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Exploring the impacts of future tourism development on land use/cover changes

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ABSTRACT

Land use/cover changes (LUCC) are central to tourism because land is used in multiple ways as a resource for tourism-focused activities. Tourism is essentially a geographical phenomenon, encompassing the movement and flow of people (seen as the demand side) and spatial distribution patterns relating to land use consumption (seen as the supply side). However, the impacts of tourism on LUCC are difficult to track and monitor. Contributing factors of this problem include a lack of empirical studies, shortage of micro-level LUCC datasets, and scarce methodological frameworks which can be used for assessments. This paper aims to provide a LUCC modelling approach in order to explore the impacts of tourism development on built-up areas. We developed a Cellular automata model (CA) which integrates Markovian transition probabilities and logistic regression transition suitability maps. LUCC rules for tourism development are framed within the national land use policy guidelines for the development of new tourism accommodation establishments (TAE). This primarily takes into consideration land cover compatibility and the proposed development's proximity to the coastline.

Three scenarios were established to explore the impacts of tourism development in LUCC for the year 2020 in a Portuguese coastal region: business as usual (BAU); tourism trends (TOUR); and natural restrictions (NATR). TOUR results indicate that the tourism and urban land use/cover growth is higher and focuses heavily on the coastal region (within 5,000 m) when compared to the other scenarios. The overall results for BAU and NATR show a general convergence with the land use policy guidelines in terms of tourism nucleation and new TAE distance to the coastline.

1. Introduction

Tourism is a geographically explicit phenomenon that encompasses the movement of people — for leisure related purposes — between their origin and destination(s). Pearce (1979) stated that movement is the fundamental element of tourism, and no other discipline concentrates on spatial patterns of tourism phenomena as much as geography (Mitchell & Murphy, 1991). Tourism geography focuses on major areas of interest including spatial patterns, geography of resorts, movements and flows, and the impact of tourism. Lew (2001) argues that the focus of tourism geography research is mainly on the 'how', 'why', and especially the 'where'.

The use and conversion of lands is central to tourism and can be directly linked to tourism development, for instance, by means of constructing tourism accommodation establishments (TAE), vacation homes, golf courses, shopping areas, roads; or indirectly, such as the production of food to supply hotels and restaurants and to manage waste; among others (Gössling, 2002). Nonetheless, one should notice that the area influenced by tourist activities is larger, including, for example, beaches and natural parks. Areas which are not built-up can also be affected by the fragmentation of neighbouring areas. Even though the use and conversion of lands is central to tourism, it is difficult to calculate and measure (Gossling & Peeters, 2015; Gössling, 2005). This is related to: (i) the lack of micro-level georeferenced datasets, (ii) the large number of assumptions required, and (iii) the difficulty to track tourism-related activities that provide services to tourists and also to local communities (e.g. restaurants).

Traditionally, tourism research has focused on conceptualizing the evolution of destinations (Butler, 1980; Christaller, 1963; Miossec, 1977; Prideaux, 2000, 2009; Smith, 1991), thus overlooking the impacts on LUCC. Methodologies used in traditional

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tourism research show limitations for monitoring, assessing, and modelling LUCC. However, the availability of new datasets and modelling tools, such as Geographical Information Systems (GIS), may provide a basis to advancing LUCC studies in tourism research. This paper aims to develop a LUCC modelling approach to explore the future of tourism development and its impact on built-up areas in close proximity to the coastline. The methodology is supported by a case study of Coastal Alentejo, a Portuguese costal region categorized as NUTS3 (Nomenclature of Territorial Units for Statistics) for statistical purposes. The modelling approach integrates Markovian transition probabilities computed from satellite-derived land cover maps, logistic regression transition suitability maps and Cellular automata (CA).

The paper is divided into six sections. Following this introduction, in Section 2 the relationship between LUCC and tourism development is discussed and empirical studies into traditional research are presented, namely applications of CA in terms of exploring the impacts of tourism development on LUCC. In Section 3, tourism development in Coastal Alentejo is described, focusing on the land use policy guidelines used since the 1980s. Implications for the current regional tourism development model are highlighted. Data and methods used in this research are described in Section 4, while Section 5 presents and discusses the model's results. The main conclusions are presented in Section 6.

2. Theoretical background

2.1. LUCC and tourism development

Tourism is one of the largest industries in the world and accounts for 1 in 11 jobs, generating 9% of global GDP and in 2014 was linked to 6% of all exports (UNTWO, 2014). While visiting a destination tourists engage in activities and produce consumption patterns that can trigger major transformations within the place, particularly in terms of LUCC. In relation to Portugal, since the 1960s the demand for summer vacations resulted in the increase of artificial surfaces to support the development of tourism establishments and second homes in coastal areas. Coastal areas provide the main tourist destinations, thus LUCC occur particularly in these areas. From 1990 to 2000 artificial surfaces registered a 20–35% increase, mostly due to residential sprawl (Freire, Santos, & Tenedório, 2009).

Given the spatial implications that tourism development encompasses one should expect that scholars are exploring its effects on LUCC. However, there are few empirical studies in the literature, mostly because of the lack of micro-level datasets that enable a relationship between both phenomena to be established. LUCC studies are based on land cover maps that rely on remote sensing data, which until recently was often acquired within an inadequate time and spatial scale. Moreover, LUCC caused directly by tourism is difficult to track. Even when considering only the direct impacts of tourism development on LUCC – such as land conversion for the constructions of TAE – georeferenced datasets of implantation polygons of establishments are often unavailable, making it difficult to assess the impacts of direct tourism development on land conversion without thorough fieldwork.

Most of the studies exploring the impacts of tourism development on LUCC use GIS and remote sensing tools (Atik, Altan, & Artar, 2010; Boori & Vozenilek, 2014; Chaplin & Brabyn, 2013; Dong, Yu, & Liu, 2008; Wang & Liu, 2013). These studies are analytical and aim to explore changes that occurred in the past, over a specific period of time. However, LUCC modelling approaches aimed at exploring the different potential futures of tourism development are scarce. Exploratory models can support the forecasting of 'what-if' scenarios by mimicking real-world dynamics, providing a means of assessing future impacts of tourism on LUCC.

