6-16-2013

A multi-dasymetric mapping approach for tourism

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to be submitted: Tourism Management

Abstract

The challenge of measuring at municipal level tourism density has been a daunting task for both statisticians and geographers. The reason of this is enforced by the fact that administrative areas, such as municipalities, tend to be large spatial administrative units, sharing a large demographic asymmetry of tourist demand within the municipality. The rationale is that geographic characteristics such as coastal line, climate and vegetation, play a crucial role in tourist offer, leaning towards the conclusion that traditional census at administrative level are simply not enough to interpret the true distribution of tourism data. A more quantifiable method is necessary to assess the distribution of socio-economic data. This is developed by means of a dasymetric approach adding on the advantages of multi-temporal comparison. This paper adopts a dasymetric approach for defining tourism density per land use types using the CORINE Land Cover dataset. A density map for tourism is calculated, creating a modified areal weighting (MAW) approach to assess the distribution of tourism density per administrative municipality. This distribution is then assessed as a bidirectional layer on the land use datasets for two temporal stamps: 2000 and 2006, which leads to (i) a consistent map on a more accurate distribution of tourism in Algarve, (ii) the calculation of tourism density surfaces, and (iii) a multi-locational and temporal assessment through density cross-tabulation. Finally a geovisual interpretation of locational analysis of tourism change in Algarve for the last decade is created. This integrative spatial methodology offers unique characteristics for more accurate decision making at regional level, bringing an integrative methodology to the forefront of linking tourism with the spatio-temporal clusters formed in rapidly changing economic regions.

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1. Introduction

Understanding the spatial dynamics of demographic transitions is of utmost importance to generate an accurate profile of distribution of spatial phenomena (Turchin, 2003). It has however been a challenge to cope with the cartographic constraints of using the available administrative boundaries. This challenge is a result of: i) size, where the scale of the area of the administrative boundary often does not correspond to the spatial distribution (Turner et al., 1989), ii) the demographic distribution at spatial level itself, that is often not homogeneously linked to the total area of the aggregate population (Rees and Wilson, 1972), iii) the rationale of ecological fallacy, where misinterpretation of the population occur due to surrounding neighbours with a certain demographic profile (Kramer, 1983). This is particularly visible in regions where peri-urban areas are detached from urban land, and possible negative externalities occur due to excessive pressure. In this sense, larger dissemination areas in a population count to estimate density over space are often an imprecise representation of the real geographical distribution. Moreover, they do not offer an integrative vision of the population dynamics both over space and time leading to misinterpretation of data. This has been described by Openshaw (1983) as the modifiable area unit problem (MAPU) where scalability of information influences the results on the spatial perception. From a statistical perspective, this limits the geostatistical interpretation of administrative boundaries and information about the space and territory (Xing-zhu and Qun, 2013). Regarding applications such as tourism, where a concise understanding of location and distribution is of utmost importance perception of the spatial distributions is of great importance. Spatial distributions reinforce strategic decision where often traditional statistical and economic information fail to respond with the same accuracy. It is noted that the contribution of spatial information develops more accurate and descriptive quantitative information that can then be

integrated in the fields of economic and sociology. In line with the traditional and often unrealistic distributions of demographic data in conventional areal units, this is of great importance for decision making. For Europe, this often pertains to the notion of municipality, where discrepancies within a single municipality are large, and spatial distribution not homogeneous. In very active tourism regions throughout the world such as the Algarve, this information may be entirely misleading. Techniques for dasymetric mapping of population, can be used as useful methods to assess the density of tourism, and allow more accurate information on demographics, than expected in the traditional interpretation of spatial administrative boundaries. In line with the importance of fomenting sustainable Tourism as well as the importance of creating tools that contribute to sustainable development and growth, dasymetric approaches become adequate for management due to their quantitative and spatial properties (Petrov, 2012). The rationale is simple and elegant: volumetric data, such as population density, can be easily adapted do different data sets, such as land use, allowing creating a more explanatory framework of the configuration of a given set of variables along space. The method itself engenders a technique to avoid the traditional ecological fallacy, often present when defining traditional mapping approaches. In observing an area such as the Algarve, this becomes even further important given the excessive growth the coastal urban region has witnessed, and the importance to monitor and perceive population density transitions accurately at local level. The changes in population dynamics have been a growing concern in Europe, and under the current economic recession, urbanisation and land use changes must be carefully planned and match drivers of economic drivers, such as Tourism in line with regional performance and spatial allocation.

