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Using cellular automata to simulate tourism growth. Case study: Iaşi city

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The analyse of land-use change has a meaningful importance in scholars research. Hence, the influence of the urbanisation beneath the conditions that lead to the increase of tourism activity in urban areas it is connected with the extinction of the land-use space. Given the fact that the development of urbanisation leads to tourism development, this paper aims to shape a model of urban growth for the city of Iaşi which emphasises the spatio-temporal growth of the city with impact on tourism growth. The data used was Corine Land Cover (CLC) for 2000 and 2006 years. The type of land use, the areas and the relationship of the driving factors were identified for further analysis. The methodology included Geographic Information System (GIS) spatial analysis and statistic functions of it. In order to obtain the model of urban growth which sustains the hypothesis that the urban increase leads to tourism development, an urban growth simulation was made through Pyhton language programming by cellular automata (CA) method.

Key Words*: Cellular automata, land use, tourism, GIS, simulation, urban growth.*

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Introduction

Cities and the urban networks they formed were always an important factor in the development and shaping of their surrounding regions. Urbanization is one of the clearest features of the development of manufacturing and service activities (Burgess and Venables, 2004). Hence, tourism development is influ-

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enced by the role of urbanisation because tourism is part of service activity. The term urbanisation can represent the level of urban relative to overall population, or it can represent the rate at which the urban proportion is increasing (UN, 2010).

The connection between the increase of urbanisation and tourism development leads to a problem for tourism planners, problem defined by the term of sustainability in tourism. Because the effects of tourism and land regulation on land-use change are intertwined, the design for sustainable tourism and the evaluation of tourism land-use policies must be considered to strike a balance between tourism development and environmental conservation. In this way, different sorts of models regarding land-use change haves been developed in order to understand the relation of human impact and natural phenomena not to affect the environment under anthropic activity changes.

Urban growth patterns are characteristic of spatial changes that take place in metropolitan areas. Urbanization is the most dramatic form of irreversible land transformation (Luck and Wu, 2002), affecting both landscapes as well the people who live in and around cities. Urban sprawl is a type of urban growth characterised by a low-density, dispersed spatial pattern with both environmental and social impacts. Possible triggers for urban growth may be identified by the measurement of externalities which exert an effect on land-use change.

Tourism development is a typical form of human activity in specific regions. Similar to land-use change, tourism is closely related to multiple societal, economic, and environmental factors. Land-use maps have become witnesses of the indisputable loss of natural habitats, as a result of artificial land uses to enable the construction of infrastructures which relate to the tourist demand.

For the proposed analysis, a mathematical model known as cellular automata (CA) has been used. The method provided information about the future growth of the urbanisation in Iaşi city, and it gave a prediction of the potential growth of the tourism city under urbanisation growth process. Urban growth models have proved to be important tools to measure land-use change in peri-urban and rural regions (Clarke and Gaydos, 1998; Herold et al., 2003; Mundia and Murayama, 2010; Tobler, 1970; White et al., 1997) in strong connection with decision support systems.

The cellular automata model was "extended by Alan Turing and John von Neumann who pioneered the notion that digital computation provided the basis for the universal machine both argued, albeit in somewhat different ways, that digital computation held out a promise for a theory of machines that would be self-reproducible" (Macrae, 1992). The concept of cellular automata came from Stanislaw Umlan and John Von Neumann during their work in the digital computing in the 1950s. In 1986, Couclelis was the one who affirmed the fact that the model of cellular automata represents a "joint product of the science of complexity and the computational revolution". It can be said that the main characteristic of the cellular automata model could be the spatial interactivity and it has this attribute due to the simple mechanism for defining the next state of a cell based on its actual state and the actual state of the cells in the neighbourhood (Couclelis, 1997a). The weighting parameters that define the neighbourhood effects are fundamental in order to emphasise the importance of the neighbourhood. Cellular automata simulation depends on the calculation of

development suitability based on neighbourhood configuration. Previous applications of CA models in urban growth consider neighbourhood as a significant factor, simulating the infilling and edge-expansion growth patterns quite well but not having the same success with simulating growth in the outlying category.

In the field of geography phenomena studies, Chopin and Weiss promoted the model in their development of land-use change models, so it resulted that the application of cellular automata in this field dates from the 1960s. In their modelling of the land development process, Chopin and his colleagues at North Carolina articulated cell space models, where changes in state were predicted as a function of a variety of factors affecting each cell, some of which embodied neighbourhood effects (Chapin and Weiss,1968). In fact, Lathrop and Hamburg (1965) proposed similar cell-based simulations for the development of western New York State but in theoretical quantitative geography, cellular automata became famous first, and it happened due to Walder Tobler (1970; 1975; 1979a;) who worked at University of Michigan during the 1970s. Tobler himself first proposed cell-space models for the development of Detroit city; in 1974, he started to investigate the way in which CA model might function in geographical systems, exploring this theory in his paper *Cellular geography* published in 1979. The defining features of the cellular automata are "first the cells, each residing in a state at any one time, states, qualities referred to the cells, the neighborhood template, and rules, transition functions, which define what the state of any given cell is going to be in the next time period based on the present state of the cells itself and that of its neighboring cells" (Couclelis, 1988; Torrens, 2000).