2.2. Exploring LUCC related to tourism development using CA

Though the traditional tourism forecasting methods are typically linear and deterministic, the system under study is dynamic and influenced by unpredictable externalities (Baggio, 2008; Faulkner & Russell, 1997; McKercher, 1999). Computational modelling and simulation approaches have been gradually applied in the context of tourism, such as system dynamics (Jamal, Borges, & Figueiredo, 2004), CA (Petrov, Lavalle, & Kasanko, 2009), and agent-based modelling (Balbi, Giupponi, Perez, & Alberti, 2013; Boavida-Portugal, Ferreira, & Rocha, 2015; Johnson & Sieber, 2009, 2010; Johnson et al., 2016; Pizzitutti, Mena, & Walsh, 2014).

The application of CA in geographical modelling was originally proposed by Tobler (1979), the author of the first law of geography which states that "everything is related to everything else, but near things are more related than distant things". This is directly related to LUCC as it is modelled on the means of transition of cellular states, and governed by spatial interactions between each cell and its neighbouring cells according to specific transition rules. CA simulation of dynamic spatial patterns has widely been applied in several LUCC studies and there is an entire body of research on this topic (e.g. Basse, Omrani, Charif, Gerber, & Bódis, 2014; Batty, Xie, & Sun, 1999; Torrens, 2003; Verburg, Schot, Dijst, & Veldkamp, 2004). However, there are still very few studies which apply CA when it comes to exploring the impacts of tourism on LUCC. For instance Petrov et al. (2009) offer a CA based approach to explore future urban LUCC scenarios (e.g. in 2020) for a tourist region in Portugal and explore the implications for urban planning. Mao, Meng, and Wang (2014a, 2014b) applied a system dynamic/cellular automata hybrid model to analyse tourism-affected LUCC (1989–2010) in China. The authors developed scenarios to project the most likely future LUCC under different development assumptions. Results show that tourism development affects LUCC by increasing the demand for construction and growth in built-up areas, while contributing to deforestation and forest degradation.

3. Study area

Coastal Alentejo is a NUTS3 region located in the south of Portugal (Fig. 1), approximately 5,300 km^2 in size and home to 98,000 inhabitants. The sub-region has recognized its tourism potential, as highlighted by the National Strategic Tourism Plan 2013–2015 (PENT) as a touristic development pole. In 2014, the sub-region had 103 TAE classified by the national tourism authority (TP), with a capacity for 6735 guests, and received 220,539 tourists in a total of 521,154 overnight stays (Statistics Portugal, 2015). Coastal Alentejo has a set of distinctive features that provides an attractive atmosphere for tourists. Around 73% of Coastal Alentejo is covered by natural protected areas encompassing several land use restrictions, namely to prevent an increase in built-up areas (presented in Table 1). This fact, together with the projected increase in tourism supply, raises awareness about issues such as the promotion of sustainable tourism development or balancing the trade-offs between TAE development and the preservation of the natural environment.

3.1. Evolution of the national land use policy guidelines

Interventions in land use planning in Coastal Alentejo took a restrictive approach in terms of managing the pressures of tourism development. In the 1980s there were several intended touristic investment opportunities characterized by projects which would

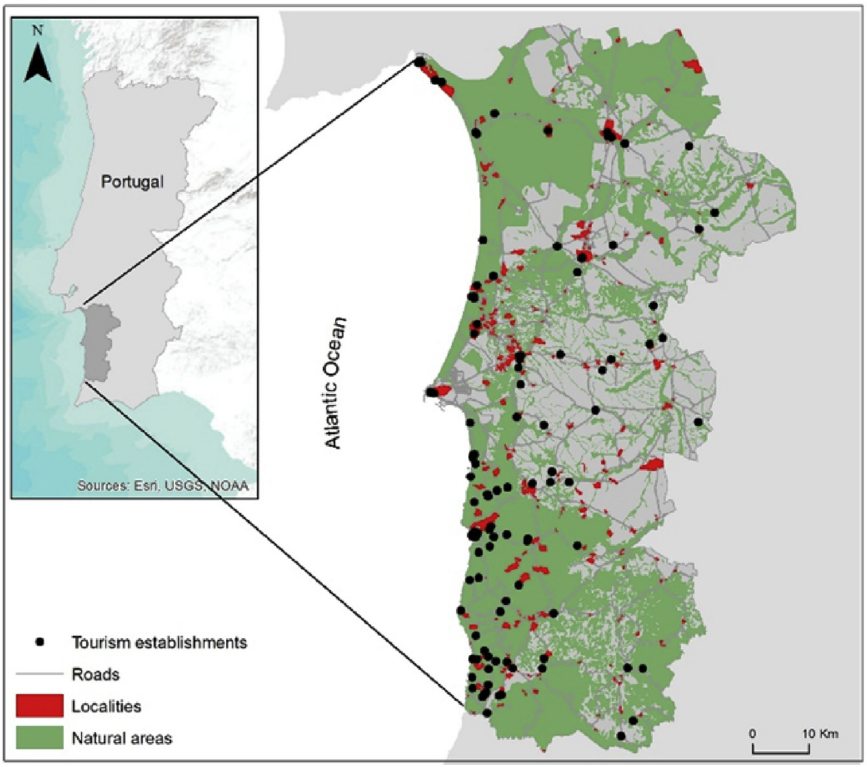

Fig. 1. Map of Portugal and the location of Coastal Alentejo NUTS3.

Table 1
PROTA rules in terms of building new TAE in Coastal Alentejo.