2. Study Area

The district's capital of Algarve is Faro, located at 37°0′52″N 7°56′7″W. The region itself presents mostly a rather shallow elevation of 11m, peaked by the mountains to the north, delimiting the three geomorphological regions of the Algarve: *Serra, Barrocal*, and *Litoral*. These three sub-regions have each a unique landscape, biodiversity and local social and economic characteristics. It is with this diversity that Algarve has become since the sixties a unique tourist region. Until the 19th century, the region was famous for its agricultural and piscatorial traditions, linking early industrial production with the exploration of rural and agricultural landscapes at the abundant wetland systems. The region itself has a strong link with three major civilizations, the Phoenicians, the Romans and the Moors. The abundance of heritage legacy surrounding the region's landscapes and the unique ecological habitats recognized by the NATURA network have generated a high demand of international travellers to visit Algarve, leading to a strong tourism industry and the shaping of Algarve as a unique destination for sun, beach, and beauty of landscapes alike (Vaz et al., 2012). As pointed out by Vaz and others (2013), Algarve is one of the regions strongly jeopardized in the NATURA 2000 initiative, as 38,6% of the territory is part of this natural ecological reserve, and is bound to constraints due to the excessive pressure brought by rapid urbanisation. With a total of seventeen NATURA sites, socio-economic growth must be monitored carefully, as to avoid continuous eutrophication of wetland reserves (Zaldivar et al., 2008) and focus on sustainable tourism opportunities by recognizing the importance of planning and management of the distribution of pressure areas at local level, that continue to add stress on the landscape. One of these pressures is the concentration of population, aggravated by the excessive disparity of the Tourism demand in the summer months. This could lead to irreversible damage on the natural landscape, as well as

negative externalities along the the coast, where most of tourism activity is located. The strategy of diversifying tourism options in line with sustainable development (Perreira et al., 2003) is quite appealing and of utmost importance, but must be matched with adequate tools to monitor, assess and define relevant indicators that cater to better and more robust policies at the local level. This is especially the case in the coastal regions of Algarve, where tourism has been rather concentrated, leading to overburdening of carrying capacity of fragile coastal perimeters, such as is the case of Loulé, Albufeira and Portimão (Figure 1).

