

# Economic Scenarios and Their Impact on Spatial Transformation: A Johannesburg Case Study

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## Summary

This paper examines how different economic growth scenarios affect the success of Spatial Development Frameworks (SDFs) in shaping urban development in the Johannesburg Metropolitan Municipality. Using the CSIR's urban growth model, the study compares two scenarios: low economic growth and recovering economic growth, to assess their impact on spatial outcomes such as informal settlement growth, urban sprawl, and housing density. The findings reveal that economic growth significantly influences the effectiveness of SDFs—higher economic growth leads to better land use management, reduced informality, and more successful densification in central areas, whereas low economic growth exacerbates informal housing and sprawl.

**KEYWORDS:** economic scenarios, urban spatial planning, urban growth modelling

## 1 Introduction

The need for spatial transformation to create more compact and inclusive cities is a critical development objective for South Africa. Spatial Development Frameworks (SDFs), which are formal planning instruments constituted by the Spatial Planning and Land Use Management Act (Republic of South Africa, 2013), are pivotal in shaping the future spatial forms of municipalities, focusing on land use planning, housing densification, job locations, mixed-use developments, and transport linkages. SDFs put in place spatial vision and the regulatory environment for land use management and link with transport planning. The general perception is that well-constructed SDFs can effectively guide the necessary spatial transformation.

However, the country's socio-economic landscape is marked by significant disparities in access to formal housing, driven by economic barriers that hinder the upward mobility of low-income households. As a result, informal settlements continue to proliferate in urban areas (Cross & Seagar, 2010). Informal settlements arise and grow rapidly in areas where it is difficult to manage development. There are broadly two types of informal development. The first occurs on undeveloped land which is close or is perceived to be close to employment opportunities such as utility servitudes, floodplains, industrial zones, or land designated for environmental protection. The second is where informal backyard dwellings are erected in formal low-income residential areas as it provides additional rental income to the property owners (South African Cities Network, 2016).

Informal settlement growth is exacerbated by the government's limited financial resources, which hinder its ability to provide enough social housing at the required pace, compounded by existing backlogs and ongoing urbanisation. The drivers of informal settlement development negate the envisioned spatial form and function of cities, as they are not bound by the regulatory environment and lead to urban sprawl (South African Cities Network, 2016).

Achieving the needed spatial transformation requires not only robust spatial planning strategies but also economic interventions, thus a coordinated approach. This paper underscores the importance of such a coordinated approach through a case study analysis of the Johannesburg Metropolitan Municipality.

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The study uses this municipality’s SDF as a guide for land use management interventions and explores the impacts of various economic growth scenarios on spatial outcomes, focusing particularly on informal residential developments and their implications for the city’s future spatial form.

## 2 Methodology

This paper makes use of the CSIR’s urban growth model, which is a CSIR adaptation of the UrbanSim model for a South African context and is used for modelling urban development. It helps planners understand how cities evolve, considering various factors like land use, transportation, and economic conditions together with the effects of various planning policies and decisions.

UrbanSim is an open-source urban simulation model designed to project the spatial distribution of urban growth over future time intervals. UrbanSim is coded in Python and consists of around eight statistical sub-models that predict or determine multiple outcomes such as building prices, movement of households, placement of residential and non-residential buildings, placement of job spaces, and growth of household and job totals to match control totals. The CSIR’s urban growth model utilises these UrbanSim statistical sub-models but additionally makes use of sub-models developed to handle informal settlements, backyard shacks, free government supplied housing and overcrowding. For more details regarding the functioning of this urban growth model, the reader is referred to (Waldeck, Holloway, & Van Heerden, 2020).

## 3 Case study

The case study is based in the Johannesburg Metropolitan Municipality, in the province of Gauteng, in South Africa. To perform this study the municipality has been divided into 4555 polygons (analysis zone), approximate 1 km<sup>2</sup> in size, with uniform underlying socio-economic characteristics. For this case study the model was calibrated with input data aligned to the city’s SDF and this paper describes two different economic scenarios within the SDF context. The SDF focuses development efforts in areas referred to as “transformation zones” and prioritises densification in these areas over urban sprawl. The first scenario is the low economic growth scenario, depicted by the blue line in **Figure 1**. The second scenario, known as the recovering economic growth scenario, is shown by the grey dotted line in **Figure 1**. The economic trajectory of each scenario influences household income levels and job availability. The low economic growth scenario was obtained from S&P Global (old name IHS Global Insight). The recovering growth scenario starts off the same as the low economic growth scenario and slowly builds back up to the pre-COVID-19 GDP (obtained from UrbanEcon).

