic effects rather than the already existing antagonistic ones. The main problem lies in the re-qualification of existing urban tissue and the capacity to cope with a further landscape for adequate urbanization of those areas. Also, new urban areas support the aggregation of previously existent urban tissues, leading to a continuous artificial land cover highly endangering the natural landscapes as well as the existent ecosystem. As a consequence of this, small towns such as Olhão have become cities, where proximity to the district capital Faro transformed Olhão into a dormitory city. The consequence of this agglomeration generated a continuous urban area of circa 5 km reaching from Faro to Olhão. This continuous urban area, due to the proximity to the Natural Reserve and the existence of important cultural heritage resources, has in fact endangered the highly valued patrimony. Monitoring and creation of prospective future scenarios is an important task to avoid similar situations in future.

Currently, ongoing regional policies, such as the Programa Regional de Ocupação do Território do Algarve (PROTAL), protect some aspects of growth in the region. Still, it is important to understand urban growth in this region, as it has been modestly studied. If assessed correctly, it



may prevent future environmental collapse by a direct impact on strategic planning or sensitizing and creating social awareness.

#### **4. An Archaeological Predictive Model for the Algarve**

Since 1970 an ongoing scientific debate regarding archaeological predictive modelling has taken place. This debate has been accompanied by technological advances which led to possibilities of better understanding and predicting archaeological past. The initial models presupposed strong statistical backgrounds (Savage 1990) mainly as a result of archaeological processualism.

It was in the beginning of the 90s that APM prompted various discussions in an attempt to design new approaches. This pragmatic decade of modelling is marked by a stage in which archaeologists become quite certain that predictive modelling should not only rely on correlations with environmental factors, but also an historic non-quantifiable data has an important tool for prediction. Clearly, if a specific site location contains archaeological vestiges, the argument becomes one of available theories of spatial distribution of archaeological material as well as empirical and historical observations of site records (Wheatley and Gillings 2002). It is in this scenario that disagreement occurs more often, as scientists do not agree yet on a common methodology and a general theory which incorporates correlative and cognitive approaches. Nonetheless, in this spirit of controversy, deductive and inductive approaches for APM have risen over the past decades. The inductive models are considered to be more spatially-related, and as a consequence of empirical and analytical tools related to environmental variables. Deductive modelling focuses mainly on the available historical data leading towards a more cognitive nature. One of the classic inductive models has been the class of Logistic Regression

Models (LRM). LRM have been used since the 70's for archaeological evaluation. Considered as a classical approach towards modelling (Kvamme 1991), these models present a lack of capability to understand anthropological change due to their simple stochastic methodologies (Sebastian and Judge 1988). The existent Roman sites from a collection of site inventories were used so as to allow a total of 370 Roman archaeological sites in the Algarve. Given the bibliographical support of topography, proximity to water (Brandt et al. 1992) and the importance of trading circuits in the Algarve area during the Roman period, these variables were combined with the location of archaeological findings from the same period. This led to the following relation:

$$A = D + f_1B + f_2C + f_i x \dots + e \quad (5)$$

where  $A$  equals site density;  $B$ ,  $C$  and  $x$  represent the independent variables considered;  $f_1$ ,  $f_2$  and  $f_i$  represent the weights for  $B$ ,  $C$  and  $x$ , respectively;  $D$  is a constant, and  $e$  is an error term. Thus,  $B$  and  $C$  represent independent variables in which the relationship to the sites is of utmost importance for our model and become the key for the parameterization of a propensity map, in which the different probabilities of finding a site in a given location may be assessed. Furthermore, geographical trades such as slope, hillshade, aspect and current land-cover as well as soil type were stochastically analysed by the dependency of the variables using Kolmogorov-Smirnov statistics to infer the statistical significance with results as follows (Table 1).

Table 1 – Results of Random / Not Random variables

<b>Variable</b>	<b>Dmax</b>	<b>D K-S</b>	<b>Dmax-D K-S</b>	<b>Relation</b>
Aspect	0.153	0.079	0.07	Not Random
Elevation	0.000	0.079	-0.08	Random
Hillshade	0.075	0.079	0.00	Random
Land use	0.005	0.079	-0.07	Random
Slope	0.849	0.079	0.77	Not Random
Soil	0.194	0.079	0.12	Not Random
River Distance	0.973	0.079	0.89	Not Random

While random variables were discarded, non-random variables allowed to draw the final equation with independent variable considered as: Aspect, Slope, Soil and River Distance. This resulted in the following propensity for finding archaeological sites, defined by the tendency of finding more Roman archaeological sites in the coastal regions, than in the interior (Figure 3). The settlement patterns of the Romans in the Algarve are quite similar to the contemporary areas of city settlement, suggesting the expected secular construction of cities as in the past. Proximity to river basins and some regions of the interior in the Algarve appeared to show however, additional importance.