Rural areas				
50 m from coastline	50 m–500 m from coastline	Coastal zone 500 m–2 km	Coastal protection strip 2 km–5 km	Other areas
Not allowed	Not allowed	Rural tourism accommodation using pre-existing buildings	Isolated tourism accommodation: Tourism in rural areas (TER)	- Isolated tourism accommodation. - Touristic Development Areas (NDT)
Urban areas				
Within urban areas:				
Urban and Tourism Nucleus (NUTL) – all **establishment typologies** are allowed				
Natural areas				
- Construction outside urban areas				
- Alteration of LU for contiguous areas superior to 5 ha				
- Amplification of existing building(s) are allowed (for TER categories) implying an increase in the implantation area under 50% of the existing building(s)				

have involved intensive construction on the coastline. They would have also added a significant number of real estate/second homes to the tourism sector. The majority of these projects were not approved or were subject to changes. However, expectations for urbanization were high. In the 1990s the regional plan for land use management of Coastal Alentejo (PROTALI) was implemented and imposed several land use rules based on three geographical buffers: coastal, central and interior. The general guidelines and rules comprised of: i) the nucleation of tourism development; ii) controlling construction along the coast by setting a *non aedificandi* buffer zone 1 km from the coastline; iii) establishing 5 km buffer areas (*non aedificandi*) between areas of occupation; iv) prohibiting new roads being built parallel to the coast; v) prioritizing TAE over real estate/second homes; vi) defining touristic occupancy thresholds; among others. This plan reversed the expectations of the tourism sector that were established in previous decades.

In the period between 2000 and 2010, the strategy for resource and landscape protection was based on the creation of several land use constraints for the protection of environmental assets, with the approval of a set of land use plans, such as: i) coastal zone management plan, ii) Natura 2000, iii) Sudoeste Alentejano e Costa Vicentina Natural Park management plan, iv) Sado Estuary reserve plan, and v) Ecological Reserve. These plans were coordinated by the environmental sector which both emphasised the environmental importance of these areas while also placing constraints on their land use. These areas (henceforth referred to as 'natural areas') cover around 73% of Coastal Alentejo's total area and place restrictions on the development of built-up areas.

In 2010, a new regional plan for the land use management of Alentejo (PROTA) was approved following the previous PROTALI general framework, and established land use zoning and specified rules (and indexes) in terms of building new TAE. The tourism planning strategy in Coastal Alentejo shifted from a model consisting of high touristic pressure on sensitive areas to a model in which tourism development is concentrated in specified areas and subject to indexes for building new TAE (presented in Table 1).

PROTA establishes specific areas for tourism development, for example, an urban and tourism nucleus (NUTL) and touristic development areas (NDT) where all TAE categories are allowed, with the exception of tourist apartments in NDT. There are no land use restrictions related to tourism in urban areas, and fewer restrictions in other areas that are more than 5 km from the coastline. PROTA defines specific indexes for new TAE, such as the number of floors, ratios for buildings and parcel development, and a maximum number of beds per municipality. In Coastal Alentejo, the maximum number of beds permitted in PROTA is a correlation of 1:1, though residents (≈98,000 inhabitants) and municipalities can (albeit occasionally) negotiate between themselves the transference of unused bed numbers within this threshold. This process allows municipalities with a higher demand to acquire more accommodation capacity from other municipalities that are not fully using the permitted maximum capacity.

These guidelines constitute an attempt to restrict tourism related investment intentions to less pressured areas and away from the coastline and natural areas. Since the 1980s, the tourism planning strategy in Coastal Alentejo has shifted from a model of high touristic intensity and pressure on sensitive areas, to a model in which tourism development is nucleated in NUTL, NDT and urban areas, and subject to specific building indexes.

3.2. Patterns in the distribution of tourism accommodation establishment

TAE in Coastal Alentejo are categorized by TP as: tourist villages and apartments; hotels and hotel-apartments; lodging houses and *pousadas*; TER; and camping parks. TER represent 54% of total TAE, and villages, apartments and hotels represent 30%. There is a clear distribution pattern of TAE category per land cover typology in 2010 (Fig. 2). This pattern is directly connected with the nature of the establishments: TER are mostly located in agricultural and forested areas related, for instance, with tourists engaging in rural/agricultural activities; to villages, apartments and hotels in urban areas; and camping parks in tourism areas due to the guidelines which encourage new buildings to be built outside urban areas in pre-established tourism areas such as NDT or NUTL.

Not surprisingly, 40% of current TAE are located in urban areas because there are no restrictions on TAE categories allowed in NUTL. Also, 26% of TAE are located in agricultural areas relating to the existence of 54% TER establishments which are predominantly located in this typology. However, only 9% of total TAE are located in tourism areas which can be related to the difficulty in tracking and classifying tourism related land use/cover.

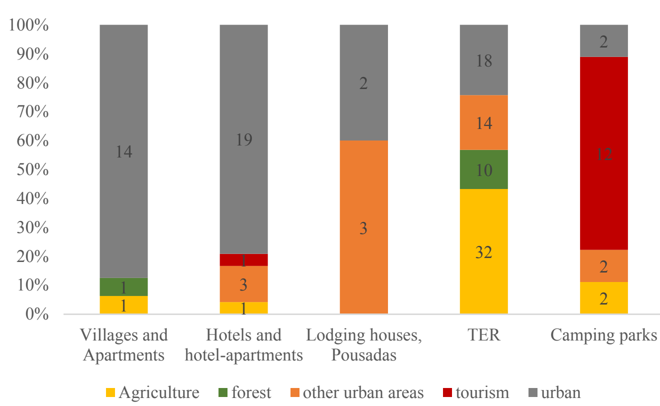

Fig. 2. TAE category per land cover typology.

4. Data and methods

4.1. Data

The data was gathered from different sources, most from official entities, such as the National Authority for Territorial Management (DGT), TP, Statistics Portugal (INE), and PROTA. The data presented in Table 2 is assumed to be potentially linked with tourism development. Some variables have restrictive characteristics and impose rules on land use/cover. Others present favourable conditions for tourism development (e.g. having an existing road network and being within close proximity to the coastline). This empirical-based assumption is later tested through a logistic regression analysis to quantify influence in tourism development (Table 3).