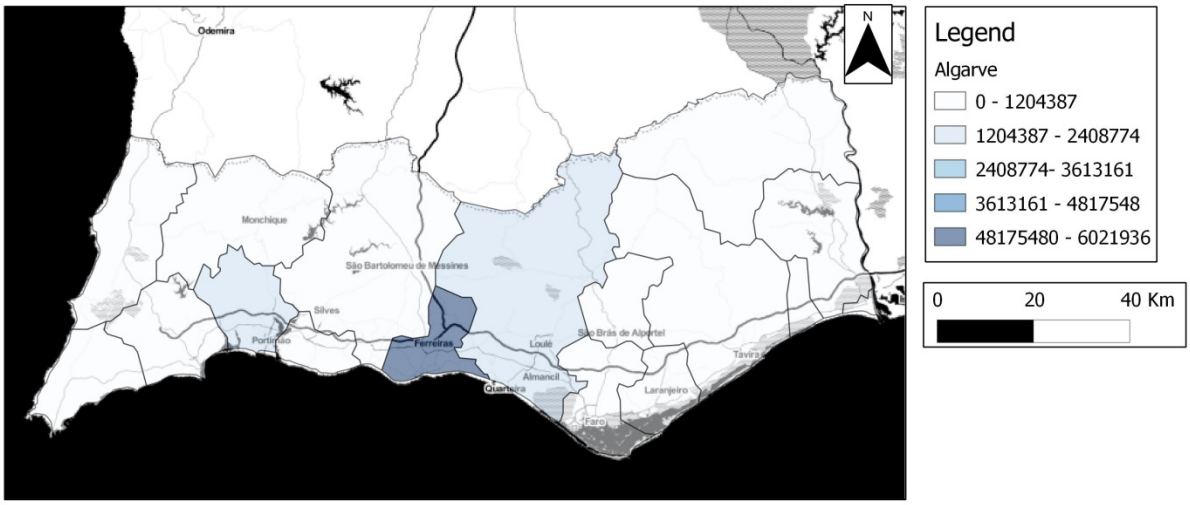
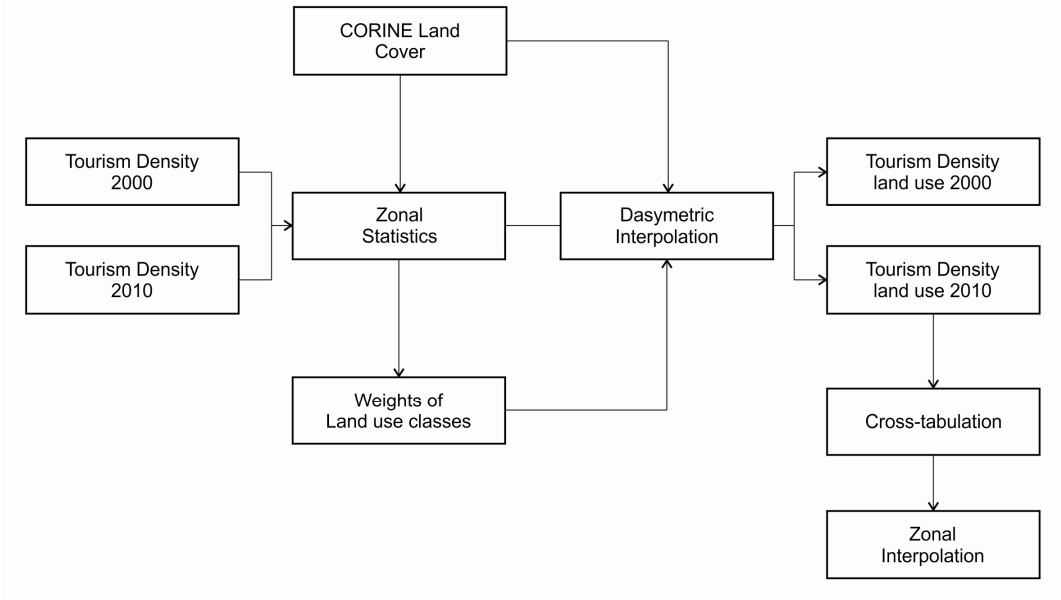


Figure 1 – Tourism count in Algarve in 2010

3. Methodology

We propose a combined methodology taking advantage of spatially weighted dasymetric calculations, and using zonal information for spatial interpolation of land use for Tourism (Figure 2)



The usability and application of dasymetric mapping has been widely well known in the field of geography since the mid-thirties (Wright, 1936). The author proposed a method to offer a more realistic vision of the distribution of population, given the constraints of terminal-mountain range ridges and areas that were located in wilderness, and therefore should not have a cartographic representation of habitable areas. The technique use consisted of a simple equation to measure out a density function of population by division of township, where m and n are obtained by the division of a given township into two parts that disaggregate population into sparse m and dense n. This was done by topographic interpretation, offering a vision of an average density of population as follows:

$$\frac{D - D_m a_m}{I - a_m} = D_n \quad (1)$$

Where D is the average density of population of the township as a whole, D_m the estimated density in m, a_m the fraction of the total area of the township comprised in m, and $I - a_m$ the fraction comprised in n, and D_n the density that must accordingly be designed to n. This allowed an approximate distribution of population density (Wright, 1936). This simple start of dasymetric mapping became much more elaborate, in particular given the definitions of the variables m and n, that is, the division per township based on cartographic evidence has in the last years become much more accurate due to the existence of spatial inventories that allow to generate stochastic methods of representing population density per land use more clearly. This has been well structured by Gallego and Peedell (2001), where an assessment of population density estimation is carried out assuming a homogenous behaviour over space, where a regression type coefficient can allow understanding population density correlated with land use over large areas. The correlation coefficient allowed the authors to estimate a weight at county level of population density per land use class, leading to a better understanding of the distribution of population density at more accurate scales then the traditional census configurations. Such approaches allow thus for a more accurate understanding of the statistical and geostatistical interpretation of space, leading to a better perception of the possibilities of evaluating zones more accurately. The techniques and the applications of dasymetric mapping in other fields have however not yet been thoroughly assessed (Eicher and Brewer, 2001). The applications of a geostatistically sound dasymetric mapping approach are well described by Langford and Unwin (1994) who offer a binary approach by comparison of land use typologies and comparison of the population density distribution rendering the distribution as a population density surface. The advances in the quality of land use inventories and high resolution satellite imagery are at present allowing mapping population density even at higher scales and for larger regions (Silva et al., 2013).

