URBAN DENSIFICATION OF INFORMAL SETTLEMENTS IN SUB-SAHARAN AFRICA: AN ANALYSIS OF RECENT DEVELOPMENTS IN MAPUTO, MOZAMBIQUE

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ABSTRACT

Despite the rapid urbanization characterizing Sub-Saharan Africa, limited scholarly works have investigated the urban densification in African cities. This paper examines built densification of three unplanned informal settlements and developments of population densities in Maputo, Mozambique. The study is based on analysis of satellite images and census data from 2007 and 2017. The study found increasing built densities in all three case study areas and decreasing population densities in two case study areas. Accordingly, increasing built densities do not necessarily lead to increasing population densities. The study corroborates recent studies suggesting that the urban population growth in Sub-Saharan Africa is mainly accommodated through urban expansion. The study found limited variation of population densities and built densities despite different distances to the city center. The paper argues that this is caused by limited investment capacities of the landholders and large informal land supply. The paper suggests that centrality is less significant for development of built densities in informal settlements where residents hold the land due to limited investment capacity. The paper argues that policy-makers should prioritize establishment of roads in peripheral areas financed through road-pricing in order to curb the urban expansion and improve the resiliency of peripheral areas.

Keywords: urban morphology, urban densification, urban expansion, Sub-Saharan Africa, Mozambique, Maputo

INTRODUCTION

In 2009, less than 40% of the population in Africa resided in cities. However, according to demographic projections, the urban population will surpass the rural population approximately by 2030 due to extensive urbanization processes (UN-Habitat, 2020). The rural to urban migration and high fertility rates lead to large-scale urban transformations of African cities in order to accommodate the urban population growth. In Sub-Saharan Africa, the urban majority resides in informal settlements. These are urban areas typified by lack of state control (Jenkins, 2006). More specifically, informal settlements are characterized by construction that does not comply with planning and building regulations or construction on land which the occupants have no legal claim to (OECD, 2008). Informal settlements proliferate due to urban poor majorities lacking the resources to comply with regulation along with limited state capacity to administer the urban growth (Yeboah & Briggs, 2001). Urban densification is advocated as benefitting sustainability, resilience, and economic growth as well cutting the costs of service delivery and infrastructure provision (OECD, 2012; UN-Habitat, 2017). However, recent studies suggest that cities in Sub-Saharan Africa are undergoing rapid urban expansion with low density developments compromising sustainable development (Xu et al, 2019). Nevertheless, limited studies have focused on the concurrent urban densification taking place within the built-up urban fabric. The lack of knowledge on urban densification of informal settlements compromises development of efficient urban planning and policy (Owusu, 2013). This paper analyses developments of built densities and population densities of unplanned informal settlements in peri-urban Maputo, Mozambique in order to contribute to the knowledge on the development of informal settlements in Sub-Saharan Africa and enhance the efficacy of urban planning and policy targeting such areas.

Limited investments in infrastructure compromises mobility in peripheral low-density areas of African cities due to inadequate provision of roads, traffic congestion, insufficient public transport systems, and vast distances within the expanding cities (Satterthwaite, 2011). Simultaneously, the densification of the built-up urban fabric exacerbates problems with public hygiene in centrally located dense neighborhoods due to limited sewage and storm water management systems along with increased risk of contamination caused by high population densities (Andreasen & Møller-Jensen, 2017). Accordingly, urban sprawl and densification discussions may be simplified to a trade-off between public hygiene and mobility in the context of Sub-Saharan Africa. Costs of infrastructure are largely determined by the size of the area while the impact of implemented infrastructure is largely determined by the population density. Consequently, impact assessments and cost benefit analyses of infrastructure investments largely depend on urban density measures. As the infrastructure deficit in Sub-Saharan African cities constitutes a major issue confronting contemporary urban development, density measures are increasingly important for efficient use of resources in urban planning and policy.

Figure 1. Inadequate infrastructure and public transportation systems in Maputo.

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Figure 2. Maxaquene A, a centrally located informal settlement in Maputo.