The model of cellular automata has gained popularity as a modelling tool for urban process simulation. The CA based methods are the common approaches used for urban prediction (Al-Ahmadi et al., 2009). The usage of cellular automata for urban growth forecasting has been increasingly linked to the possibilities of understanding land use change from a policymaking perspective (Pontius et al., 2004). Therefore, the contribution of this study is to see the evolution of the urbanisation according to cellular automata framework with implications in tourism development.

The shape of cellular automata has been realized with the aid of GIS techniques. Although current GIS techniques have restrictions in modelling changes in the landscape during the years (Itami, 1988; Deadman et al., 1993), an appreciable potential has been demonstrated from the integration of cellular automata by a geographic information system.

Study area

The city represents a regional metropolis, which is situated in the Northeastern part of Romania, in the historical Moldavia Region, being the most important urban centre from the region. The city of Iaşi experienced significant changes, concerning built-up area expansion, but also concerning modifying the urban space configuration (Figure 1).

The capital city of one of the most extended and populated Romanian historical regions, an underdeveloped socio-economic region, Iaşi is one of the

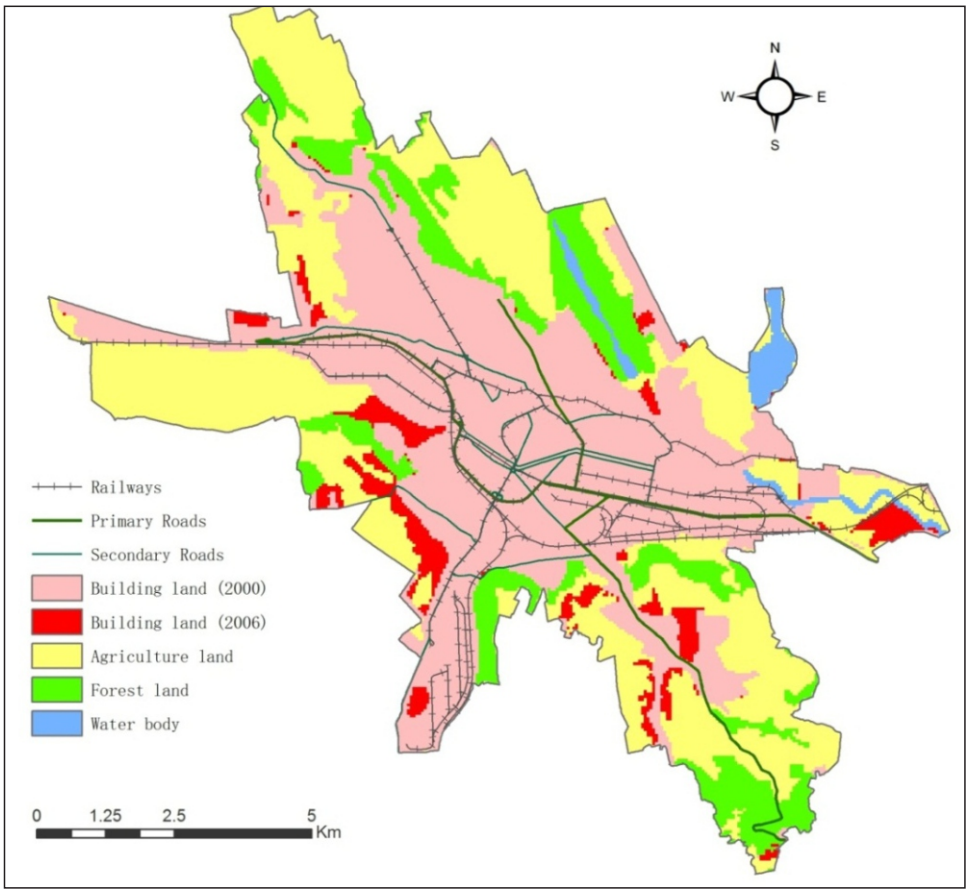

Figure 1. The map of Iaşi city

biggest urban centres which offer an intense and positive trend of tertiary sector process. Its peri-urban area is confronted with dysfunctionalities derived from political errors before 1990 some "others being 'accumulated' during the transition period mainly due to the legislative discontinuities and to the inconsistent development strategies" (Popescu, 2009). Also, the city suffers an unprecedented urban sprawl which took the form of peri-urbanisation.

Materials and methods

The analysis made implied the finding of some relevant indicators in order to indicate the characteristics of land use changes in Iaşi city during the years 2000 and 2006. Some critical parameters affecting urban growth include accessibility to the central business district, population centres, main roads and railways, proper physical condition (such as slope, elevation, distance to faults, water courses and land capabilities), considering zoning policies and distance to sensitive ecological areas.