These advances have started to bring new interpretations of spatial demographic distributions over density surfaces, applied to different fields of research (Mitsova et al., 2012; Shannon and Harvey, 2013). The ability offered by dasymetric mapping has over a century of applications where the recent advances are bringing additional possibilities for regional and local techniques, and have been applied to different fields in line with Geographic Information Science and cartography. It is only natural that such a concise technique, while allowing a better extrapolation of crucial spatial information, should be applied in the social science, in particular, in fields of research that merge planning, with population distributions and optimization of land and environment. One of these lines of research is tourism, where spatial analysis has shown to lead to optimization of planning and more sustainable and better management.

3.1. An application of dasymetric mapping to the Algarve

Mass tourism developed in the Algarve in the sixties lead to a growing demand and often irreversible construction of infrastructures for the tourist sector. The hundreds of infrastructures that were built, ranging from hotel units in fragile coastal stretches to abandonment of rural areas, led to an intensive destruction of the natural landscape and fragile ecosystems. This brought a great challenge on the region to cope with urbanisation processes in the nineties that lead to a soaring local economy. The International Airport of Algarve, located in the district capital of Faro, is an example of the growing supporting tourist infrastructure that at present is expanding and led by international stakeholders. Nevertheless, tourism concentration is intrinsically spatial. This spatially explicit characteristic of tourism is visible in the attempt of finding the optimum of location to satisfy demand, and offer in return unique landscapes and ecosystems that show the

diversity of Algarve. This locational optimum however is often directly linked to the productions of goods and services that may have fundamental impacts on the carrying capacity of the environment. In the case of Algarve, this has been found to be a result of the increasing tourism demand that must be followed by better monitoring of the supporting urban and rural infrastructures. This creation of supporting urban regions is often linked to discontinuous urban fabric, resulting from leapfrogging as to find the most attractive value in the most pristine locations for tourism. Figure 2 accounts for the distribution of land use cells for the Algarve, where discontinuous urban fabric is much more present than any other land use class.