Different urban models have been developed in order to describe the relationship between location, land value, land use, and urban densities. The cost of friction hypothesis underscores the relation between centrality and built densities by suggesting that land values are determined by transportation costs to the city center and that these determine the land use and densities (Haig, 1926). The concept was further developed in the sector model, highlighting that different sectors surround the Central Business District (CBD) and radiate outward along transportation routes from the city center (Hoyt, 1939). The Spatial Equilibrium Model assumes that differences across space in productivity, amenities, and the construction sector drive differences in density, incomes and home prices (Alonso, 1964; Mills, 1967; Muth, 1969). Bertaud (2018) argues that density is an indicator of land consumption, reflecting the equilibrium between supply and demand for land in a specific location. Population density is thus an indicator dependent on market parameters, mainly household income, land supply elasticity, and transport speed and cost. This implies that housing costs plus transport costs are constant across space and that housing costs will decline as transport costs rise with distance to the city center. However, Kombe (2005) argues that theories of land rent and spatial structures of cities do not apply to the organic form of informal settlements. Visagie and Turok (2020) argue that the relationship between location and urban density of informal settlements in Sub-Saharan Africa remains under-researched. This paper seeks to improve the knowledge of this relationship by examining developments of built densities and population densities in Maputo, Mozambique as well as discussing factors driving these developments. The paper includes analysis of developments of tree canopy cover in order to assess the impact of densification on biodiversity and microclimate. Furthermore, the paper analyses developments of public space in order to assess conditions for access and implementation of infrastructure. Finally, the paper discusses a number of policy proposals to address issues with low mobility and public hygiene based on the findings.

METHODOLOGY

This study is based on official census demographic data from the Mozambican government and self-produced spatial data based on Google Earth satellite images. Longitudinal data was used in order to examine the development over time. The demographic data was examined to assess the distribution of population across space. The spatial data was examined to assess the relationship between the distribution of population across space and the built environment. The spatial data includes indicators of built density, public space, and tree canopy cover for three case study areas. The built density was examined to assess the relationship between population density and built density. The public space was examined to assess the impact of built densification on the street network, with possible implications on mobility, public hygiene, and economic performance. The tree canopy cover was examined to assess the impact of built densification on the environment as private yards constitute the largest green space type in the city.

The census data was taken from the National Institute of Statistics (Instituto Nacional de Estatística) website in 2018. The census data presents recorded population for the city across the 2007 and 2017 national censuses in individual districts within the municipality and neighboring municipality of Matola, Marracuene district, and Boane district comprising the greater Maputo metropolitan area.

The self-produced data is based on three case study areas of unplanned settlements of Maputo. Cases with different distances to the city centers were selected in order to assess the significance of centrality for the development of built densities. All three areas are characterized by unplanned spatial structures and all three areas are relatively homogenous residential areas without any major roads, industry, businesses or public institutions, thus enabling data extraction relevant for comparison. The study examined 300x300 meter areas located in Maxaquene A, Hulene, and Guava.

Satellite images of all three areas were extracted from Google Earth. These were recorded the following dates: Maxaquene A: 16.09.2007, 03.05.2017; Hulene: 16.09.2007, 03.05.2017; Guava: 12.01.2007, 03.05.2017. The satellite images were imported and scaled in AutoCad. Buildings, streets, and trees were traced on separate layers. Each layer was subsequently joined using the Region and Union commands and the total area and number of entities for each layer was extracted from the properties bar. Attributes for total building coverage, number of buildings, total public space size, tree canopy coverage and number of trees were extracted using this method. All buildings in the three settlements were single-story. Accordingly, the floor area ratio was calculated based on the total building footprint area divided by the total sample area. Similarly, public space ratio and tree canopy cover ratio was calculated using this method. Parts of the data were used in a separate study (Jenkins & Mottelson, 2020).

CONTEXT

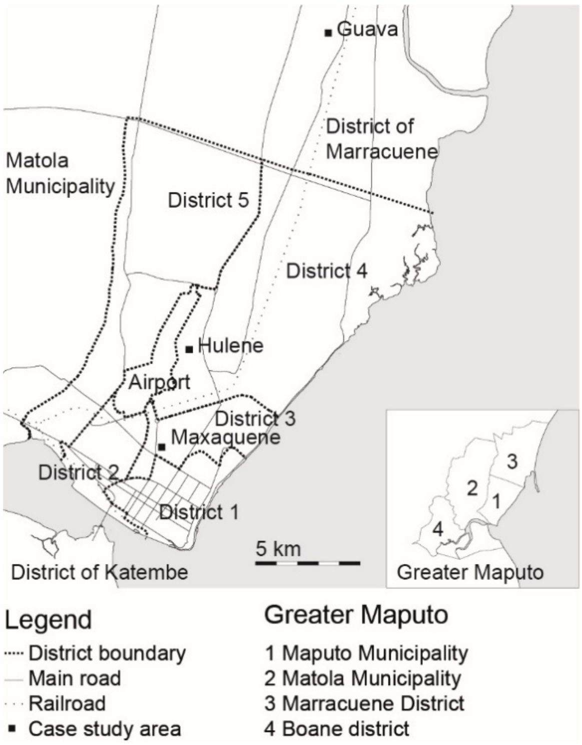

Figure 3. Maputo overview.

