Chapter 3
Modelling Land-Use and Land-Cover Changes:
A Hybrid Approach to a Coastal Area

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ABSTRACT

In this chapter, a hybrid approach integrating cellular automata (CA), fuzzy logic, logistic regression, and Markov chains for modelling and prediction of land-use and land-cover (LULC) change at the local scale, using geographic information with fine spatial resolution is presented. A spatial logistic regression model was applied to determine the transition rules that were used by a conventional CA model. The overall dimension of LULC change was estimated using a Markov chain model. The proposed CA-based model (termed CAMLucc) in combination with physical variables and land-use planning data was applied to simulate LULC change in Portimão, Portugal between 1947 and 2010 and to predict its future spatial patterns for 2020 and 2025. The main results of this research show that Portimão has been facing massive growth in artificial surfaces, particularly near the main urban settlements and along the coastal area, and reveal an early and intensive urban sprawl over time.

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INTRODUCTION

Sustainable land-use and land-cover (LULC) development requires increasingly more reliable and high-quality spatial information to guide smart spatial planning and land-use decision-making (Magarotto, Faria-De-Deus, Ferreira Costa, & Masanet, 2017; Rocha, 2019). This applies in particular to the geographical context of coastal areas, which have been undergoing rapid and strong urbanization dynamics in the past few decades. The fast population and economic growth along coastal areas presents both an opportunity and a challenge for the sustainability of coastal ecosystems and built environments (Freire, Santos, & Tenedório, 2009; Martinez et al., 2017). Presently, 2.5 billion people, i.e., 40% of the world's population, live within 100 km of the coast (Burke, Reytar, Spalding, & Perry, 2011) adding great pressure to these productive and valuable coastal ecosystems. As coastal populations increase and natural coastal protection is reduced or lost, the sea level rise and local impacts of land-based stress factors, namely LULC change, occur together with global and regional stressors, such as climate change (Burke et al., 2011), resulting in altered dynamics and the subsequent reduced resilience of territories (Rocha, Ferreira, Simões, & Tenedório, 2007; Rocha, Gutierres, Gomes, & Teodoro, 2018).

In Portugal, as in the rest of the world, this has posed the challenge of rethinking the types of innovative actions that may contribute to more efficient LULC planning policies. Moving in this direction implies the application of state-of-the-art technologies to the studies targeting the analysis, monitoring, assessing and modelling of the process of LULC change in coastal areas (Boavida-Portugal, Rocha, & Cardoso Ferreira, 2016). The scientific advances that have been made in the field of urban growth and LULC change Cellular Automata (CA)-based simulation since the late 1990s have confirmed CA-based simulation as one of the most remarkable and promising geographic modelling approaches to interpret and represent the spatiotemporal complexity of LULC change, mainly due to their natural ability to capture and reproduce complex bottom-up processes through simple rules (Bone, Dragicevic, & White, 2011; Verburg et al., 2015; White, Engelen, & Uljee, 2015).

Research on LULC change CA-based modelling has since evolved a great deal, moving from its main focus on understanding the drivers and impacts of LULC change towards novel approaches (see, for example, Li & Gong, 2016; Gomes, Abrantes, Banos, & Rocha, 2019), which use this knowledge to properly develop sustainable land-use management practices and spatial policies. Even though CA-based models have already proven to be very effective at modelling and predicting large-scale LULC change, research on the development of fine-scale and long-term series LULC datasets to evaluate, quantify, and model LULC change, particularly at the local level, is still lacking. In order to produce more realistic urban phenomena simulations, CA-based models should improve their ability to simulate at a high level

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