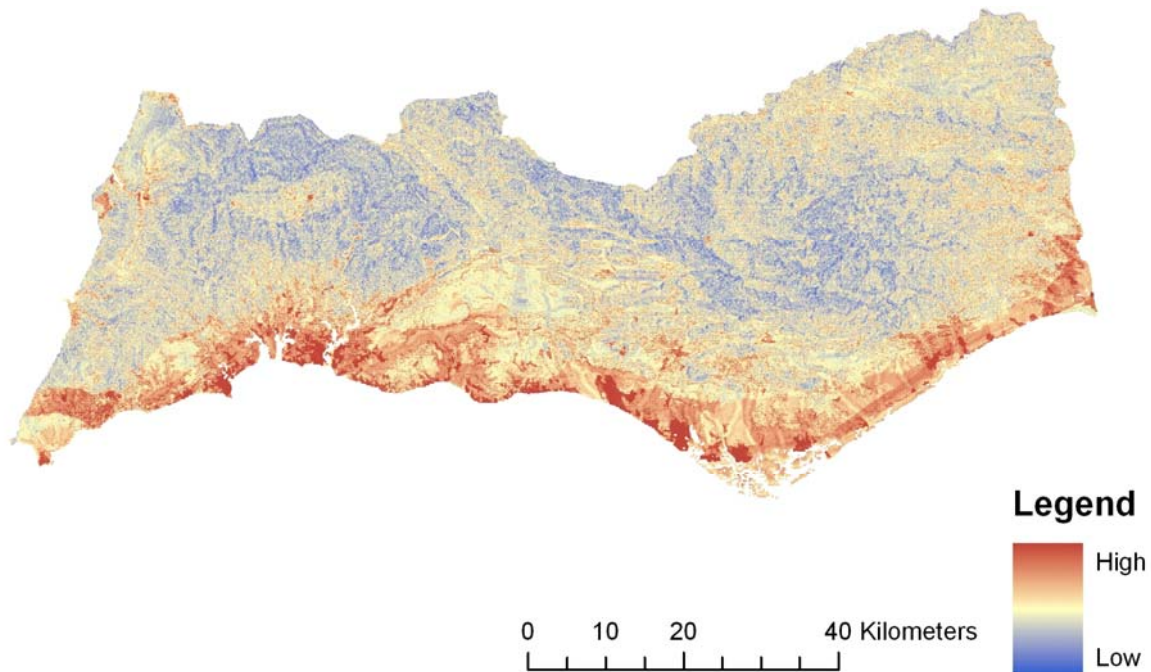


Figure 3 – Archaeological Predictive Model for the Algarve

This predictive model consisted of a sensitivity analysis of low to high propensity of finding Roman archaeological sites. As proposed by Kvamme (1999), a jack-knife sample of 70 random archaeological sites was left out of the model, so as to test the effectiveness of predicting archaeological sites. Most sites were found within the 70 to 80% range, corresponding to a satisfactory result for archaeological site propensity.

Most archaeological sites are located in the perimeters of the larger city boundaries, suggesting a settlement pattern in the Algarve since the Roman period. This relationship is consistent with the available historical resources, pointing out the location of the ancient Roman cities of *Ossonoba* in present days, viz. Faro, *Balsa* (Tavira), *Esuris* (Castro Marim), *Portus Hannibalis* (Portimão) among others. Surrounding those regions, the interior of the Algarve shares also a high propensity for Roman sites. These areas are of particular archaeological interest, and should be cherished for scientific purposes to better understand Roman civilization in the Algarve.

## 5. Urban Cultural Endangerment - A spatial modelling framework for the Algarve

The importance of cultural assets leads to the construction of a model which compares urban growth with archaeological site propensity in the Algarve. Understanding these dynamics permits a better decision process regarding: (i) preservation of archaeological sites from a cultural heritage perspective, (ii) proactively taking measures on construction sites to cope with existing heritage, (iii) awareness of for archaeological heritage preservation while sharing the local information on existing heritage. The comparison of both models was achieved by the analysis of urban growth and archaeological heritage propensity (see Table 2).

Based on the average mean of those propensities per municipality, the urban heritage endangered per municipality was assessed.

Table 2 – Urban Heritage Endangerment ( <sup>(1)</sup> Urban Growth, <sup>(2)</sup> Archaeological Heritage)

Municipality	Urban Growth	Heritage	Average risk	UHE (%)	Pressure:
Lagoa	181	185	182.92	71.74	UG <sup>(1)</sup>
Olhão	182	166	174.23	68.33	UG <sup>(1)</sup>
Faro	185	157	171.16	67.12	UG <sup>(1)</sup>
Portimão	181	153	166.81	65.42	UG <sup>(1)</sup>
Albufeira	171	157	163.91	64.28	UG <sup>(1)</sup>
Vila Real de Santo António	156	150	153.11	60.04	UG <sup>(1)</sup>
Vila do Bispo	109	148	128.61	50.43	AH <sup>(2)</sup>
Loulé	121	125	122.96	48.22	AH <sup>(2)</sup>
Tavira	76	119	97.38	38.19	UG <sup>(1)</sup>
Castro Marim	93	141	117.43	46.05	AH <sup>(2)</sup>
Silves	108	120	114.35	44.84	AH <sup>(2)</sup>
Aljezur	100	115	107.35	42.10	AH <sup>(2)</sup>
São Brás de Alportel	104	104	104.22	40.87	UG <sup>(1)</sup>
Alcoutim	79	118	98.72	38.71	AH <sup>(2)</sup>
Monchique	92	95	93.38	36.62	AH <sup>(2)</sup>