Mozambique is located in South East Africa and is one of the poorest countries in the world. Maputo is the capital of the country and the city is characterized by a formal urban center surrounded by informal settlements to the West and North as well as the Maputo Bay to the East and South. The urban center was established in 1781 by Portuguese colonialists, while the majority of the informal urban areas were established after independence in 1975. The urban development after independence was characterized by a large influx of rural population due to the ongoing civil war causing large numbers of refugees along with abolishment of previous restrictions on movement of people (Jenkins, 2000). Maputo consists of 7 administrative districts. District 1 covers the formal city center, district 2-5 cover the largely informal urban areas to the North and West of the center, while district 6-7 cover the island of Inhaca and Katembe south of the bay, which was connected to the city via a new bridge in 2018. However, the continuous urban fabric of the greater Maputo metropolitan area includes the neighboring Matola Municipality as well as Marracuene and Boane districts (Barros et al., 2014). This study includes sample areas in Maxaquene A, Hulene and Guava, respectively one, five and 20 km from the formal city. The three case study areas are located in district 3, district 4, and in Marracuene district beyond the municipal boundaries. Maxaquene and Hulene were largely developed during the influx of population subsequent to independence (Pinsky, 1982) while Guava was developed during the period under examination.

RESULTS

The 2007-2017 national census data shows 1% population growth within the Maputo Municipality during the ten-year period. However, the population of the Greater Maputo Metropolitan area grew approximately 60% in the same period. Accordingly, the population growth of the city primarily occurred beyond the municipal boundaries, in neighboring Matola Municipality, Marracuene District and Boane District. The data shows large variations in population growth between districts within the Maputo Municipality, as the three most centrally located districts had negative population growth, while the remaining districts had increasing populations during the ten-year period. The average household size decreased within the Maputo Municipality.

The spatial data shows increasing building coverage and decreasing tree coverage in all three case study areas from 2007-2017. The public space decreased in Maxaquene A and Hulene and increased in Guava. While the numerical increase in Floor Area Ratio (FAR) was relatively low, the case study area in Maxaquene A which had the highest FAR in both 2007 and 2017 showed the lowest proportional increase, while Hulene showed moderately higher numerical and proportional increase of FAR and Guava showed very high numerical and proportional increase of FAR.

	Population 2007	2007 p/h	Population 2017	2017 p/h	2007-17 change (%)
Maputo Municipality	*1,094,305*	5.0	*1,101,170*	4.9	*1%*
District 1 - KaMphumu	*107,530*	*4.0*	*80,550*	3.4	-25%
District 2 - Nlhamankulu	*155,385*	5.1	*129,306*	5.4	-17%
District 3 - KaMaxakeni	*222,756*	5.4	*199,565*	5.6	-10%
District 4 - KaMavota	*293,361*	5.2	*331,968*	5.0	13%
District 5 - KaMubukwana	*290,696*	5.0	*321,438*	4.9	11%
KaTembe	*19,361*	4.3	*32,248*	3.5	67%
KaNyaka	*5,216*	5.4	*6,095*	4.1	17%
Matola Municipality	*672,508*	4.8	*1,616,267*	4.4	140%
Boane District	*104,627*	-	*210,498*	-	101%
Marracuene District	*87,183*	-	*230,530*	-	164%
Greater Maputo	*1,920,261*	-	*3,070,259*	-	60%

Figure 4. Population and people per household of Greater Maputo 2007-2017, (INE, 2018).