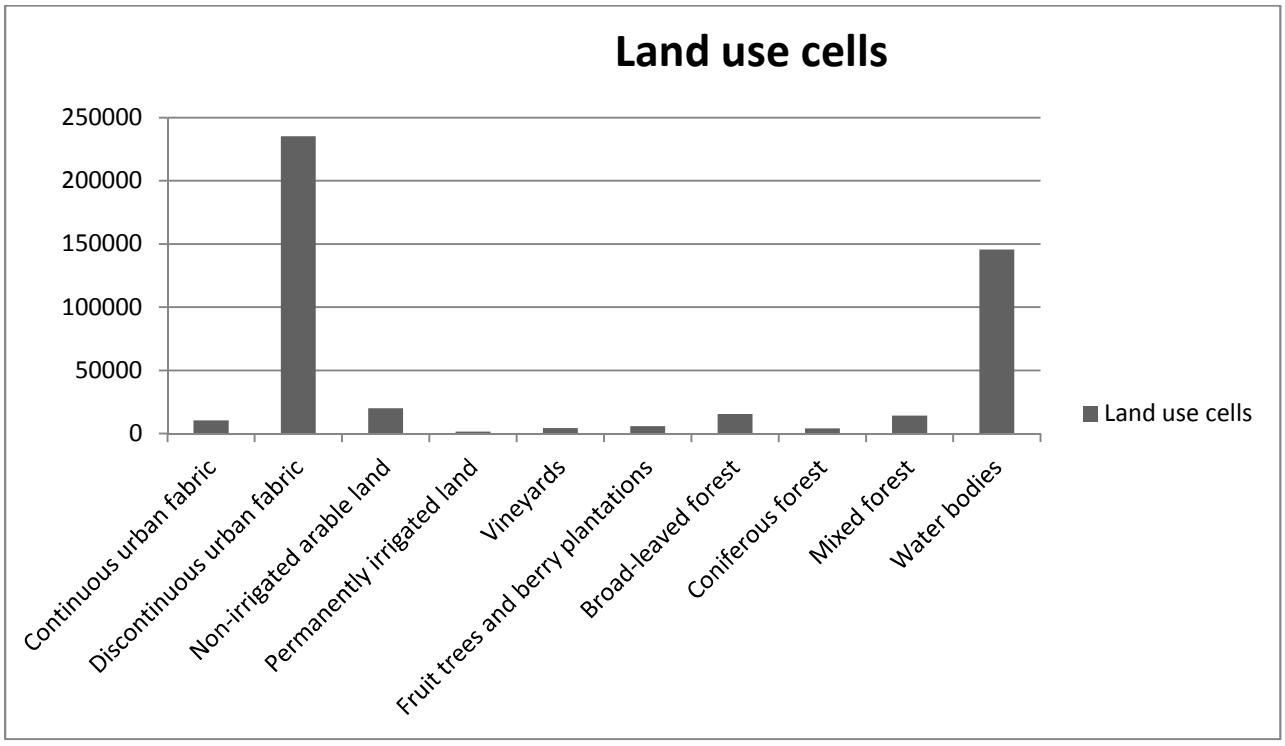


Figure 2 – Distribution of land use in the Algarve

Urbanisation and population increase are a consequence of economic growth, showing from one side the importance of tourism for the region, but adding on the need to inspect carefully the

relations of population dynamics, in particular tourism concentration in regions, and the integration of strategies of planning per land use sustainability. Dasymetric and Geographic Information Systems combined may lead to better awareness of the multi-temporality of tourism density change, and Algarve offers to be a fascinating study case for such an assessment. The assessment was first observed by means of interpolating the CORINE Land cover data for 2006 into raster format. This permitted a cell based division where a count function of every single land use cell per municipality was carried out.

3.2. Dasymetric results for the Algarve

The weighting coefficient was calculated by creating a zonal histogram of land use per municipality.

$$LU_n = \frac{LU_i}{\sum_{i=1}^{n} LU_i} \tag{2}$$

Where, LU_n is the normalized land use type per each class in a municipality, and LU_i corresponds to each individual land use type. This leads to the calculation of C_i, defined as the coefficient weight where:

$$C_i = \frac{LU_n}{\sum_{i=1}^{n} LU_n} \tag{3}$$

The weighting coeficients were applied for the entire region of the Algarve, and a dasymetric test was sampled by means of a the demographic estimate originating the following maps (Figure 3).