4.2. Methods

In order to derive the most suitable areas for tourism development in Coastal Alentejo independent variables were derived from the base data as with the methods presented in Table 2. We hereby discuss these methods:

i) The land cover maps for 1995, 2007 and 2010 were dissolved into five land cover categories: agriculture, forest, water bodies, urban areas, tourism (comprising of golf courses, leisure related facilities and camping parks), and other urban areas (industrial/commercial areas and transportation networks).
ii) The Euclidean distance from each cell to the road network, coastline and localities was computed.
iii) An inventory of the TAE was made based on the TP and municipalities' databases. Several difficulties were faced during this process due to differences in the TAE categorization criteria (denomination and inventory) for TP, INE, and the municipalities. The authors adopted the previously presented TP categorization.
iv) The Kernel density (using a 5,000 m search radius) was calculated in order to identify the concentration of TAE. Population per building was also subject to a density estimation using a 1,000 m neighbourhood around those features.
v) The results from the stakeholder workshop served as inputs to support the CA scenario building. The workshop gathered around 40 participants representing a wide range of tourism stakeholder groups, including: municipalities, local ENGOs, TAE managers, business owners in catering, beachfront stores and stall owners, tourism entertainment and events. Stakeholders were asked to pin the region's touristic hotspot areas on a map. These included: the most attractive areas, the least attractive areas, and the areas with most touristic potential. The areas were georeferenced and used as input variables in the CA model. The participants were also asked to choose from a set of images the one that best represented the desirable future for Coastal Alentejo as well as completing a form describing their vision for the area including key words. After being divided into groups each participant presented his/her vision to the group. The aim was to reach a consensus in terms of the group's overall vision. The visions developed from abstract images selected by the stakeholders stimulating the creativity of the participants (see Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006). Stakeholder visions provide the storyline, which combined with TP tourism future scenarios for 2020, support the derived scenarios. Another result of the workshop was the mapping of areas considered to be the most and least

Table 2
Tourism related base data, methods and independent variables.

Base data	Source	Methods	Independent variables
Land cover maps	DGT 1995, 2007, 2010	Dissolve 5 categories	Land cover maps 1995, 2007, 2010
Road network	DGT	Euclidean distance	Distance to road network
Slope	DGT	–	Slope
Coastline	DGT	Euclidean distance	Distance to coastline
Tourism development areas	PROTA 2010	Georeferencing	Touristic Development Areas Urban and Tourism Nucleus
Tourism establishments	TP and field work	Survey, georeferencing, Kernel density 5,000 m	Tourism establishment density
Touristic hotspot areas	Tourism stakeholders	Stakeholder workshop	Most attractive areas Least attractive areas Areas with touristic potential
Localities	INE Census 2011	Euclidean distance	Distance to localities
Land cover/use regulation	PROTA/INE 2010	–	Rural areas Urban areas
Population Buildings	INE Census 2011	Kernel density 1000 m	Population density per building

Table 3
Regression coefficient matrix.

Variables	Coefficient
Population density/building	5.8389
Land use regulation	0.1737
Slope	−1.9717
Distance to coastline	9.1146
Distance to road network	0.4398
Distance to localities	−1.9774
Tourism development areas	4.0110
Tourism establishments	−0.5209
Areas with touristic potential	1.0745
Most attractive areas	4.7059
Least attractive areas	−1.6932

attractive to tourists as well as those with the most potential according to the stakeholders' own perception.

vi) The data was converted to raster format (10 × 10 m pixel size) and then normalized in order to constitute the independent variables inputted in the model.

The methodological framework developed is shown in Fig. 3.

4.2.1. Fuzzy membership

The independent variables were normalized with fuzzy logic, which enables the attribution of degrees of membership to a given fuzzy set, i.e. a collection of elements that belong together based on specified criteria. In fuzzy membership each cell degree varies from 0 (highly unsuitable) to 1 (highly suitable), displaying continuous increment of non-membership to full membership. The use of fuzzy membership (sigmoidal function) mimics the relationship of spatial determinants and the suitability for the category of tourism land cover. In this case study the proximity to existing infrastructures is considered most suitable for tourism development (high suitability: 1) because of the decreased infrastructural costs of investment, the proximity to the road network, proximity to localities and high population density per building, as well as proximity to existing tourism establishments. Other areas considered most suitable (1) are related to natural/physical characteristics of the landscape, including the proximity to the coastline, lower degree of slope, proximity to the most attractive touristic areas, and areas with touristic potential. From a land use management point of view, tourism development areas (NDT and NUTL) and urban areas are considered highly suitable for tourism development (1). Rural areas, less attractive touristic areas, and distance to infrastructure and to natural landscape features are considered less suitable for tourism development (0).

4.2.2. Logistic regression analysis

The influence of tourism development related independent variables on LUCC was tested by a logistic regression analysis. Logistic regression undertakes binomial logistic regression to estimate the probability of a binary response based on one or more independent variables (Aldrich & Forrest, 1990). Logistic regression measures the relationship between the land cover categories for the year 2010 (dependent variable) and the independent variables, by estimating probabilities or suitability of a given land cover category to occur using a logistic function. The output is a collection of transition suitability maps and an individual regression coefficient for each land cover category. The regression coefficient matrix (Table 3) shows that the variables that most influence the tourism land cover category are the proximity to the coastline and to the road network, the most attractive areas and areas with touristic potential, the defined tourism development areas (NDT and NUTL), and areas with a high population density per building.

4.2.3. Markov chain analysis

The Markov chain analysis input is a pair of land cover images, for the years 1995 and 2010, and produces a transition probability matrix, a transition areas matrix, and a set of conditional probability maps. In the Markov process it is assumed that the state of a cell at a given point in time is merely a function of its preceding state (Takada, Miyamoto, & Hasegawa, 2010). Based on this assumption, it is possible to explore future probabilities of transition in a system consisting of discrete states. The transition areas matrix records the number of cells that are expected to change from each land cover type to each other land cover type, over the specified number of time periods (15) based on the transition probability matrix.