The municipalities with the highest probability of urban heritage endangerment were identified as Lagoa (71,74%), Olhão (88,33%), Portimão ( 65,42%) and the district capital of Faro (67.12%). All these municipalities represented also the highest propensity for urban growth, identifying urban growth as a key pressure for archaeological heritage endangerment.

The role of Archaeological Predictive Models is twofold: As the analysis of site location allows a better understanding of behavioural civilization patterns as proposed by traditional APM literature, nowadays it has an important impact (and less explored) in the decision-making process for sustainable development. In a region such as Portugal, where historico-cultural heritage is an important asset for the tourism industry, evaluation of the site potential can create regions with specific niches for heritage tourism.

It has been shown that Predictive Archaeological Models may be important to understand spatial dynamics from the past. Not only in a historical context could they make sense, but mostly, the capability to predict accurately the location of archaeological sites may help future technology to discover new findings as well as understanding behavioural patterns of past societies. There is much need for such work in an area such as Portugal, where little of such work has been done, although there is a vast historic and civilization background.

We may conclude generally, that the Romans in the Algarve had a similar preference as ours to spatial occupation, as the highest propensity of sites is in fact in proximity to current urban areas. This characteristic concatenated to the fact of constant urban expansion and sprawl, justifies the need of the present study. Urban growth has been a constant process in the last decades. This is an eminent concern, and has been largely discussed in a European context. Regionally, the Algarve is suffering from this problem, and the continuous growth at the constant rate it has had in recent years, will quickly in the next 15 years endanger natural and artificial patrimony. One

of the reasons which appear to be related to the urban growth areas in the Algarve is tourism, as urban areas with higher tourist activity are more rapidly expanding than others. As cultural heritage is a phenomenon which may work as a tourist product by itself, it is up to stakeholders to allow a more sustainable development of further tourist growth having in mind cultural patrimony. It is clear that urban growth cannot be hindered, and that the tendency is for the creation of mega-cities. The question is then: how can cosmopolitan areas be sustainable and conciliate fauna, flora and manmade patrimony simultaneously? This is indeed a challenge for the short future and may be a decisive step for future generations.

Monitoring in the next years the proposed areas may be a proactive approach for future preservation. As cities grow, cultural heritage teams may become engaged as housing is planned, recovering archaeological sites and cataloguing this valuable patrimony considered to be “the most universally valued and most even distributed resource in the world”. (Box, 1999). Also, the decision-making process on where to build may become more accurate, as strategies such as the PROT (Plano Regional de Ordenamento do Território) exist. Until 2020, the urban landscape will change rapidly and cultural heritage may be jeopardized. The need for action is absolute and urgent to avoid future endangerment of the studied municipalities. Special care should be taken in the municipalities of Lagoa, Olhão and Albufeira that, due to a mix of existing archaeological vestiges and historico- cultural background as well as rapid growth, seem to be mostly jeopardized. Olhão shows a very high propensity for cultural heritage and further excavations and ongoing research regarding this municipality should take place especially in the areas of imminent urban construction. Much work can still be done regarding both studied dimensions. Regarding Archaeological Predictive Modelling, it has been shown that despite divergences from the scientific community, they are an important tool which may be used in a regional context.

Thus, new methodologies that intertwine the doubts of the scientific community are of much importance. As APM become more accurate avoiding the problem of accuracy and consistency (Berman, 2006), urban growth models have to be better understood. Using GIS for UGM is a mandatory direction for future urban planning and predicting the scenarios in such a context is very important. Analysing urban growth with CORINE Land Cover seems to be a sound direction, as it is the actual European spatial data inventory that shows the scenarios for an entire European tendency of growth. Still, the Minimum Mapping Unit of the CORINE Land Cover as we have seen is quite large, and as a result, it would be an interesting opportunity to study how accurate CORINE Land Cover may become, or actually, is in an urban growth study context.

The future is challenge indeed a question of European and regional synergies in an attempt to build solid information as well as to create knowledge. The transversal research areas called for in such a venture share a common ground in the usage of IT and GIS in order to shed clear light of monitoring and sustainable planning. Above all, the present study has made us realize that the most important future step for sustainability is the need to work together and think together in an attempt to grasp new processes and ideas that may create more accuracy on proposed methodologies in the hope of sustainable preservation and growth. From a short-term perspective, a stronger focus should stakeholders must lead to the promotion of cultural awareness supporting, for example, tourist services related to heritage tourism which might boost the local and regional economy while reducing negative externalities (Vaz and Nijkamp 2009).



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