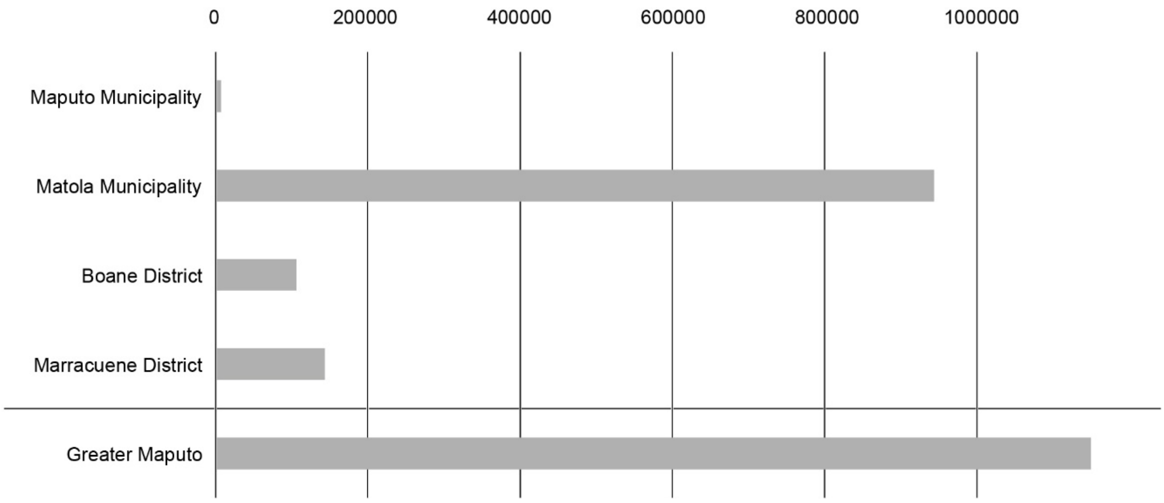

Figure 5. Population growth by administrative area 2007-2017, (INE, 2018).