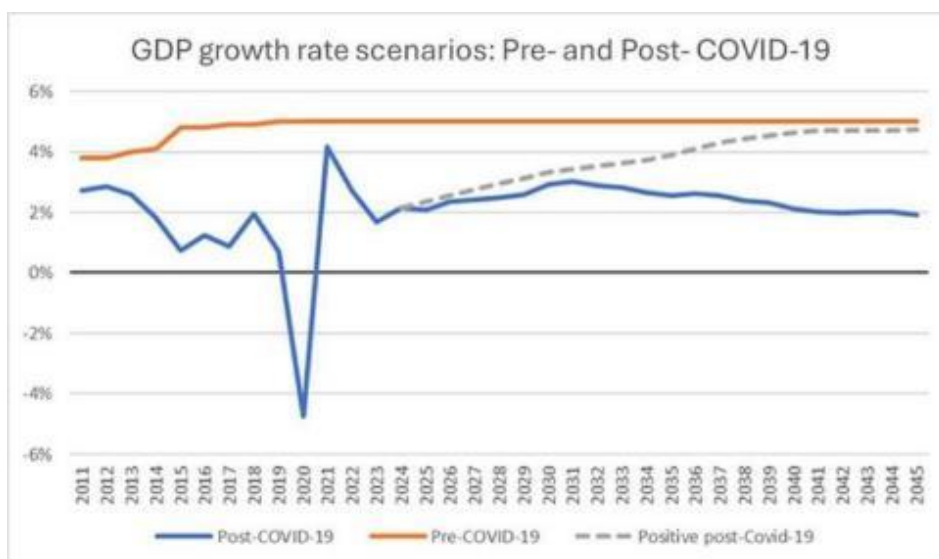


Figure 1 GDP Annual Growth Rate scenarios.

**Figure 2** shows the breakdown of the households per income quantile for the two economic scenarios. The low growth scenario predicts a higher percentage of households in the lowest income basket (below the poverty line) as well as a lower number of jobs created by the end of the scenarios in 2042, compared to the recovering growth scenario. This demonstrates that a reduction in jobs leads to a higher number of households that fall below the poverty line. In both scenarios the model was run for the years starting in 2018 and ending in 2042. All other model inputs were kept constant between the two scenarios.