To simulate the spatio-temporal evolution of a potential tourist town, the driving factors and comprehensive mechanisms of tourism urbanisation evolu-

tion must be studied. In this case, the type of land use, and the area of the building land were considered the most appropriated indicators to outline the changes produced in urbanisation growth process. Most urban CA models deem that urban development takes place in peripheral areas, which means that only regions adjacent to urban development zones can be converted into urban land.

The distance to primary and secondary roads has been chosen for the urban extension simulation which has driven to tourism growth. Various types of infrastructure within destinations are crucial for regional tourism growth because they provide location-specific resources on which different kinds of tourism are based (Smith, 1994). Infrastructural utilisation plays a critical role in the tourism development process and the tourist experience. A large number of empirical studies have confirmed the importance of infrastructure in tourism development (Eugenio-Martín et al., 2004; Khadaroo and Seetanah, 2007; Louca, 2006; Naudé and Saayman, 2005).

Transport appears to be one of the leading factors that should be considered, since the distance between functional urban areas is increasing, and local authorities have difficulties keeping pace with the rhythm of urban expansion in order to ensure a sustainable development of the networks and to reduce its impact on the environment and the society (Li et al., 2003).

Regarding the GIS analysis, the tools used for the analysis were the Spatial Analyst, with the application of Euclidian Distance (Processing Extent and Raster Analysis). Hence, the neighbourhood function for tourism analysis has been presented. Neighbourhood size is a central element of a CA model, as it defines the extent of interactions between land use and the dynamics of the system (Caruso et al., 2005). The distance analysis process used the *Reclassify tool* in order to reclassify the old values for the land use type with new values into an urban land that can be used for urbanisation, and non-urban area that could not be used for urbanisation.

The CORINE Land Cover (CLC) project started in 1985, and addressed the following issues at the spatial level: state of individual environments; geographical distribution and state of natural areas; geographical distribution and abundance of wild fauna and flora; quality and abundance of water resources; land-cover structure and the state of the soil; quantities of toxic substances discharged into the environment; and a list of Natural Hazards (EEA, 1995).

The land use data for the years 2000 and 2006 was collected from European Environment Agency as Corine Land Cover and, a*ccording to a European Union decision, the CLC may be seen as (85/338/EEC, Council Decision 27/6/1985)* an experimental project for gathering, coordinating and ensuring the consistency of information on the state of the environment and natural resources in the Community. Due to its multi-temporal land-use inventories, the Corine Land Cover project may be considered a very suitable methodology to trace and to better understand the land-use change (Paínho and Caetano, 2006).

Urban expansion results from land-use change, usually through the transformation of non-urban land into urban land (Lopez et al., 2001). Thus, it may be related to topography, transportation, land use, social structure and economic activities, but demography and economies are the two most important driving factors for urban expansion (Li et al., 2003). Hence, the land use change in the metropolitan area of Iaşi emphasises the economic development and the

population growth (Ursu et al., 2016), a reason for being chosen as one of the driving factors for the urban growth. Usually, economic development involves the transformation of a country from a rural agricultural-based economy to an industrial service-based economy (Henderson, 2003).

The different applications of the CA technique are based on the knowledge of the drivers of land use change, which according to Dendoncker et al. (2007) are often classified as: biophysical constraints and potentials, economic factors, social factors, special policies, spatial interaction and neighborhood characteristics (Dendoncker et al., 2007). The most common factors incorporated as drivers into CA models are according to Santé et al. (2011), among others, accessibility and distance to roads, distance to urban centres, population density and urban zoning (Santé et al., 2011). Thus, the weight coefficients for the driving factors have been determined using the Analytic Hierarchy Process (AHP) method. Introduced by Thomas Saaty (1980), the analytic hierarchy process (AHP) method has the chance to make the best decision and set priorities in choosing the right weighted factors. The method represents a good way to capture both subjective and objective aspects when making a decision (Figure 2, Figure 3).

Through the AHP method, it has been determined the weight coefficients of the driving factors and the restriction factors used are water body and forest land. In order to achieve sustainable development and effectively protect tourism resources, natural reserves were taken as a spatial limiting factor. An