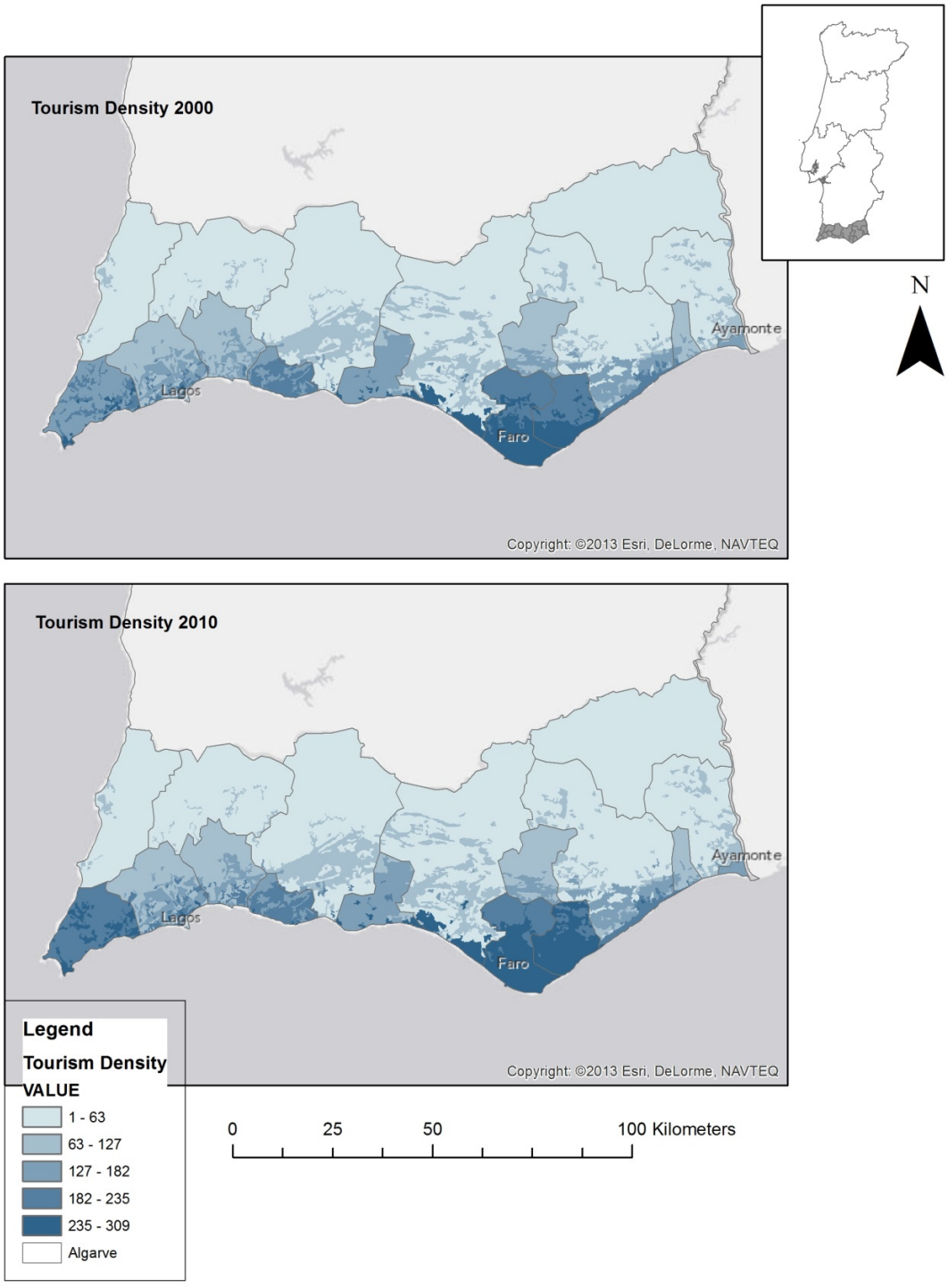


Figure 3 – Dasymetric calculation of Tourism density in the Algarve in 2000 (top) and 2010 (below)

Discussion

The Algarve region took part of tourism growth during the 60s, when Faro International Airport started operations. The rapid growth of tourist demand that followed meant, from the supply perspective, the continuous increase of accommodation offer, related touristic facilities and enclave tourism spaces (Brito, 2009), catering for visitors in search of sun, sand and sea experiences. The specialization in sun, sand and sea type products that dominated for over four decades (Martins and Centeno, 1999) have been a growing regional concern, given the high seasonality during summer, overburdening the carrying capacity at local level. This monoculture of tourism generated both socio-economic and environmental negative impacts, professing profound impacts on unmanned urban sprawl as well changes in traditional economic sectors. The impacts of dasymetric change at land level show an interesting trend in the distribution of tourism in Algarve over the last decade (Figure 4)