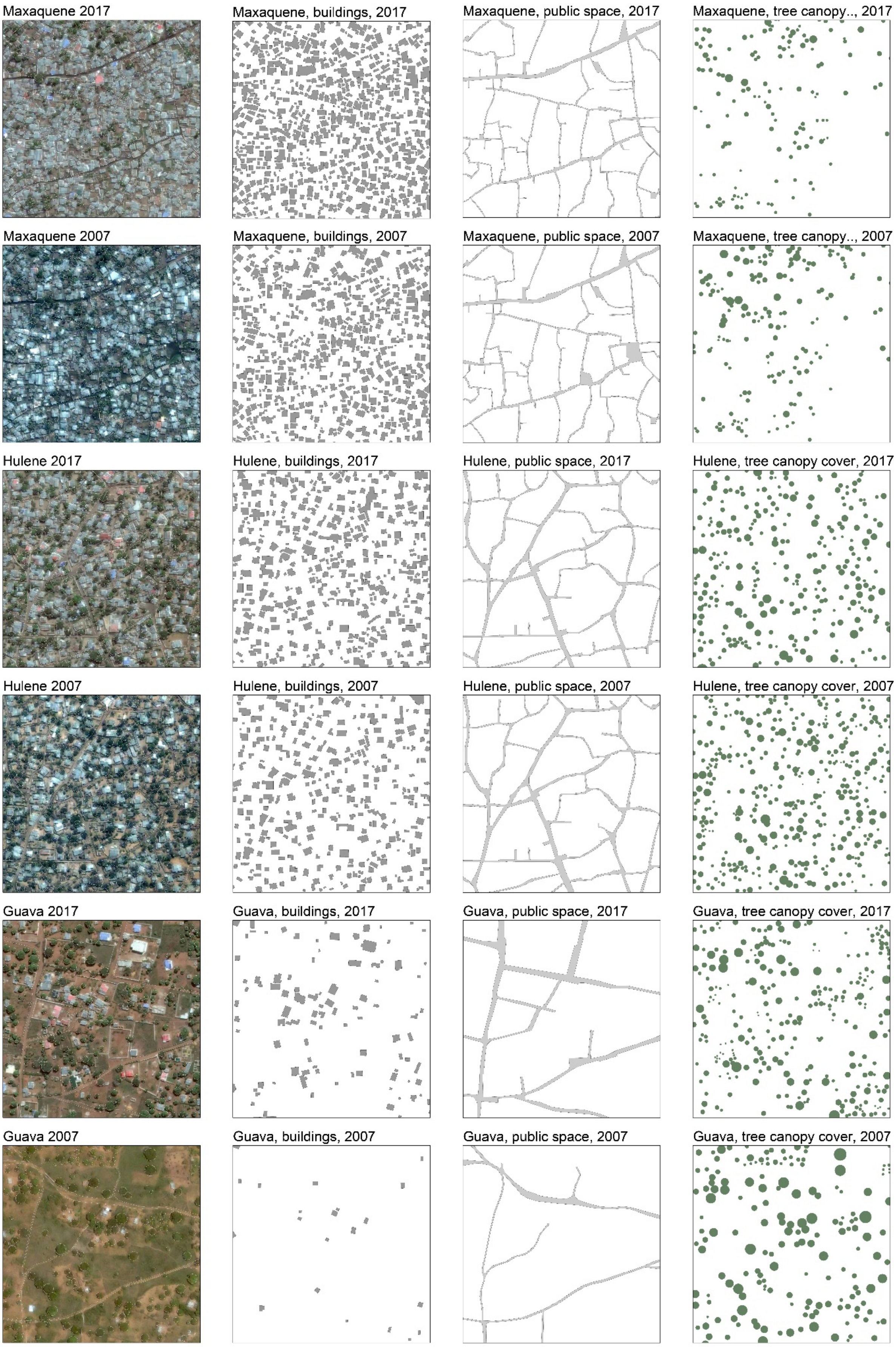

Figure 6. Case study areas 2007-2017

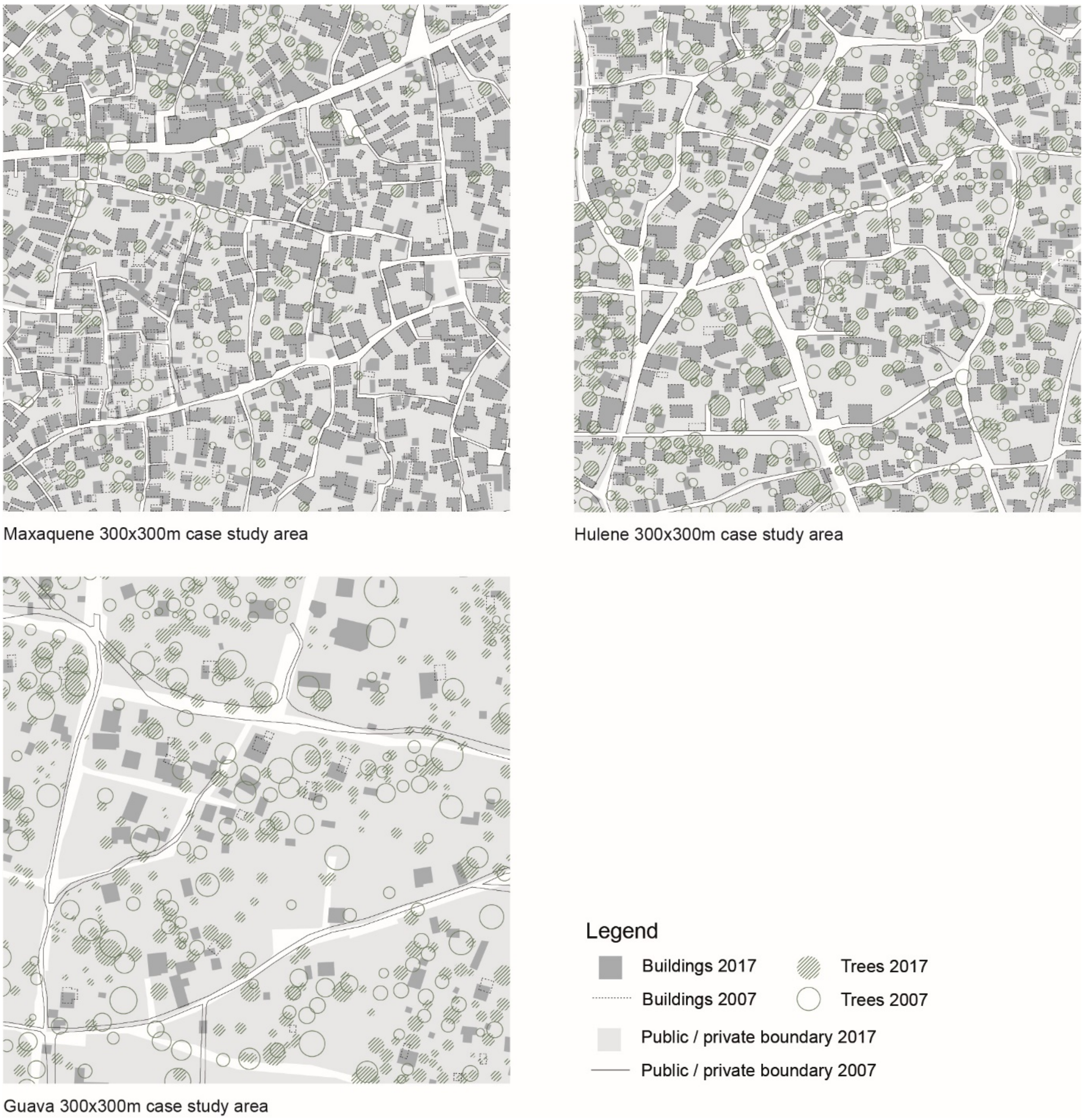

Figure 7. Case study areas 2007-2017

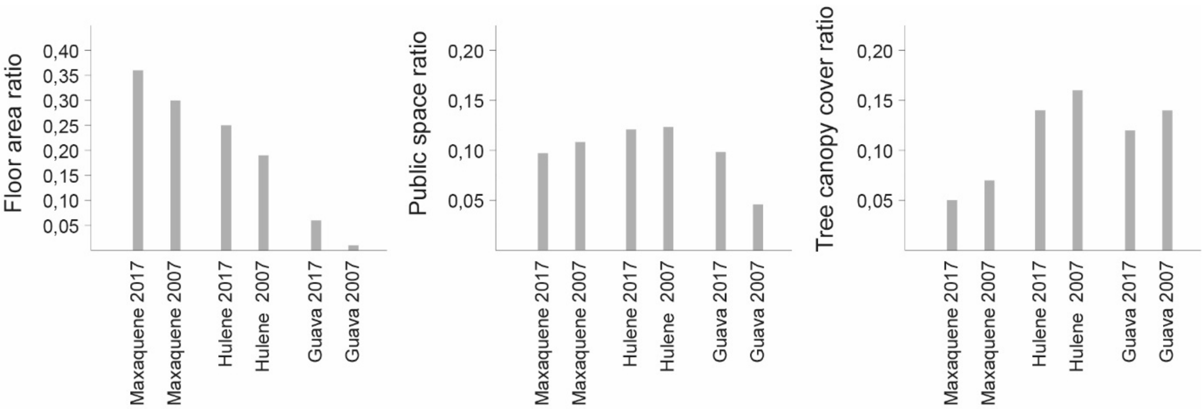

Figure 8. Case study areas 2007-2017

	Maxaquene A, 07	Maxaquene A, 17	Hulene, 07	Hulene, 17	Guava, 07	Guava, 17
Floor area ratio	0.30	0.36	0.19	0.25	0.01	0.06
Number of buildings	482	537	284	348	21	96
Public space ratio	0.1080	0.0970	0.1232	0.1209	0.0460	0.0984
Tree canopy cover ratio	0.07	0.05	0.16	0.14	0.14	0.12
Number of trees	137	122	348	261	160	255

Figure 9. Spatial data extracted from case study areas 2007-2017.

	Maxaquene	Hulene	Guava
Floor area ratio 2007-2017 change	21%	32%	723%
Number of buildings 2007-2017 change	11%	23%	357%
Public space ratio 2007-2017 change	-10%	-2%	114%
Tree canopy cover 2007-2017 change	-30%	-45%	-12%

Figure 10. Changes in spatial data extracted from case study areas 2007-2017.

DISCUSSION

The study found significant population growth in the periphery of the city along with negative population growth in the three most centrally located districts. This represents a center to periphery shift of the spatial distribution of the population. The study thus supports other recent works suggesting that growing urban populations in Sub-Saharan Africa increasingly are accommodated through urban expansion. This development may compromise the efficacy of future investments in infrastructure due to decreased population densities. Furthermore, while built densification occurred in all three sampled areas, the peripheral areas show higher numerical and proportional increase of built densities, underscoring the center to periphery development. The study suggests that increasing built densities do not necessarily lead to increasing population densities and do not necessarily enhance the sustainable aspects of compact city development due to the increased space consumption per capita.