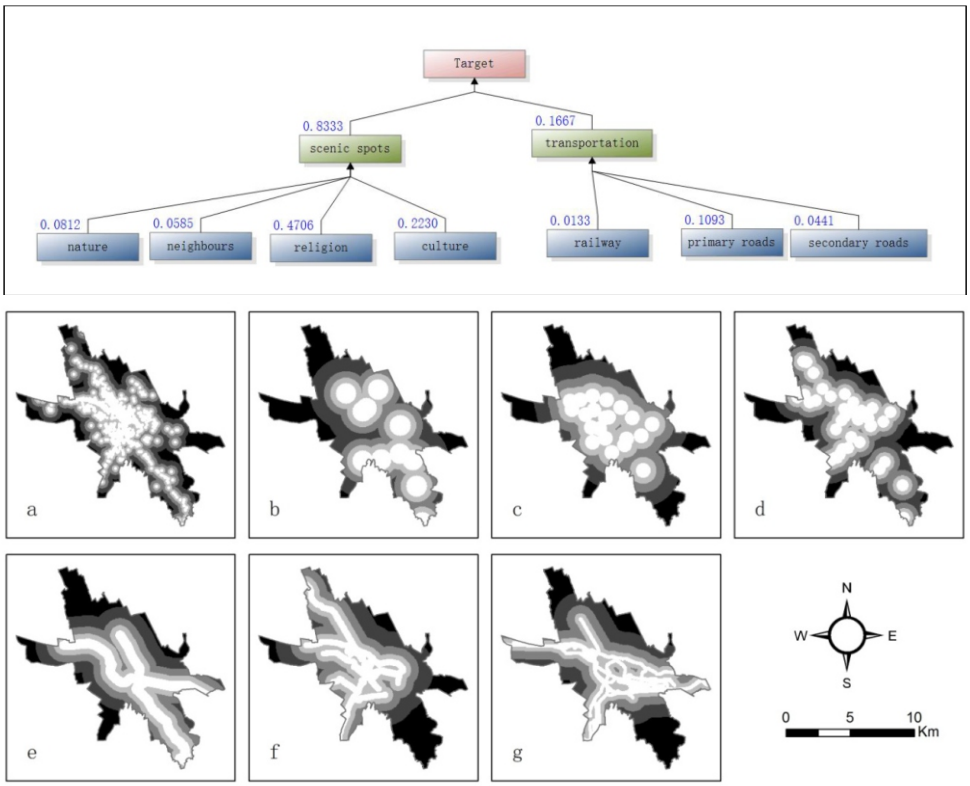

Figure 3. The results of distances to the main driving factors. a – distance to cultural objectives; b – distance to natural tourism spots; c – distance to neighbourhoods; d- distance to religious points; e – distance to primary roads; f – distance to secondary roads; g – distance to railways

important role for the territorial expansion of built-up area is played by the natural factors. It has favoured supplementing the unoccupied spaces. For the city of Iasi, the newest built-up spaces were mainly in areas favourable in terms of declivity or slope orientation.

In general, urban growth is used to describe the physical expansion of urban areas, being used as an indicator of industrialisation and it has a negative impact on the environmental health of a region (Suditu et al., 2010). The present study examines the effects of urbanisation increase on tourism development at the local level, namely in Iaşi city. The objective of this study is to analyse and determine the nature of the relationship between urbanisation process and local tourism development in Iaşi city. Landes (1969) and Williamson (1987) situated urbanisation as an essential ingredient in modernisation.

Building land in 2006 (Figure 4) is offering a good example of an experience city contraction, the real growth of building land concurs with the simulated value, except the fact that the simulation extended urban growth in more extensive areas but near the real ones and nearby the primary and secondary roads. The high degree of accessibility, characterised by the proximity to the principal communication axes of Iaşi city, acts as main factors in selecting the areas suitable for constructions, hence the territorial expansion of the peripheral Iaşi area was made along the roads (Ursu et al., 2016).