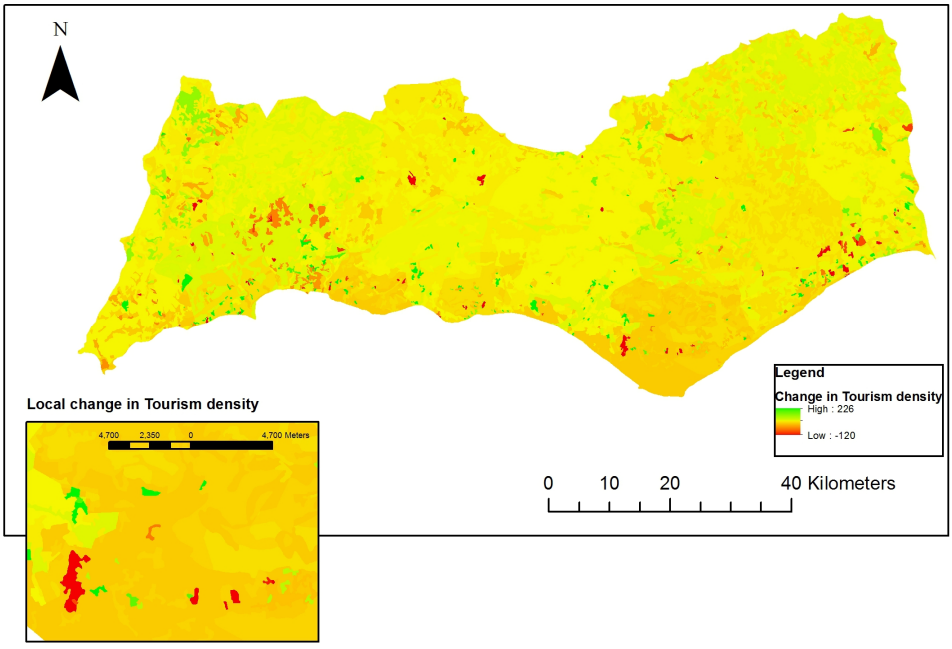


Figure 4 – Changes in Tourism density patterns between 2000 and 2010

Alterations in tourism distribution in Algarve point to an increase of occupation of inland areas, mainly in the *Barrocal* strip and, in contrast, a decrease in coastal areas. From a geographical perspective, data obtained are most revealing in terms of the evolution of tourism in the region.

In fact, changes observed are due to the convergence of factors of demand, supply, as well as the investment made by regional governmental bodies in the adoption of policy instruments adapted to a holistic approach to tourism development.

In general terms, it is now widely acknowledged that tourism behavior has changed relatively to previous decades during the predominance of the mass consumption and production paradigm (Torres, 2002). In what has been labeled 'the experience economy' (Pine and Gilmore, 1999) of post-modern societies (Cova, 1996), tourists as consumers are adopting new personal and consumption values and expressing new motivations with impacts on destination choice. Despite individualism manifestations in behavior, ethical and sustainability concerns are surpassing considerations of strictly egoistic wants and needs (Yeoman et al., 2007), and destinations offering sustainable environmental and social systems are more likely to capture the attention of touristically experienced and mature visitors. In addition, there is greater awareness of the complexity behind tourist motivations, and educational motives associated with discovery, knowledge acquisition, learning, and personal development (Andersson, 2007, Morgan et al., 2009) add to more traditionally known motivations of relaxing and escaping from everyday environment and routines (Bansal and Eiselt, 2004).

In terms of evolution in the tourism industry, most prominent mutations relate to the globalization of competition, with destinations available in almost every corner of the globe (Page and Connell, 2006), and the pervasive awareness of planning the development of tourism

destinations in harmony with principles of economic, social, and environmental principles and values (Ritchie and Crouch, 2003) which followed the announcement and approval of international programmes meant to address global sustainability issues, such as the United Nations Environment Programme and the AGENDA 21 (Middleton and Hawkins, 1998).

The design and use of policy instruments to regulate tourism growth and development at the destination level currently integrate sustainability concerns identified by international bodies and agencies, and the same is true of the Algarve region. Algarve is undergoing changes in terms of instruments conceived to divert four decades of unplanned tourism growth, and these have been acknowledging the dependence of tourism activity from spatial contexts and their particular characteristics, either natural or man-made. For instance, in PENT (*Plano Estratégico Nacional Para o Turismo*), the national plan for the strategic development of Portuguese tourism, it is stated that 'in order to improve the [Algarve] region's performance it is necessary to create a set of initiatives for product development, as well as transversal actions aiming at all tourism products, while paying special attention to land use, environmental resources, protection of the coastline, and heritage preservation'.

PROTAL 2007 (CCDR, 2007) is a plan for the land use of the Algarve region. In this document, tourism is considered a strategic and competitive dimension in the development of the region and recognition of regional asymmetries claims urgent regulation of tourism development in the coastline, on one hand, and the need of developing touristic activity in inland areas, on the other, through stimulation of diversification of traditional tourism products. Similar propositions may be found in the *Development Strategy for Algarve 2007-2013* (CCDR, 2006), designed by the Regional Committee for the Development of Algarve (CCDR), namely the need to spatially distribute tourism offer. Spatial distribution is to foment coastal rearrangement and restoration,

environmental protection and enhancement, but also the renewal of urban heritage mainly found in inland zones (e.g. traditional settlements and villages).