4.2.4. Using cellular automata/Markov chains to explore LUCC

According to Benenson and Torrens (2004) in CA an individual cell represents the discrete spatial border of an automaton which is surrounded by other neighbouring automata. Each cell has a current state and knowledge on neighbouring cell states. CA models are able to propagate information through space via neighbouring cells, resulting in adaptive and self-organizing behaviour. The CA method used combines Markov Chains output with logistic regression analysis. The state of neighbouring cells, the transition areas matrix and the transition suitability maps provide the input to simulate future tourism related LUCC. CA produces land use/cover simulation for the year 2020 (10 time periods forward) based on the previous 15 time periods defined in the transition areas matrix (1995–2010). The cell neighbourhood was defined as a 5 × 5

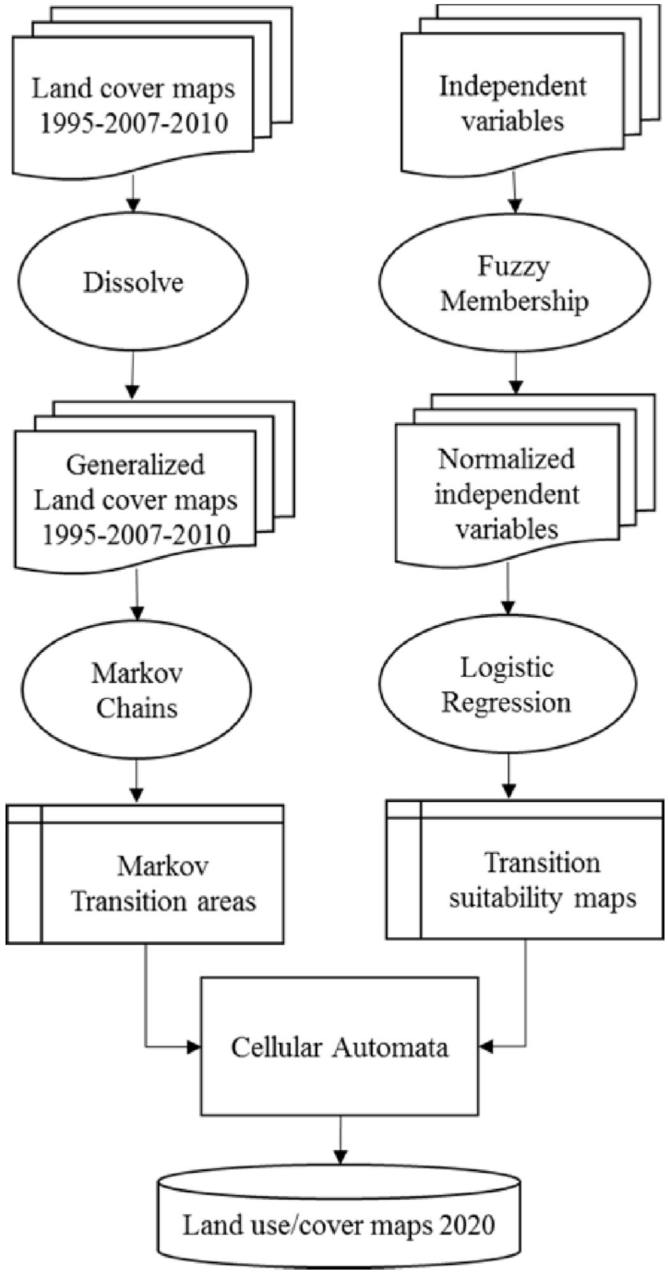

Fig. 3. Methodological framework.

Von Neuman contiguity filter (see Fig. 4), creating spatially explicit contiguous weighing factors, so that the furthest away cells have lower suitability than the nearest cells (Subedi, Subedi, & Thapa, 2013).

4.2.5. Validation

The methodology presented relies on a previously carried out validation process using the data in Table 2 to derive the matrix of Markov transition areas and transition suitability maps from 1995 to 2007 and then applies CA to forecast 2010 land use/cover. Model validity was measured by cross-tabulation of the 2010 land use/cover map with the CA simulation results, producing a 0.90 overall kappa index of agreement. Fig. 3 framework was developed after the validation of results.

5. Scenarios for future tourism impacts on LUCC

Three scenarios were developed to explore tourism related LUCC for 2020: i) business as usual (BAU), ii) tourism trends (TOUR), and iii) natural restrictions (NATR). The conceptual and methodological framework for each scenario is presented hereafter. The scenario development took into consideration the stakeholders' future visions which were presented in the workshops.

From a methodological standpoint, it is relevant to mention that the output of the logistic regression is common to all of the scenarios, i.e. it served as an input to all CA LUCC scenarios. The logistic regression analysis results are presented in Fig. 5.

5.1. Business as usual (BAU)

The BAU scenario is based on the logistic regression transition suitability maps (Fig. 5) and the matrix of Markov expected to transition in 2020 based on the changes registered during 1995–2010 (Table 4). Thus, BAU represents a linear model in which the trends from 1995 to 2010 are maintained and projected forward to 2020.

According to BAU, in 2020 there will be a transition in which agricultural land will become forested land (11%), and vice-versa (3%). Furthermore, other urban areas will significantly transition towards becoming urban areas (40%). The biggest expected increase of tourism areas is at the expense of forested areas (21%) and other urban areas (9%), while 66% of tourism areas are expected to remain within the same category in 2020. Urban areas do not register significant changes for the year 2020. This was predictable because it is very unusual for urban land cover to transition to another category.

5.2. Tourism trends (TOUR)

The rationale of this scenario states that when the demand for a destination increases, accommodation capacity might be reached and new TAE emerge in the most suitable cells embedded in the transition suitability maps. This scenario grows from Boavida-Portugal et al. (2015) agent-based modelling approach to simulate the dynamics of tourism demand and the authors' theoretical framework. TP developed a “growth with ambition” scenario for 2020, based on the IMF's 2020 GDP forecast for tourism source

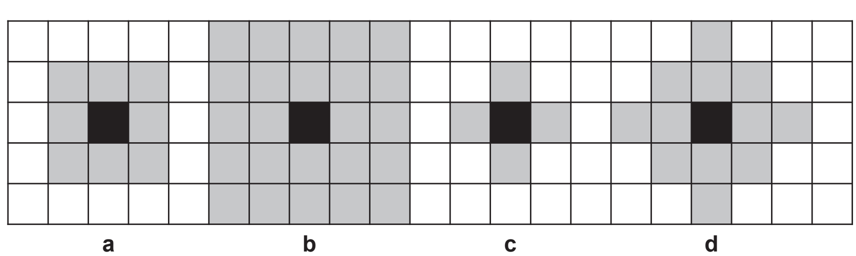

Fig. 4. Typical neighbourhood configurations of CA: (a) Moore 3 × 3; (b) Moore 5 × 5; (c) Von Neumann 3 × 3; (d) Von Neumann 5 × 5.