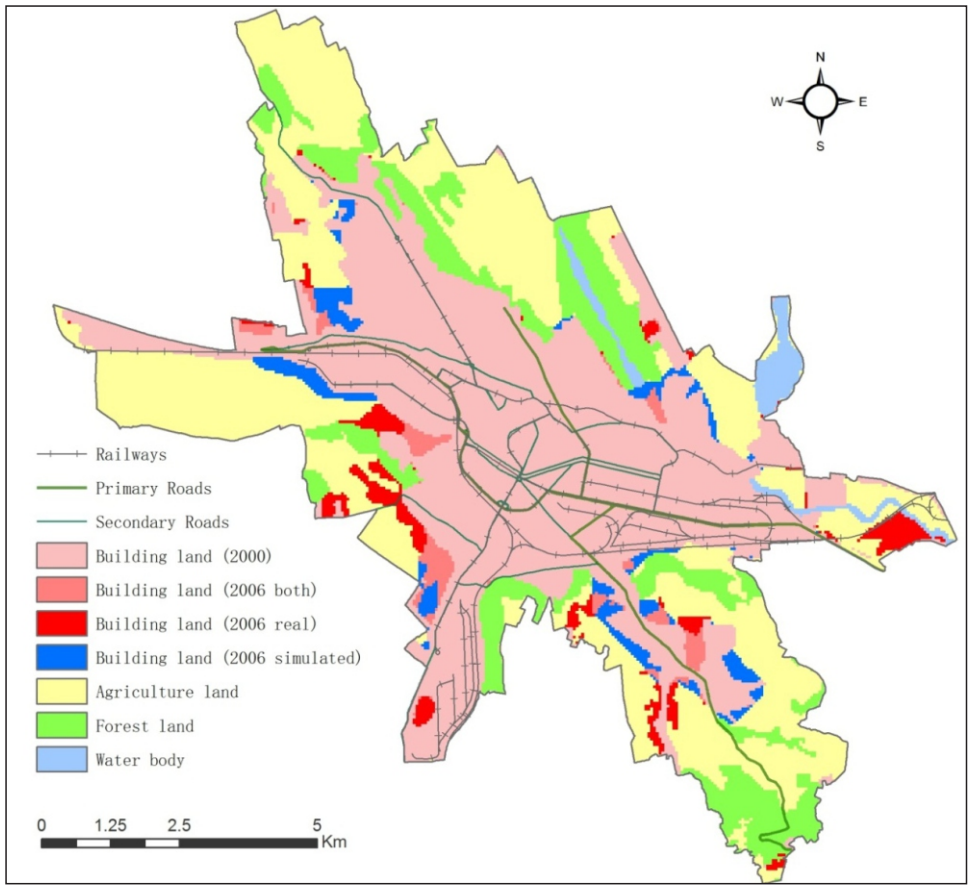

Figure 4. Land use in 2000 and 2006

With regard to Iaşi city, an industrial one, the development of tourism shows an increase over the years. This fact can be closely associated with the rise of urbanisation after the fall of communism, especially from the year 2000 when the construction of the building land has experienced an escalation, with special influences in the metropolitan area of the city. Between 2006 and 2012 it can be noticed a noticeable increase of the built-up areas less bidding from a natural point of view, which shows that the built-up area expansion was realised as a result of reaching a saturation level of the building in the most favourable areas.

The growth of construction land includes the increase of residential and industrial areas. The growth of residential areas is primarily influenced by population growth, whereas industrial areas are subject to investment changes. The proximity of the roads is a result of good accessibility, representing a significant aspect of the development of tourism. In these conditions, the increase of building land near roads is explained by the importance of the roads for the tourists' transit. The road network is used for transit from one site to another. In the city centre, the road network has high connectivity, being characterised by narrow and arched streets framed as a *cul-de-sac* (Figure 5).

In order to offer a better explanation of how the model of cellular automata in Iaşi city works, it was realised a statistic image of the model. As the neighbourhood function represents one of the most important elements of the model, it can be shown using the following expression:

- *Neighbourhood Urbanization Function*

The degree of urbanisation was represented within the current cellular neighbourhood, expressed by the proportion of urbanised cells within the scope of a neighbourhood.

$$P_{(x,y)} = \frac{1}{N} \sum {}^{\omega}_{i=1,j=1} X_{(i,j)}$$

Where $P_{(x.y)}$ represents the percentage of urbanised cells within the neighbourhood space, N represents the number of cells within the neighbourhood space, $X_{(i,j)}$ represents urbanisation cells, and ω represents neighbourhood space.

- *Cellular Conversion Probability*

The following expression represents the integrated value of the three major influencing factor groups and neighbourhood urbanisation function, describing the current cost value of cellular conversion.

$$P_{ij}^{t} = \phi\left(\quad r_{ij}^{t} \quad \right) = \exp\left[\alpha\left(\frac{r_{ij}^{t}}{r_{\max}} - 1 \right) \right]$$

where α represents the diffusion coefficient and $r_{\max}$ represents the highest property value. The simple expression r_{ij}^{t} is:

$$r_{ij}^{t} = \left(\quad \sum\nolimits_{k=1}^{m} F_{ij}^{t} \quad \right) \prod\nolimits_{k=m+1}^{n} F_{ijk}^{t}$$

a. when $1 \leq k \leq m$, r_{ij}^t represents the tourism urbanisation driving factor;
b. When $m<k$, r_{ij}^t represents the spatial limiting factor, referring to natural reserves and rivers.

To express the uncertainty of tourism urbanisation, (probability of developing into urban land - P_{ij}^t) and ($pregiventhreshold - P_{threshold}$) were added in a cycle for comparison to determine whether the current cell can develop into a town, expressed in this way:

$$\begin{cases} P_{ij}^t \geq P_{threshold} convertedinurbanland \end{cases}$$

$$\begin{cases} P_{ij}^t > P_{threshold} notconvertedinurbanland \end{cases}$$

The core methodology behind the CA models is based on a grid of cells, for which the model accounts for the state of the cells. The models apply transition rules to determine the potential of state change for each cell, based on a series of factors and weights on each cell (Santé et al., 2011). A cellular automaton (CA) is a collection of cells arranged in a grid, such that each cell changes state as a function of time according to a defined set of rules that includes the states of neighbouring cells.