In fact, inland Algarve (especially Barrocal and Serra) have been hugely affected by massive investment and concentration of tourism activity and business in the coastline, eventually becoming low density areas in terms of population and urban settlements. Low density areas in Algarve have been characterized as declining spaces in terms of rural life, cultural and economic activity, yet with great potential for sustainable tourism development (CCDR, 2002). The lack of proper tools for sustainable tourism development had been found a major weakness of the region (CCDR, 2006). Stronger efforts are being made to overcome this specific problem and programmes have been implemented to stimulate economic, cultural and touristic dynamics in most affected areas. Particularly the PROLOCAL programme (CCDR, 2002) comprehends four lines of action (*Algarve Villages, Thematic Networks, Urban Renewal, and Endogenous Potential- Pilot Projects*) which together aim to achieve the following objectives: the restructuring of urban settlements, the protection of natural resources and tangible and intangible heritage, infrastructures improvement necessary to assist local production, quality improvement of human resources, improvement of public performance, and diversification of regional production. Planning instruments for a sustainable and holistic approach to regional development, in which tourism plays a key role, converge to common notions of Algarve's weaknesses and strengths alike. The intensification of use and implementation of these instruments, in harmony with stronger efforts to promote the region as a quality sustainable destination (CCDR, 2007) may explain partially the data found on tourism density changes.

Many spatial clusters, especially located along the coastal areas have changed, some of these areas had been prone in the nineties to summative investments in the tourism industry in Algarve.

Areas such as Vilamoura, Quinta do Lago, and an overall trend in the coastal regions of Algarve has witnessed a decrease in tourism. This is a result of two antagonistic forces felt in southern Europe: the clash between traditional tourism ventures of sun and beach products and more attractive destinations at international level with equally competitive prices, and the demand for alternative tourism products related to sustainable and ecological tourism choices. In an attempt to satisfy tourist demand, businesses disinvested in traditional economic activities, such as fishing, agriculture and manufacture of regional productions, and residents abandoned rural areas in search of better life conditions in the coastline towns, with dire consequences in terms of inland desertification. The specialization in tourism along with highly seasonal visitor flows eventually pushed inhabitants to face severe constraints related to sustainable economic dynamics, urban and coastal traffic, carrying capacity of places, leading to the gradual jeopardize of local communities' quality of life (Ahn et al., 2002). On the other hand, the growing investment made by the private sector on *coastal* tourism generated environmental negative effects, such as massive building in sensitive areas (cliffs, wetlands, and dunes), soil and aquifer contamination, natural resources depletion, and generally speaking, disruption of ecosystems' balance (CCDR, 2007). This in fact, represents an opportunity for consequently redefining the current structure of tourism demand in Portugal and in southern Europe. The Algarve region, given this spatial change in moving to more pristine areas and natural areas, could consolidate the demand for ecological tourism and reconfigure the morphology of the overburdening coastal tourism. Alas, the existing infrastructures built largely three decades ago share a lesson learned for the future and a warning that tourism must be thought in line of unexpected changes in economic growth, and therefore must be a reflex in line with the landscape and sustainable development. The current strategy foments this by integrating public authorities and stakeholders

involved in regional development progressively started to address critically the issue of traditional tourism development. This is achieved by becoming aware of the need to deal with negative externalities of tourism growth in destinations by adopting a sustainability approach to management (CTP, 2005, Coelho et al., 2010). Policy instruments have been designed and implemented to meet the needs of the tourism system stakeholders, and concrete actions have been taken to leverage the rehabilitation and renewal of urban areas, requalification of accommodation units and the promotion of cultural heritage and activities (Brito, 2009). From an environmental point of view, regulations have been adopted to control environmental damage by means of restrictions applied to construction in sensitive areas, delimitation of protected areas, and use of zoning methods (CCDR, 2007, Taveira Pinto, 2004). No tourist destination is immune to external and internal forces that influence and can endanger its attractiveness and competitiveness (CTP, 2005). Globalized competition, fashion issues, changes in visitors' preferences and motivations, and widespread ecological awareness are among the factors that affect the spatial distribution of tourist flows and, as a consequence, destinations' competitiveness and attractiveness. On the other hand, problems associated with the lack of residents' quality of life due to pressures put on the natural and built environment claim urgent action in terms of design and use of planning, management and monitoring tools able to assist the making of decision. The sustainability paradigm applied to tourism means the adoption of instruments adequate to support the controlled development of the system so that social, economic, and environmental positive effects occur to the benefit of stakeholders (Inskeep, 1991, CCDR, 2007). In light of the above, as Bansal and Eiselt (2004) argue, government and tourism planners must converge in dealing with tourism development main issue which is *where to locate new facilities and which type*. In this context, dasymetric mapping in addition to Geographic

Information Systems may provide valuable assistance to tourism management and the making of responsible decision.

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