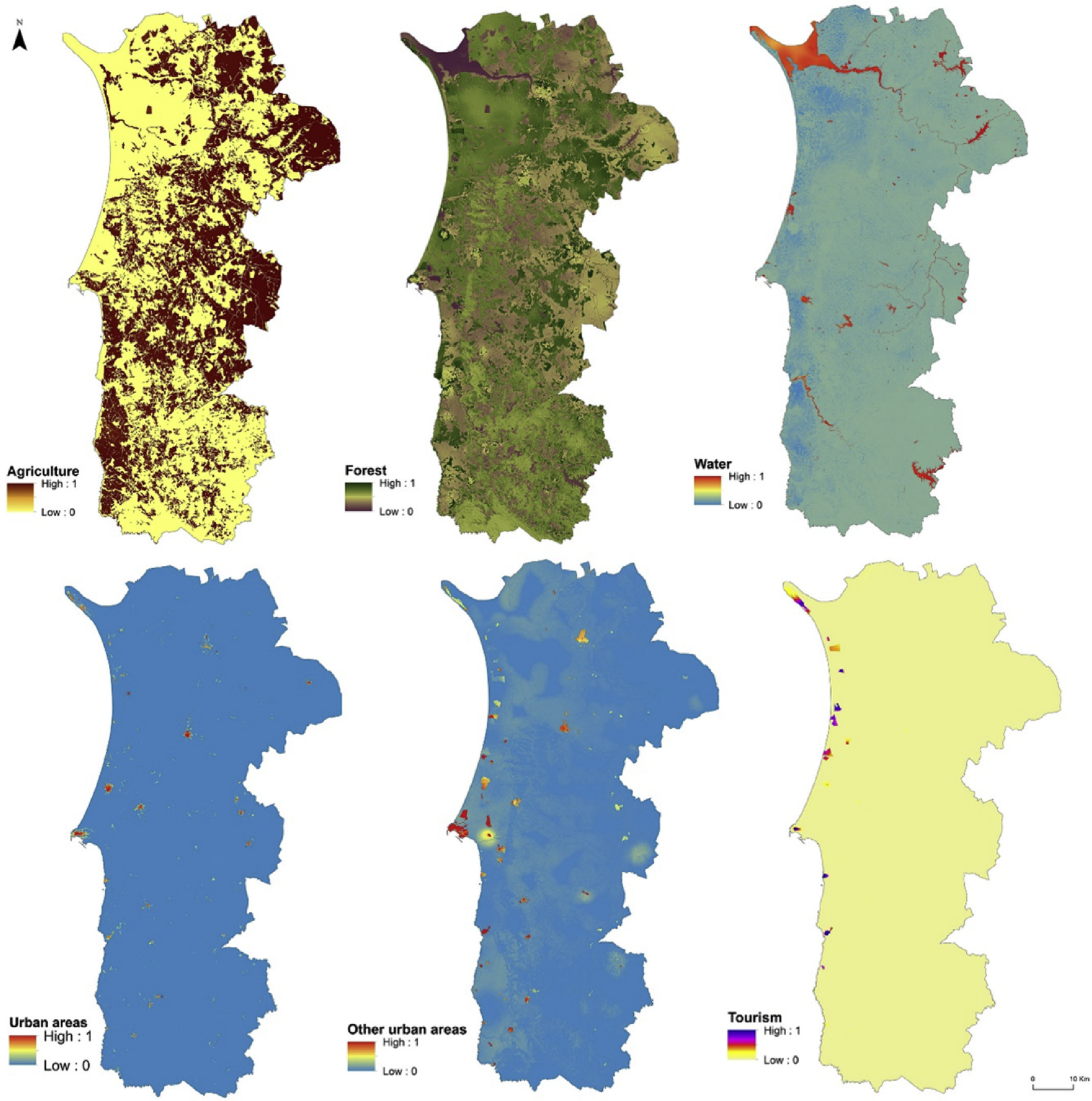

Fig. 5. Logistic regression transition suitability maps.

Table 4
Matrix of Markov chains transition areas for BAU.

Land cover 2010	Expected transition of land cover cells in 2020					
	Agriculture	Forest	Water bodies	Other urban areas	Tourism areas	Urban
Agriculture	15,608,938	1,746,013	16,370	16,209	2,649	47,957
Forest	511,147	18,978,465	3,955	20,285	15,637	93,687
Water bodies	0	0	1,708,412	0	0	0
Other urban areas	0	1,568	0	180,909	6,545	86,731
Tourism areas	0	999	0	0	48,871	0
Urban	3,923	7,786	413	442	746	487,413

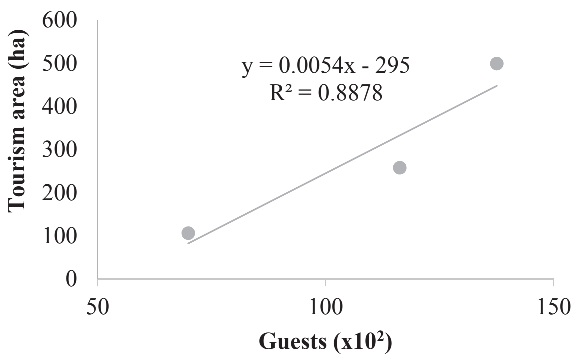

Fig. 6. Regression analysis between tourism area (ha) and guests for the years 1995, 2007, and 2010.

markets. This scenario estimates an annual growth of 3.5% in nights spent TAE. The stakeholders' future visions accessed in the workshop also aspire to this goal. Based on (1.1) the annual increase in guests is 3%.

$$\frac{\sum_{NS_{TAE}=1}^{n} NS_{TAE} \cdot IF_{NS} \cdot \overline{X}_S^{-1}}{TTA} \cdot 100 \quad (1.1)$$

Where NS_{TAE} is the nights spent in TAE, IF_{NS} is the increasing factor of nights spent, $\overline{X}^{-1}$ is the average stay and TTA represents the total number of guests.