The decreasing population densities in more central areas are likely caused by decreasing household sizes, economic development, and increased commercial activities in the center. Decreasing household sizes lead to decreased population density if the number of households remain constant and may thus partially account for the negative population growth in the centrally located districts. Economic development may in part account for the increased space consumption as it entails increased resources for investments in housing. As commercial functions are concentrated in the CBD, the growth of the city and consequent increased competition for central areas may have caused increasing pressure to convert residential space into commercial space, which may partially account for the decreasing population densities in the center. The parallel urban expansion is likely primarily driven by relatively cheap and accessible peripheral land and low transportation costs. Particularly, the lack of state control of the land market and consequent vast availability of low-cost informal land, subdivided and sold in the periphery of the city without formal planning, provides affordable accommodation and is thus likely a primary driver of the urban expansion.

As residents of informal settlements typically have limited economic resources and cannot obtain loans in banks as their properties are extra-legal, the investment capacity for construction is largely limited. Households in informal settlements typically develop incrementally when economic resources for expansion are available (Andersen et al., 2015). As overcrowding is common in informal settlements, residents typically seek to expand their dwellings. However, built densification is largely constrained by the limited household economy. Accordingly, the limited built densification of the more central informal settlements may be a result of limited investment capacity of the landholders. The limited share of tenants in the informal settlements of Maputo (Jenkins, 2013), may amplify this development as the landholders have limited additional income from tenants and thereby fewer resources for investments.

The Guava case study area was largely undeveloped in 2007 and had suburban levels of built density in 2017, while the other two cases were already developed in 2007. Although the three cases are located at different distances to the city center, the study found relatively little variation in built densities. Aside from the relatively low transportation costs, the limited variations in built density may in part be a result of low standards of initial construction. After the household is established, the level of expansion may be curbed by costs of home improvements and maintenance, thereby limiting the urban densification subsequent to the initial rural to urban land-use change.

The decreased public space in the case study areas in Maxaquene A and Hulene are likely caused by street encroachment by local residents. However, as the amount of public space in both cases were relatively low in 2007 the decrease in public space was minor. The public space increased in the case study area in Guava during the same period, as land was subdivided into residential plots and new roads were established to access the smaller plots. The data thus suggests that public space increases during the initial formation of informal settlements and subsequently decreases due to street encroachment. This development compromises access conditions as well as infrastructure provision as street spaces become narrower. In the more extreme cases, the development has negative implications for public hygiene and mobility.

The study found decreasing tree canopy cover in all three cases and decreasing number of trees in Maxaquene A and Hulene along with increasing number of trees in Guava. The decreasing tree canopy cover may be explained by the increasing urban densities as construction of buildings take up land previously occupied by the trees. In the Guava case, the expansion of the streets in the area may have been an additional contributing factor. The increasing number of trees in Guava suggests that the residents planted trees when transforming the area from semi-rural to a suburban residential area. The built densification likely leads to decreased tree canopy cover with possible negative implications for urban microclimate, biodiversity, and rainwater infiltration.

The newly established ring road, along with the new bridge to Katembe, will likely decrease transportation costs to peripheral areas, if not directly, then indirectly through decreased time spent on commuting to the center. According to the cost of friction hypothesis and the Spatial Equilibrium Model, these major infrastructure instalments will likely increase urban development along these transportation routes, and thus further increase the urban expansion. However, increasing gasoline prices and traffic congestion caused by increasing urban population and economic development may have the opposite impact. The likelihood of continued lack of state control of the land markets in the neighboring districts and municipalities will likely maintain the supply of affordable land on the market. It is thus likely that the current urban expansion will continue in the coming years in Maputo which may result in decreased impact of investments in infrastructure and increased resource consumption.

Road pricing is already used on the main traffic artery between Matola and Maputo. Similarly, road pricing could be considered for accessing the new ring road in the northern periphery of the municipality, in order to generate public revenue, decrease traffic congestion, decrease the CO2 emissions, and curb the urban expansion. This may create a market based 'green-belt' effect, which would otherwise require land management capacities which local authorities lack. Exemption of public transport for the road pricing may ensure a more socially balanced urban development and provide incentives for the middle class who can afford investments in infrastructure to settle within the municipal boundaries and drive the urban densification. The government may consider supporting the local authorities in countering street encroachment in order to increase mobility, improve public hygiene and lower costs of upgrading the infrastructure. Finally, the government may consider establishing roads in peripheral areas in one-kilometer grids in order to establish street networks for traffic and public transportation for the future urban expansion before the settlements consolidate and thereby constrain implementation of such basic infrastructure.