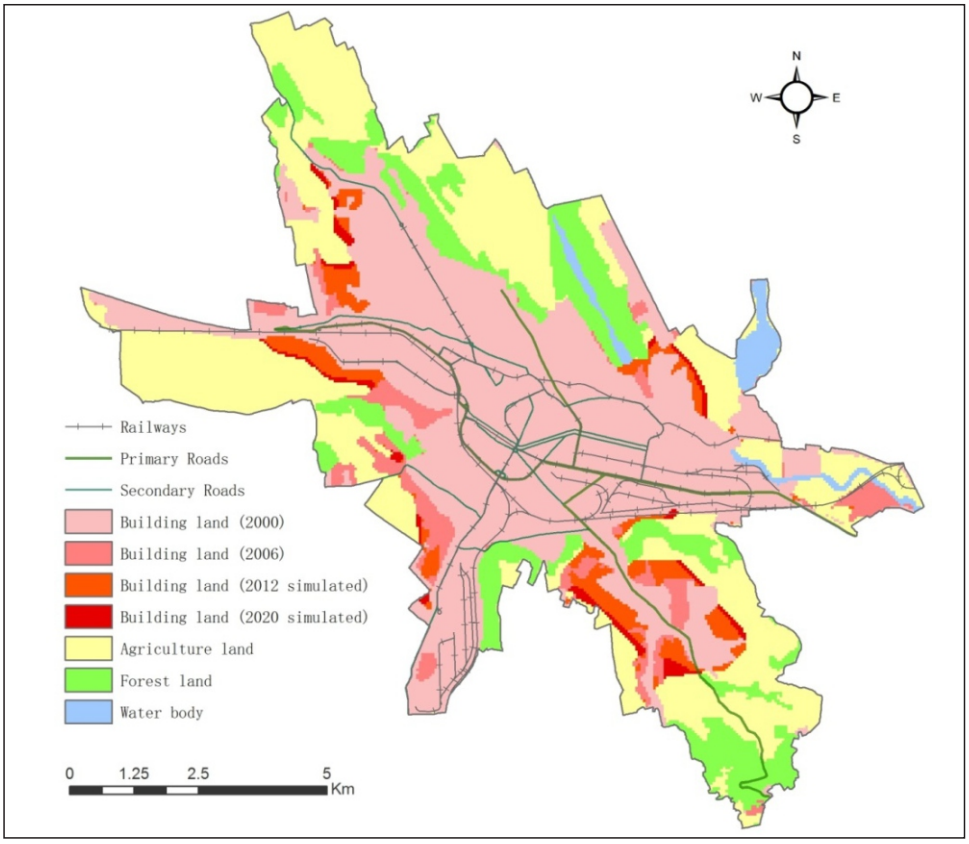

Figure 5. Land use in 2012 and 2020

The probability is a neighbourhood function defined by transition rules that involve immediate neighbouring cells and a number of contributing factors such as topography, proximity to urban centres and proximity to transportation network (Qi et al., 2004).The simulation process for the year 2012 gains more space for the development of building land. In the last years, several facilities have occurred (markets, churches, sports facilities) for minimising the cost related to the distance to attend them, indicating a growth of the built space density, as a consequence of the immovable market's pressure (Stoleriu and Stoleriu, 2004).

The year 2020 simulation indicate the same space which had grown in building land which is remarkable adjacent to the area simulated in 2012. This fact can lead to the improvement of the urbanisation process. Thus, the new emerged Palas Mall project is situated in the heart of the city having a food access due to its position and quality of the infrastructure (Rosu and Oiste, 2015). In this way, the city experiences an impact of tourism growth due to the increase of the areas of the buildings. Along these lines, the urban density has a role in this process, and its dynamic could be an incipient to the action of tourism growth. For the period analysed, it can be noticed a tentacular expansion of the built-up areas, along with the main communication axes of the city. After this, the areas suffered a rapid densification of built-up space, as a result of the economic growth, with increased pressure on the less favourable areas in terms of housing needs (Ursu et al., 2016). As it can be noticed in the simulation map from years 2012 and 2020, the simulated areas are overlapping. A thing that could reveal that the increase in urbanisation until the year 2020 will not experience a development further, at least not a meaningful one.

Conclusion

CA (cellular automata) models are well-proven methods of predicting development. Based on spatial data of different scales coupled with relevant socio-economic data, the models estimate the future land use demand based on an analysis of the drivers of land use change. This study presents findings in estimating the impact of urbanisation on the growth of tourism development in Iaşi city. Hence, the spatiotemporal growth analyses of Iaşi using GIS and CA models were used to illustrate the role of tourism factors in regional urbanisation and the most important to predict the future trend of development of city regarding the dependability in resolving the spatiotemporal growth of the city. Both local and regional factors will play a role in determining the potential success of tourism in any given region. Thus, the understanding of a regional-based tourism growth model is paramount in helping to identify both the advantages and disadvantages of tourism development in any given area. Therefore, examining tourism with regard to land-use change might help to foster tourism development while mitigating its negative environmental effects.

The results emphasise that the city was influenced by urban density, economic development, population growth, and other complex factors which induce to a tourism development of the city through the changes produced in the land-use utility.

The growth rates of tourist town attractions were slow in the process of urban growth. The development of the urban infrastructure, roads connectivity and urban facilities contributed in a meaningful way to the increase of tourism activity in Iaşi city.

The necessity of this kind of study resulted from the hypothesis that the urbanisation development of the city has appeared due to urban tourism. Its growth is very strongly correlated with urban life. As a result of the fact that urbanisation is a complex process influenced by the economy, culture, society, land use development, and other factors, cellular automata is a method that is still in full evolution.

References

Allan, M.W. and Gareth, S. (2009), "Future play: tourism, recreation, landuse", *Land Use Policy*, p. 326-335.

Al-Ahmadi, K., See, L., Heppenstall, A. and Hogg, J. (2009), "Calibration of a fuzzy cellular automata model of urban dynamics in Saudi Arabia", *Ecological Complexity*, vol. 6, no. 2, p. 80-101.