Following this, a regression analysis was performed to discover whether there is a correlation between tourism land cover and guests (Fig. 6). Since the analysis resulted in a significant positive correlation ($R^2 \approx 0.89$), the regression line (y) was used to calculate the value for the tourism area increase in 2020 based on the annual increase of guests of 3%. To incorporate this value in the matrix of Markov chains transition areas, the weight of existing tourism establishments in each land cover was calculated. Then, based on these values the matrix was changed. Results show that in 2020 an increase of 8747 tourism cells is estimated compared to 2010's LUCC. This represents an increase of 26% in agriculture, 8% in forest, 40% in other urban areas, 9% in tourism, and 16% in urban areas. The proportion of the increase in tourism areas is minimal compared to Coastal Alentejo's total area. However, compared to the tourism area recorded in 2010 (49,871 cells) this transition represents a significant increase ($\approx$18%).

5.3. Natural restrictions (NATR)

The NATR scenario intends to explore LUCC in 2020 under the premise that the natural protected areas are restricted to new TAE construction. This scenario assumes that tourism development would have to be in areas which do not encompass land use restrictions. The natural areas were used as a mask and attributed the value of 0 for suitability transition potential. The rationale is substantiated by the existing rules for TAE building in natural areas (Table 1). Stakeholders also pointed out the need to preserve the region's natural features because they are considered an essential factor in attracting tourists.

6. Results and discussion

6.1. CA scenarios

The CA results for each scenario can be seen in Fig. 7 and produced land use/cover forecasts for 2020 according to different assumptions. BAU reflects the LUCC trend from 1995 to 2010 (Table 4). There is a slight decrease in tourism land use/cover and an increase in urban area. This is related to several parameters PROTA imposed, such as specific areas for tourism development (NDT and NUTL) in an attempt to create geographical concentrations of infrastructure and services related to tourism. In regard to PROTA, in 2010 several tourism land use rules were implemented, which defined the areas where building is permitted and TAE construction indexes, and aimed at decreasing potential tourism investment in more sensitive or overexploited areas.

TP data shows that there are several TAE projects approved by TP and the municipalities from more than 5 years ago, of which

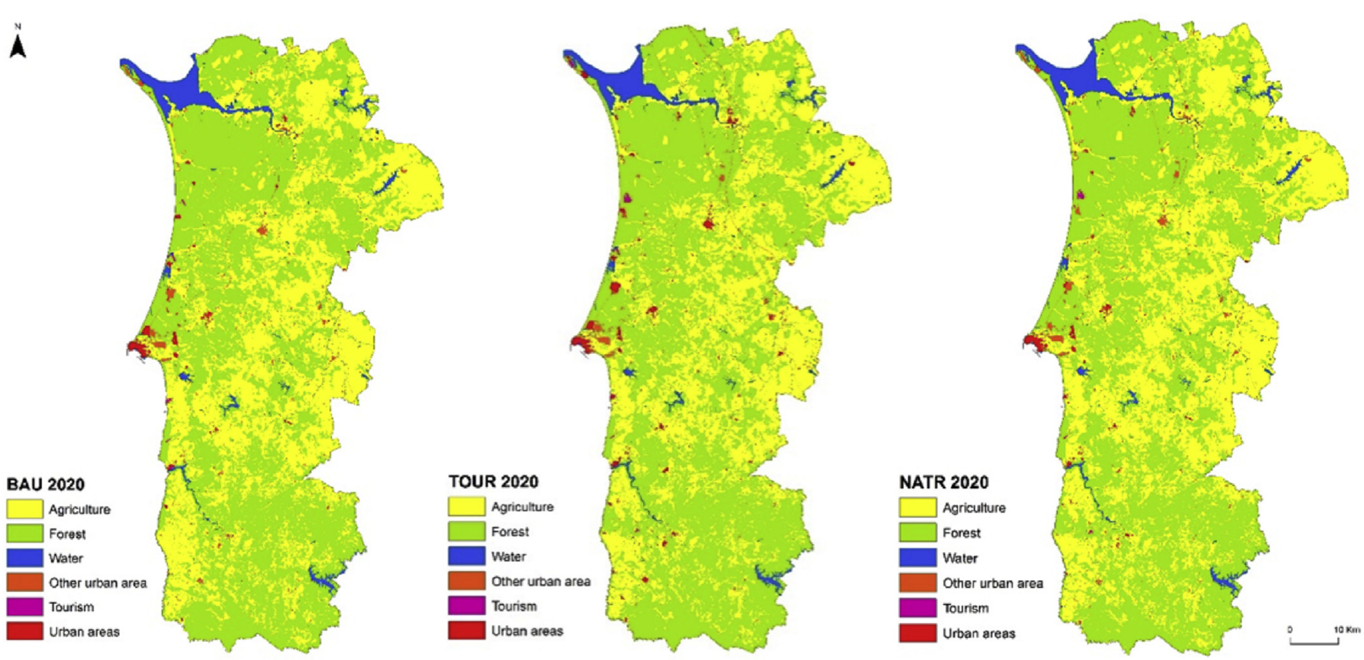

Fig. 7. CA scenario results, from left to right: BAU, TOUR, NATR.

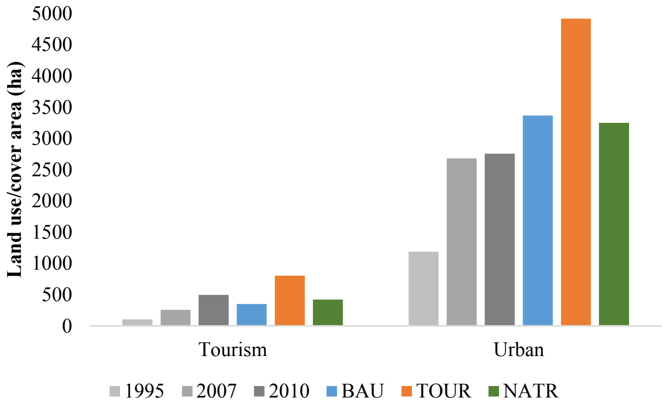

Fig. 8. Tourism and urban land use/cover for the years 1995, 2007, 2010, and for the 2020 scenarios: BAU, TOUR, NATR.