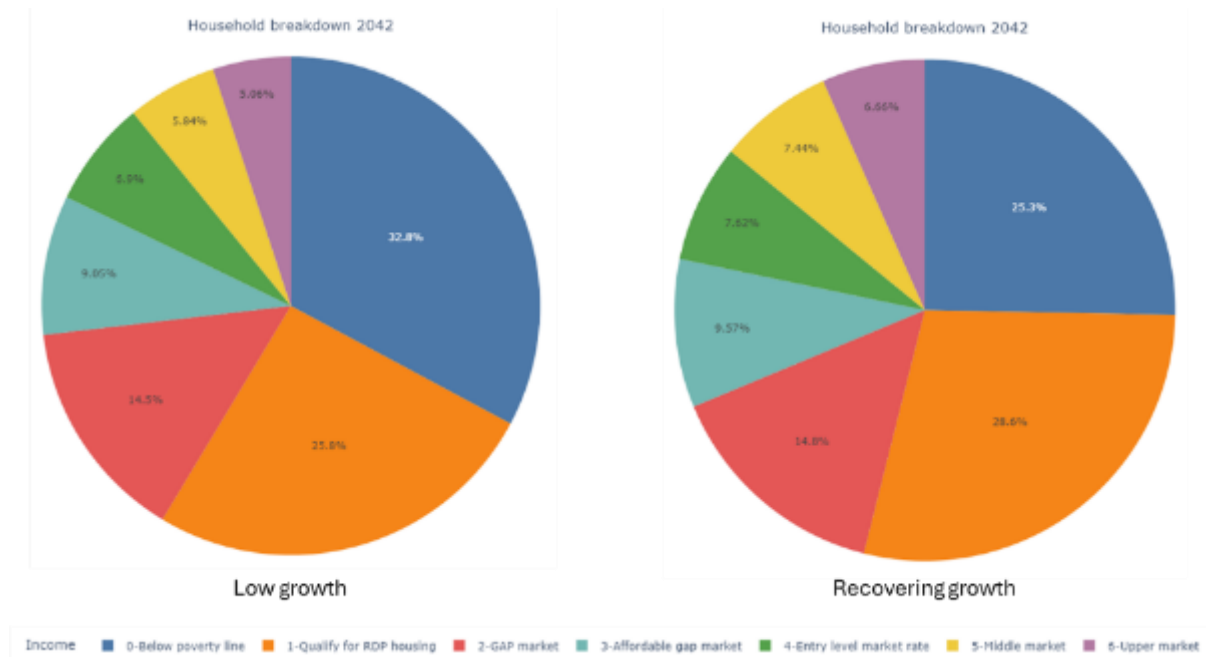
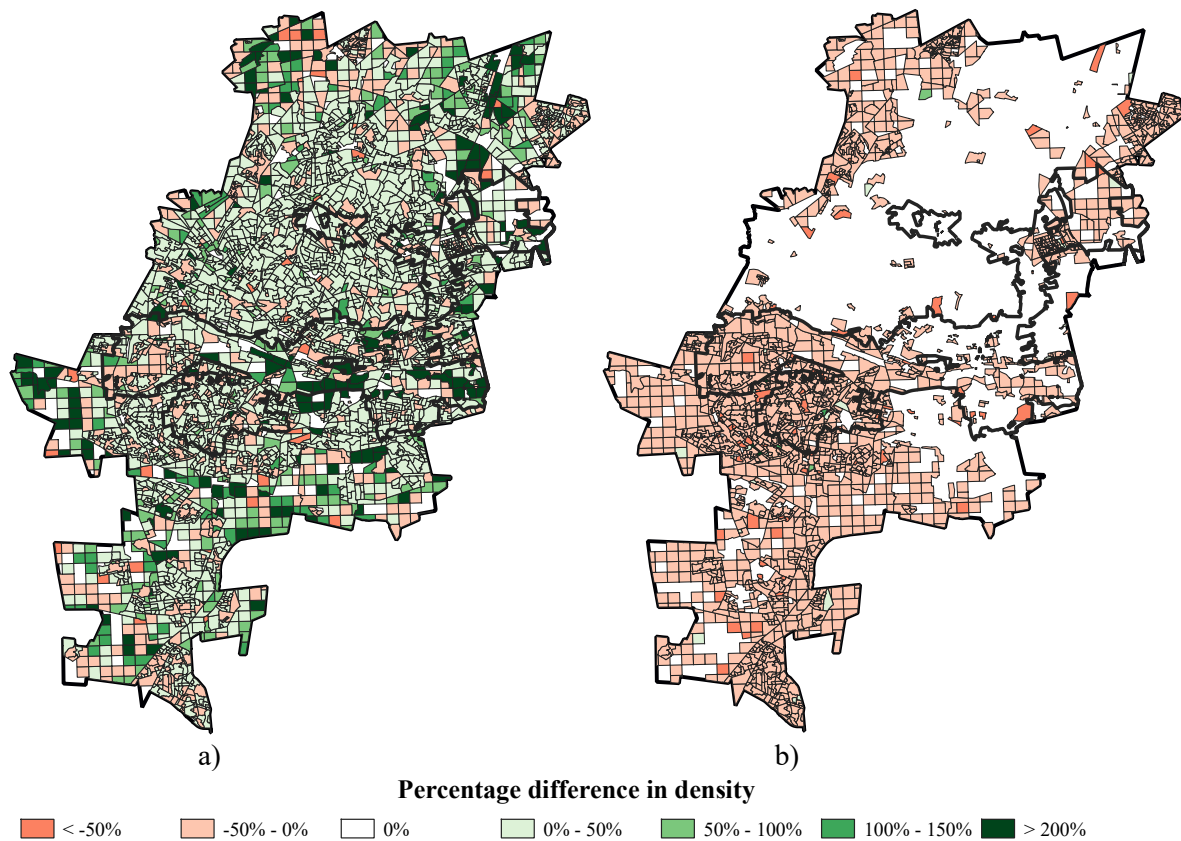


Figure 2 Percentage of households in each income quantile based on the two economic growth scenarios.

#### 4 Results and conclusion

One objective of the SDF is to densify central built-up areas of the city and restrict urban sprawl. The simulation output from the SDF scenario with low economic growth and the SDF scenario with recovering economic growth were compared to analyse the impact of economic growth on the strategic plans. The results indicate that the informality in 2042 in the low growth scenario is 30%, while for the recovering growth it is reduced to 23%. **Figure 3** shows the difference (delta) between these two scenarios in terms of residential unit density by 2042, with positive values indicating higher density in the economic recovery scenario and negative values indicating higher density in the low economic growth scenario. The map on the left (a) shows the delta for formal residential units and the map on the right, the delta for informal residential units.