Alpopi, C. (2009), "The urban system in Romania", *Economia - Management*, vol. 12, no. 2, p. 167 - 153.

Aledo, A. and Mazon, T. (2014), "Impact of residential tourism and the destination life cycle theory", *Sustainable Tourism*, p. 25-35.

Alireza, E., Hadi, S. and Zahra, B. (2012), "The Role of Urban Tourism to achieve Urban sustainable development", *International Journal of Geology*, vol. 6, no. 1, p. 9.

Barredo, J.I., Kasanko, M., McCormick, N. and Lavalle, C. (2003), "Modelling Dynamic spatial processes: simulation of urban future scenarios through cellular automata", *Landscape and Urban Planning*, vol. 64, p. 145-150.

Batty, M., Couclelis, H. and Eichen, M. (1997), "Urban systems as cellular automata", *Environment and Planning B: Planning and Design*, vol. 24, no. 2, p. 159-164.

Buckley, R. (1999), "Tourism and Biodiversity: Land-use, planning and impact assessment", *The Journal of Tourism Studies*, vol. 10, no. 2, p. 47.

Burgess, B. and Venables, A.J. (2004), "Towards a microeconomics of growth", World Bank Working Paper 3257, Washington, D.C.

Caruso, G., Rounsevell, M. and Cojocaru, G. (2005), "Exploring a spatio-dynamic neighbourhood-based model of residential behaviour in the Brussels periurban area", *International Journal of Geographical Information Science*, vol. 19, no. 2, p. 103–123.

Clarke, K.C. and Gaydos, L.J. (1998), "Loose-coupling of a cellular automaton model and GIS: long-term growth prediction for the San Francisco and Washington/Baltimore", *International Journal of Geographical Information Science*, vol. 12, p. 699–714.

Cîmpianu, C. and Corodescu, E. (2013), "Landscape Dynamics Analysis in Iaşi Metropolitan Area (ROMANIA) Using Remote Sensing Data", *Cinque Continents Revue Roumaine de Geographie*, vol. 3, no. 7, p. 17-32.

Deadman, P.D., Brown, R.D., and Gimblett, H.R., 1993, "Modeling rural

residential settlement patterns with cellular automata", *Journal of Environmental Management*, vol. 37, p. 147-160.

Dendoncker, N., Rounsevell, M. and Bogaert, P. (2007), "Spatial analysis and modelling of land use distributions in Belgium", *Computers, Environment and Urban Systems*, vol. 31, no. 2, p. 188-205.

EEA (1995), *CORINE Land Cover*, EEA Report, 17 April 2018, (https://goo.gl/ywmmpN).

Herold, M., Goldstein, N. and Clarke, K. (2003), "The spatio-temporal form of urban growth: Measurement, analysis and modelling", *Remote Sensing of Environment*, vol. 85, no. 9, p. 105.

Hassan, M.M., Jamileh, T.N., Hadi, K., Asghar, T. and Mohammad, K. (2016), "Monitoring land use change and measuring urban sprawl based on its spatial forms: The case of Qom city", *The Egyptian Journal of Remote Sensing and Space Sciences*, vol. 30, p. 14.

Henderson, J.V. (2003), "The urbanization process and economic growth: The so-what question", *Journal of Economic Growth*, vol. 8, p. 47 –71.

Itami, R.M. 1988, "Cellular worlds: models for dynamic conceptions of landscape", *Landscape Architecture*, vol. July/August, p. 52-57.

Jun, Y., Peng, X., Jianchao, X., Quansheng, G., Xueming, L. and Fanqiang, K. (2013), *Spatiotemporal Simulation of Tourist Town Growth Based on the Cellular Automata: The case of Sanpo Town in Hebei Province*, Hindawi Pulishing Corporation.

Kytzia, S., Walz, A. and Wegmann, M. (2011), "How can tourism use land more efficiently?A model-based approach to land-use efficiency for tourist destinations", *Tourism Management*, vol. 32, p. 629-640.

Landes, D.D. (1969), *The Unbound Prometheus*, Cambridge: Cambridge University Press.

Li, X. and Gar-On Yeh, A. (2000), "Modelling sustainable urban development by the integration of constrained cellular automata and GIS", *International Journal Geographical Information Science*, vol. 14, no. 2, p. 131-152.

Li, L., Sato, Y. and Zhu, H. (2003), "Simulating spatial urban expansion based on a physical process", *Landscape Urban Plan*, vol. 64, p. 67–76.

L´opez, E., Bocco, G., Mendoza, M. and Duhau, E. (2001), "Predicting land-cover and land-use change in the urban fringe: a case in Morelia city, Mexico", *Landscape Urban Plan*, vol. 55, p. 271–285.

Meryem, A., Turker, A. and Mustafa, A. (2010), "Land Use Change in Relation to Coastal Tourism Developments in Turkish Mediterranean", *Polish Journal of Environmental Studies*, vol. 19, no. 1, p. 21-33.