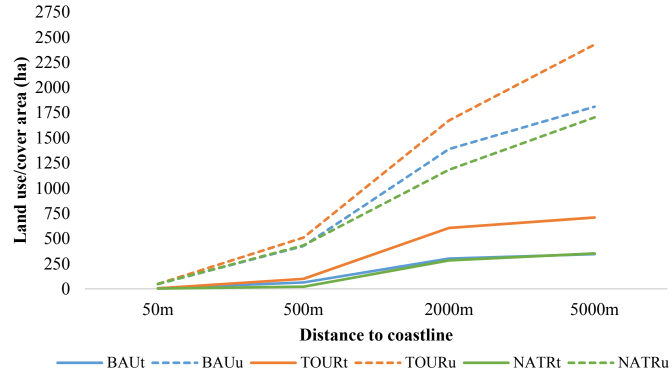

Fig. 9. BAU, TOUR and NATR tourism (t) and urban (u) land use/cover area in relation to distance of the coastline.

construction has not yet begun. These projects are mainly resorts with high accommodation capacity that are based on consortia with international tourism enterprises (e.g. Hyatt). However, as a result of the Portuguese economic crisis some uncertainty about the future construction of these projects remains.

The TOUR scenario explores TP's “growth with ambition” forecast and its implications for LUCC. According to the model a 3.5% annual increase in nights spent in TAE would mean that the year 2020 would see a 129% increase in tourism areas and 46% growth in urban areas when compared to BAU (Fig. 8). The substantial increase in tourism land use/cover occurs due to land conversion of forests and other urban areas. Although this scenario relies on some assumptions based on the regression analysis trend line (Fig. 6), there is a clear indication that an increase in demand would be followed by direct LUCC through the intended investment in new TAE; and indirect LUCC as the pressure on existing infrastructure and demand for services could be translated in urban growth.

Coastal Alentejo has several types of natural protected areas. The NATR scenario analyses tourism related LUCC for 2020. The results show that there is a 19% increase in tourism areas and a 3.5% decrease in urban areas in relation to BAU (Fig. 8). New tourism development areas defined in PROTA are outside natural areas. These areas were designed and planned from scratch, considering the need to comply with existing land use policy guidelines. As for urban areas, these usually expand around pre-existing urban fabric. By assigning restrictive guidelines in terms of building in natural protected areas a decrease in the expansion of urban fabric in these areas seems logical.

6.2. *Distance from the coastline*

In order to explore the impacts of tourism development on LUCC, in-line with PROTA land use policy guidelines (Table 1) the distance of tourism and urban areas from the coastline for the CA scenarios was assessed, as seen in Fig. 9. The three forecasts produced for 2020 register the same trend for higher tourism and urban land use/cover frequency as the distance from the coastline increases.

When looking at proportions, in all the scenarios more than 84% of urban and 95% of tourism areas are located more than 5,000 m of the coastline (Table 5). An analysis of the distribution of land use/cover areas within 5,000 m of the coastline is also relevant because it is in these areas that PROTA imposes more restrictions. One common factor is that for the three scenarios the biggest increase in tourism area is within 2,000–5,000 m of the coastline. Urban land use/cover higher is concentrated within 500 m of the coastline.

Table 5
Percentage of land use/cover area by distance from the coastline and CA scenario.

Scenario	Land use/cover	Distance from the coastline				
		50 m	500 m	2,000 m	5,000 m	+5,000 m
BAU	Tourism	0.8	0.8	0.9	0.3	97.3
	Urban	5.0	5.1	3.9	1.7	84.2
TOUR	Tourism	0.7	1.2	1.7	0.7	95.7
	Urban	5.1	6.1	4.8	2.3	81.7
NATR	Tourism	0.3	0.3	0.8	0.3	98.3
	Urban	5.1	5.2	3.4	1.6	84.8

However, the overall proportion of tourism and urban LUCC for each scenario changes according to distance from the coastline. For instance, TOUR has the highest concentration of tourism (4.3%) and urban (18.3%) in areas within 5,000 m of the coastline. NATR has the lowest percentage of tourism (1.7%) and urban (15.2%) areas located within the 5,000 m coastal strip. These results show that the distribution tendency of tourism and urban areas is convergent with PROTA land use guidelines for tourism nucleation and location in, what PROTALI defined as, the central and interior geographical buffers.

7. Conclusions

Spatially explicit LUCC models are fundamental for sustainable land use planning because they provide a tool which enables the evaluation of future land use/cover scenarios. Exploring the impacts of tourism development on LUCC provides better knowledge of the effects on land conversion, enabling the adjustment of land use policies. LUCC is central to tourism, thus researchers should find ways to cope with the difficulty in tracking and monitoring, usually related to the lack of micro level datasets. In Portugal, TP recently began collecting detailed georeferenced data on TAE but is still incipient and inconsistent. This data can support the assessment of tourism related land use/cover and land use policy compliance. Tourism development impacts on LUCC should be addressed as an inter- or trans-disciplinary problem involving theoretical background from tourism studies, tourism geography while using geographical modelling tools.

Although CA has been widely applied to model LUCC, applications in tourism research are limited. This paper presents a step forward in developing a CA methodology to explore tourism development impacts on LUCC. The scenarios developed suggest that tourism development is associated with an increasing demand for land conversion, which is mostly done at the expense of forests and agricultural land. In a scenario of increasing tourism demand

(TOUR) impacts on LUCC are greater than in a BAU scenario, with increasing concentrations of tourism and urban areas near the coastline. Overall scenario results point to the compliance of future tourism development with land use policies, suggesting that tourism development will mostly likely occur in areas with less tourism and environmental pressure to a distance of 5,000 m to the coastline. The application of more restrictive rules and indexes (NATR) could promote a regional development model that values environmental assets over a model of unregulated touristic development and growth.

The LUCC modelling approach developed highlights interesting aspects of Coastal Alentejo's recent (1995–2010) and future (2020) land use/cover model. The study area showed high touristic pressures and intentions to invest in the 1980's, which were blocked by restrictive land use policies, thus producing a shift in the regional tourism development model. The current land use/cover model is orientated towards sustainable guidelines, focused on balance and trade-offs of tourism development, which is substantiated by the stakeholders' views of a quality over quantity approach. The integration of sustainability concepts in tourism development poses new challenges for land use planning in coastal areas in Portugal.

Disclosure statement

No potential conflict of interest was reported by the authors.

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