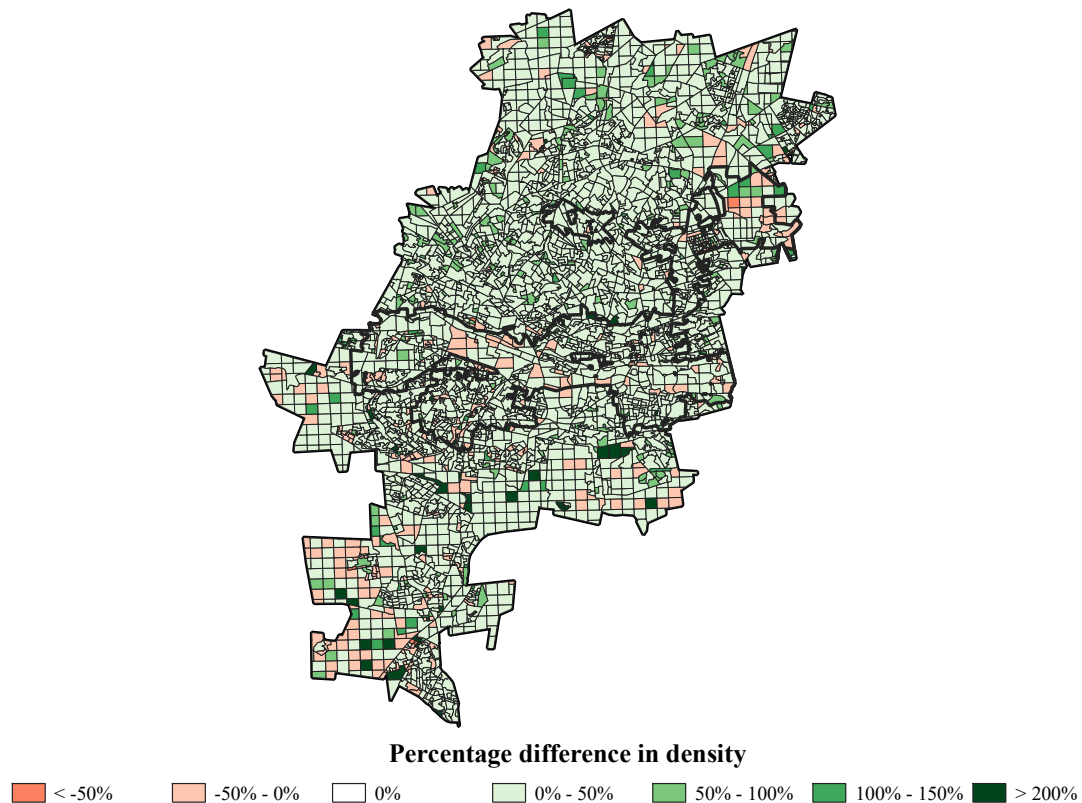


**Figure 3** Percentage difference in residential unit density in 2042 between low economic growth scenario and recovering economic growth scenario a) Formal residential units b) Informal residential units.

Central areas for formal housing are mainly green, indicating higher densification for the recovering growth scenario relative to the low economic growth scenario. Most of the orange areas, i.e. where the low economic growth scenario achieves higher density than the recovering growth scenario, are generally more towards the outer areas of the city in map (a). From the informal map it is seen that the low economic growth forces more people to resort to informal housing, typically on the outskirts of the city.

**Figure 4** **Error! Reference source not found.** shows the difference (delta) between these two scenarios in terms of job density by 2042, Throughout the city, but especially towards the centre of the city, the map is green, indicating higher densification for the recovering growth scenario relative to the low economic growth scenario. Once again, the orange is located more towards the outskirts of the city, indicating more urban sprawl in the low growth scenario.

Income diversity is a metric used to measure income segregation in an area with 0 indicating no mix of income and 1 indicating a fully integrated area. The results show that the income diversity in the transformation zones increased from 0.526 to 0.597 from the SDF low growth scenario to the SDF recovering growth scenario. This 0.526 is also lower than the 0.545 of the “as-is” (non-SDF) recovering growth scenario. This is significant since even without city interventions but with a recovering economy, the income integration is better than when spatial planning is applied to a low growing economy.



**Figure 4** Percentage difference in job density in 2042 between low economic growth scenario and recovering economic growth scenario.

To conclude, cities have plans such as the SDF to guide growth of the city. However as presented above, the economy has a significant impact on the effectiveness of these plans on the city development as well as urban sprawl.

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## 6 Biographies

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Jenny Holloway is a senior statistician at the CSIR with more than 30 years' experience and holds an MSc from the University of Cape Town. Her expertise lie in research and application of quantitative methods to complex problems and has vast experience involving forecasting urban growth and housing demand.

Gerbrand Mans is a principal researcher at CSIR with a Master's degree in Geo-Information Sciences from Stellenbosch University. His research focuses on understanding regional and urban dynamics within the context of development planning.

Carla Beetge is an engineer at the CSIR and holds a B.Eng in industrial engineering from the University of Pretoria. She focuses on creating client-specific web-interfaces and implementing data analytics for various applications regarding the group's speciality in urban growth modeling and forecasting.

Paul Burger is an engineer at the CSIR and holds a B.Eng in industrial engineering and a B.Eng.Hons in computer engineering from the University of Pretoria. His focus is on creating GIS decision support systems to aid in complex spatial analysis problems.