Mohammad, R.Z.M. and Maryam, R. (2010), "Impact of Tourism Activities on the Use of Urban Land", *Iranian Journal of Tourism and Hospitality*, vol. 1, no. 1, p. 11.

Mundia, C.N. and Murayama, Y. (2010), "Modelling spatial processes of urban growth in African cities: A case study of Nairobi city", *Urban Geography*, vol. 31, no. 2, p. 259–272.

Narimah, S. and Norhidayah, S. (2013), "Urban Development Pressure: Challenges in Ensuring Sustainable Tourism Development in Langwaki Island", *Procedia Social and Behavioral Sciences*, vol. 91, p. 385-994.

Norhidayah, H. and Narimah, S. (2016), "GIS based multicriteria evaluation

approach planning tourism development sites in environmentally sensitive area", *SHS Web of Conference*, vol. 23, p. 16.

Petrişor, A.-I. (2012), "Land Cover and Land Use Analysis of Urban Growth in Romania", *Human Geography - Journal of Studies and Research and Research in Human Geography,* vol. 6, no. 1, p. 45-51.

Paínho, M. and Caetano, M. (2006), *Cartography of land-use: Continental Portugal, 1985–2000: CORINE Land Cover 2000*, Amadora: Instituto do Ambiente.

Pontius, R.G.Jr., Shusas, E. and McEachern, M. (2004), "Detecting important categorical land changes while accounting for persistence", *Agriculture Ecosystems and Environment*, vol. 101, p. 251–268.

Popescu, C. (2011), "The demographic component in the development of metropolis. A case study: Iaşi", *Romanian Review of Regional Studie*s, vol. 7, no. 2.

United Nations, (2010), *World urbanization prospects: The 2009 revision*, New York, NY: Department of Economic and Social Affairs, Population Division.

Qi,Y., Henderson, M., Xu, M., Chen, J., Shi, P., He, C. and Skinner, W. (2004), "Evolving core–periphery interactions in a rapidly expanding urban landscape: the case of Beijing", *Landscape Ecology*, vol. 19, p. 375–388.

Rosu, L. and Oiste, A.M. (2015), "Urban landscape patterns of Iaşi city. Analysing city relations between urban land use, topography and inhabitants pressure", *Bulletin UASVM Agriculture*, vol. 71, no. 1.

Saaty, T.L. (2008), "Decision making with analytic hierarchy process", *International Journal Services Sciences*, vol. 1, no. 1, p. 83.

Santé, I., García, A.M., Miranda, D. and Crecente, R.R. (2011), "Cellular automata models for the simulation of real-world urban processes: a review and analysis", *Landscape Urban Planning*, vol. 96, no. 2, p. 108-122.

Smith, S.L.J. (1994), "The tourism product", *Annals of Tourism Research*, vol. 21, no. 3, p. 582-595.

Stankov, U., Klauco, M., Dragicevic Vujiciv, M.D. and Solarevic, M. (2016), "Assesing land-use changes in tourism area on the example of Cajetina municipality (Serbia)", *Geographica Pannonica*, vol. 20, no. 2, p. 105-113.

Stephen, W. (1984), "Cellular automata as model of complexity", *Nature,* vol. 311, no. 5985, p. 419-424.

Suditu, B., Ginavar, A., Muică, A., Iordăchescu, C., Vârdol, A. and Ghinea, B. (2010), "Urban sprawl characteristics and typologies in Romania", *Human Geography - Journal of Studies and Research in Human Geography*, vol. 4, no. 2, p. 79–87.

Stoleriu, O. and Stoleriu, C. (2004), "The spatial evolution of Iaşi city: tradition and landscape", *Science: Tradition and Trends*, p. 363-367.

Tobler, W.R. (1970), "A computer movie simulating urban growth in the Detroit region", *Economic Geography*, vol. 46, p. 234–240.

Torrens, P.M. and O'Sullivan, D. (2001), "Cellular autómata and urban simulation: where do we go from here?", *Environment and Planning B: Urban Analytics and City Science*, vol. 28, p. 163-168.

Ursu, A., Andrei, M., Chelaru, D.A. and Pavel, I. (2016), "Built-up area change analysis in Iaşi city using GIS", Present Environment and Sustainable Development, vol. 10, no. 1.

Xiyan, M., Jijun, M. and Qi, W. (2014), "Modelling the effects of tourism and

land regulation on land-use change in tourist regions: A case study of Lijiang River Basin in Guilin, China", *Land Use Policies*, vol. 41, p. 368-377.

White, R., Engelen, G. and Uljee, I. (1997), "The use of constrained cellular automata for high-resolution modelling of urban land use dynamics", *Environment and Planning B: Urban Analytics and City Science*, vol. 24, p. 323–343.

Williamson, J.A. (1987), "Did England's Cities Grow Too Fast During the Industrial Rev-olution?" (discussion paper 1311), Cambridge, MA: Harvard Institute of Economic Research.

Wu, F. (2002), "Calibration of stochastic cellular automata: The application to rural-urban land conversions", *International Journal of Geographical Information Scienc*e, vol. 16, p. 795–818.