



Development of a cellular automata model using open source technologies for monitoring urbanisation in the global south: The case of Maputo, Mozambique



Jamal Jokar Arsanjani^{a,*}, Casper Samsø Fibæk^a, Eric Vaz^b

^a Geoinformatics Research Group, Department of Planning and Development, Aalborg University Copenhagen, A.C. Meyers Vænge 15, DK-2450 Copenhagen, Denmark

^b Department of Geography and Environmental Studies, Ryerson University, Toronto, ON, Canada

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ABSTRACT

Cities throughout the world are expanding, and globally we are witnessing a significant amount of urbanisation. Currently, 54% of the world's population lives in cities, and an increase of 66% is expected by 2050. Based on the World Urbanisation Prospects' report, most of this growth is projected to concentrate in Asia and Africa. The resulting uncontrolled urbanisation can lead to many issues with profound impacts on health, poverty, and social inequality. Monitoring our global landscapes in the most rapidly growing regions particularly in the global south becomes thus an important endeavour. The estimation of future urban patterns become thus part of important topics that foresight the necessary support systems that efficiently cope with the carrying capacity of these urban regions. In this sense, this paper aims to i) monitor historical land cover changes in one of such major cities - Maputo, Mozambique, and, ii) project future patterns of urban fabric in its metropolitan region. To achieve this, satellite imagery from Landsat between 2000 and 2015 was collected and classified using a maximum likelihood algorithm. Spatiotemporal monitoring of urban settlements showed that within the proposed temporal scope, massive urban development took place while depleting a substantial amount of other land use types. Based on this spatiotemporal cognisance, a customized cellular automaton (CA) model was built that embeds the trends of changes while predicting future patterns. Our predictions exposed a significant amount of urbanisation will evolve over the next years if no significant controlling mechanism to cope with rapid urbanisation is integrated. Our findings, as well as conclusions, aim to aid local urban planners and policy makers in the course of urban planning in the region while taking advantage of novel open source methodologies that offer cost reduction and enable efficient monitoring for large urban extents.

1. Introduction

The cities of the world are expanding, and globally we are witnessing a large amount of urbanisation (UN-Habitat, 2010). Currently 54% of the world's population lives in cities and this is projected to increase to 66% by 2050. Most of this growth is expected to be concentrated in Asia and Africa (World Urbanisation Prospects, 2015). Urbanisation has many problems e.g. health issues due to pollution, urban poverty and slum creation. What goes on with Urbanisation and how the increase in people is handled and planned, is integral to living up to the UN sustainable Development Goals (World Urbanisation Prospects, 2015). Urbanisation is also a force of good as they present economic centres, innovation drivers and an opportunity to mitigate issues of consumption and production. In a large part of the planet, especially in developing countries, uncontrolled and rapid growth is resulting in the

creation of slums, inequality and a lack of proper infrastructure - both in regards of roads, housing and WATER, Sanitation and Hygiene (WASH) (UN-Habitat, 2010; UN-Habitat, 2016).

An extensive amount of literature has shared an ex-ante vision of the culprits of urbanisation (Arsanjani & Vaz, 2015; Tayyebi et al., 2013; Verburg, Neumann, & Nol, 2011; Arsanjani, Tayyebi, & Vaz, 2016). Nevertheless, policy-makers may argue that controlled urbanisation, may become an active force for economic drivers, where dynamics of innovation and employment play a significant role in the growth of new economic centres, which respond within their urban metabolism to issues linked to the sinks of consumption and production (Loures & Vaz, 2016). Urbanisation fundamentally occurs due to the process of growth of industry and economic development (He, 2016), leading to significant agglomeration of population density in urban environments (Wei, Taubenböck, & Blaschke, 2017), and creating a feedback loop

* Corresponding author.

E-mail address: jjja@plan.aau.dk (J. Jokar Arsanjani).

between economic activity and consumption of resources within urban fringes (Firman & Fahmi, 2017; Jat, Choudhary, & Saxena, 2017). It is in this feedback loop between stakeholders, economic activity, and policy that land use results in detriment of economic growth (Goerlich Gisbert, Cantarino Martí, & Gielen, 2017). The importance of land use activity within the context of urban development has a two-fold role: on one side, to guarantee the diversity of economic growth without jeopardizing scarce ecological resources, on the other hand, to equate liveability and societal equity within the dynamics of modern city growth (Banzhaf et al., 2017). This makes land use hold a particularly valuable role in the function of decision making and sustainable urban environments (Arsanjani, Helbich, Kainz, & Darvishi Bolorani, 2013a,b). The integration of landscape and land use diversity must therefore be precisely understood and forecasted, to avoid negative aspects over the long run to occur (Loures, Heuer, Horta, Santos, & Silva, 2008). The assessment of land use change thus is a centrepiece of the ongoing economic construct of generating modern and liveable cities (Vaz & Arsanjani, 2015) in developing countries, that have to face challenges in positioning themselves as future urban hubs (Hachmann, Arsanjani, & Vaz, 2017).

Hence, the main objective of this study is to monitor historical urban developments in a highly dynamic city in the global south as well as to predict its future urban expansion. To do so, we aim at developing a method based on open source technologies, which can be used worldwide at no cost, in order to assist the planning in developing countries and help in the efforts to mitigate some of the planning issues stemming from rapid urbanisation.

The remainder of this paper is structured as follows. Section 2 provides an overview to the materials and methodologies used in the study. Section 3 presents the findings and discussions on them. Section 4 concludes the key findings and identifies future research directions.