REFERENCES

Alonso, W. (1964). *Location and land use: Toward a general theory of land rent*, Cambridge, MA.: Harvard University Press.

Andersen, J. E., Jenkins, P. & Nielsen, M. (2015). Who Plans the African City? A Case Study of Maputo: Part 2 – Agency in Action. *International Development Planning Review (IDPR) Vol. 37 (4)*.

Andreasen, M. & Møller-Jensen, L. (2017). Access to the city: Mobility patterns, transport and accessibility in peripheral settlements of Dar es Salaam, *Journal of Transport Geography, Vol. 62*, 20-29

Barros, C. P., Chivangue, A., Samagaio, A. (2014). Urban dynamics in Maputo, Mozambique, *Cities, Vol. 36,* 74-82

Bertaud, A. (2018). *How markets shape cities*. Cambridge, MA.: MIT Press. 143-219.

Haig, R. M. (1926). Towards an Understanding of the Metropolis. *Quarterly Journal of Economics, Vol. 40 (2)*, 402-434.

Jenkins, P. (2000). City profile: Maputo, *Cities, Vol. 17 (3),* 207-218.

Jenkins, P. (2006), Informal Settlements: Infernal and Eternal? The role of research in policy advocacy and urban informal settlements in Angola. In M. Huchzermeyer, A. Karam, (Eds.) *Informal Settlements: A Perpetual Challenge?*, (1st ed., pp. 84-100). South Africa: University of Cape Town Press.

Jenkins, P. (2013), *Urbanization, Urbanism, and Urbanity in an African City: Home Spaces and House Cultures*, United Kingdom: Palgrave Macmillan. 112-128.

Jenkins, P. & Mottelson, J. (2020). Understanding Density in Unplanned and Unregulated Settlements of Peri-urban Africa: A Case Study of Maputo, Mozambique. In M, Rubin, A, Todes, P., Harrison, A. & A. Appelbaum, (Ed.), *Densifying the City? Global Cases and Johannesburg* (1st ed., 116-127), United Kingdom: Edgar Elgar Publishing.

Kombe, W. (2005). Land use dynamics in peri-urban areas and their implications on the urban growth and form: the case of Dar es Salaam, Tanzania. *Habitat International, Vol. 29 (1)*, 113-135.

Mills, E. (1967). An Aggregative Model of Resource Allocation in a Metropolitan Area. *The American Economic Review, Vol. 57 (2)*, 197-210.

Muth, R. (1969). *Cities and Housing: The spatial Pattern of Urban Residential Land Use*. United States: University of Chicago Press.

OECD (2008). *OECD Glossary of Statistical Terms*, France: OECD Publishing. Page 267.

OECD (2012). *Compact City Policies: A Comparative Assessment*, France: Organisation for Economic Co-operation and Development.

Owusu, G. (2013). Coping with Urban Sprawl: A Critical Discussion of the Urban Containment Strategy in a Developing Country City, Accra. *Planum: The Journal of Urbanism, Vol. 1 (26)*.

Pinsky, B. (1982). The Urban Problematic in Mozambique: Initial Post-Independence Responses, 1975-80, Canada: University of Toronto Press.

Satterthwaite, D. (2011). Upgrading dense informal settlements; the potential for health and well-being. *Cities, Health and Well-Being*.

UN-Habitat (2017). *The New Urban Agenda*. Kenya: United Nations Settlement Programme, 15-25.

UN-Habitat (2020). *Sub-Saharan Africa Atlas*, Kenya: United Nations Human Settlements Programme, 3-4.

Visagie, J., & Turok, I. (2020). Getting urban density to work in informal settlements in Africa. *Environment and Urbanization*.

Xu, G., Dong, T., Cobbinah, P., Jiao, L., Sumari N., Chai, B. & Liu, Y. (2019). Urban expansion and form changes across African cities with a global outlook: Spatiotemporal analysis of urban land densities, *Journal of Cleaner Production, Vol. 224*, 802-810.

Yeboah, I. & Briggs, J. (2001). Structural Adjustment and the Contemporary Sub-Saharan African City. *Area, Vol. 33,* 18-26.

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