2. Materials

2.1. Study area

The selected study area for this study is Maputo, the capital of Mozambique, which is shown in Fig. 1. The reason for choosing this city is twofold as follows: firstly, Mozambique in general and Maputo province, in particular, has undergone tremendous urbanisation at a rapid pace both creating new slum areas and expanding existing (WHO, 2014; Jenkins, 2001), since the Mozambique's independence from Portugal in

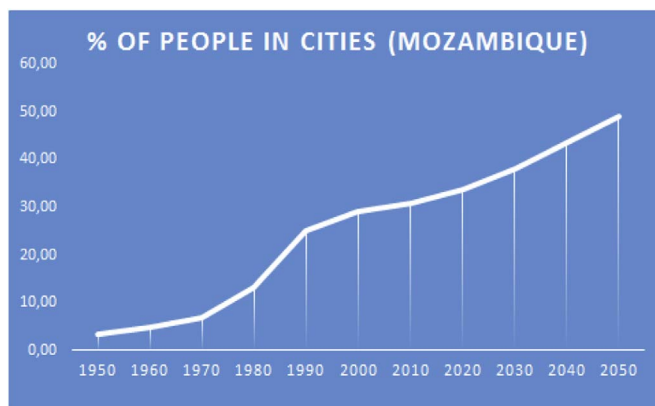


Fig. 2. Percentage of people living in cities of Mozambique by 2050 (Source: World Health Organization).

1975 as outlined in Fig. 2. In Mozambique, 80.3% of the urban population lives in slums, which is the fourth highest rate per country in the world (World Urbanisation Prospects, 2015).

Secondly, Maputo is considered as a complex city comprising of two cities, the old colonial city center nicknamed ‘Cidade de Cimento’ or ‘City of Cement’, and the pre-independence ‘Canico’ or ‘Reed city’ districts. The Canico districts are named after the building material available to the indigenous population during colonial rule. Today few reed buildings are left, but the Canico districts are still hurt by improper infrastructure, urban poverty, sanity and access to electricity (Castán Broto, Salazar, & Adams, 2014). Thirdly, Maputo has experienced rapid economic developments through the last decades. However, the wealth arising from the developments has unequally distributed, and poverty is still rampant. (Worldbank - Mozambique Overview, 2016). A looming civil war, a corruption scandal, and a debt crisis have currently resulted in a major crisis as inflation and food costs rise (International Business Times, 2016). Thus, urban slums have shaped and increased in the region. Fourthly, other externally funded development projects are occurring, which boost the development pace in the region. These examples include a) an underway funded by loans from the Chinese Export-Import Bank to build a major ring road linking Maputo and the neighboring city of Matola, and b) the longest suspension bridge in Africa across the Bay of Maputo.

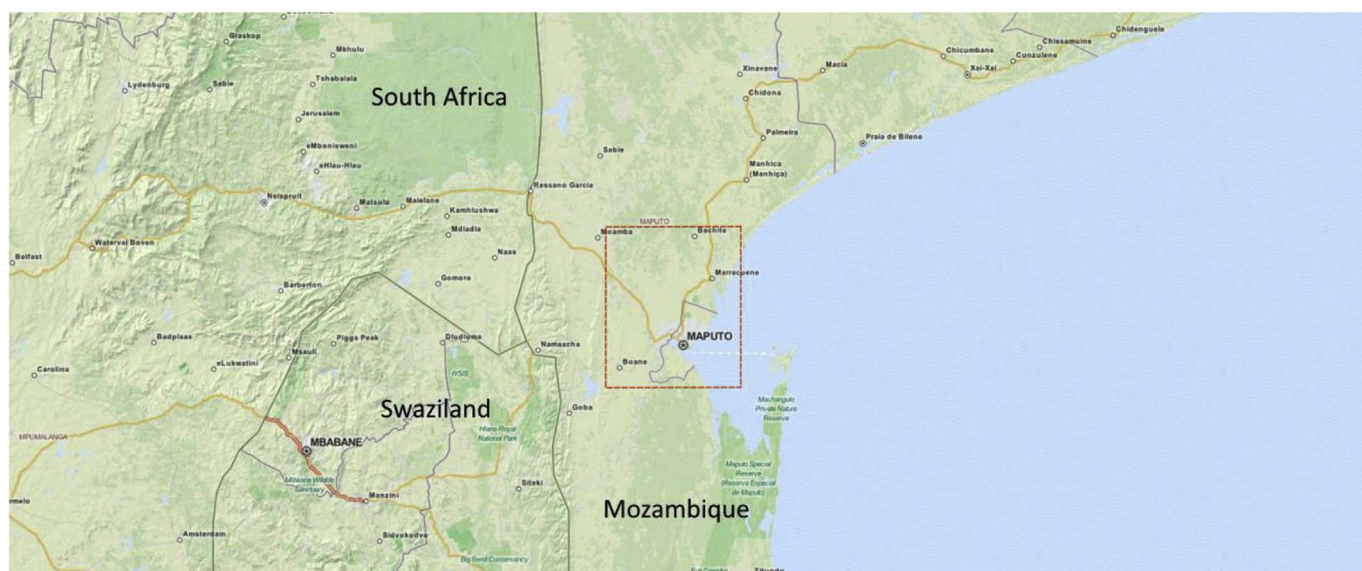


Fig. 1. Maputo and the surrounding area.

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