

Spatial Modelling of Indian Cities by Parameterising Building Codes A Case Study of Navi Mumbai

Varun Phadke, Arnab Jana
Indian Institute of Technology, Bombay
work.varunphadke@gmail.com

INTRODUCTION & AIM

Indian metropolitan cities under rapid urbanisation pressures and are undergoing a 'redevelopment' phase where the traditionally less dense urban cores are being rebuilt plot by plot in-situ with liberalised building control norms to allow for higher permissible built-up area in the same land parcel. This densification is not being mapped in policy or spatially leaving the stress it brings onto existing urban systems unmapped. The aim of this study is to visualise and analyse this change using a 'digital shadow' extensible to a digital twin.

The study focuses on the Mumbai Metro Region which is seeing massive changes in built-up due to policy changes in the last decade. It maps out all policies and statutory documents that control urban development process and to translate them into rule-based systems that parametrically generate a city-wide spatial model that predicts the future urban morphology strictly based on the updated building by-laws and spatial development plans.

As permissible FAR increases up to three-fold, the urban fabric transitions from mid-rise to high-rise typologies, enabling intensified built volumes and incentivising vertical redevelopment. With no existing policy blueprint for this shift, the spatial and quantitative ramifications on urban systems remain unstudied, and this research addresses that gap. The goal then remains to derive key urban metrics from these models for evaluation and explore the ramifications in urban planning, economic growth, liveability and environmental sustainability.



Fig: Typical Redevelopment Scenario

RESULTS AND DISCUSSION

The procedural modelling framework was successful in modelling a plot-based redevelopment scenario for two horizon years 2038 and 2058 using a probabilistic distribution model for growth. A complete 3D geo-spatial model was the output with high degree of accuracy as to the buildings developed. It replicated the city as is for a 2018 base case and predicted the subsequent development. The generated models were evaluated using a multifaceted methodology to account for spatial accuracy, regulatory compliance, and scenario plausibility.

Quantitatively, the model was validated using census figures and development plan data, which matched the projected population numbers to an error of less than 5%.

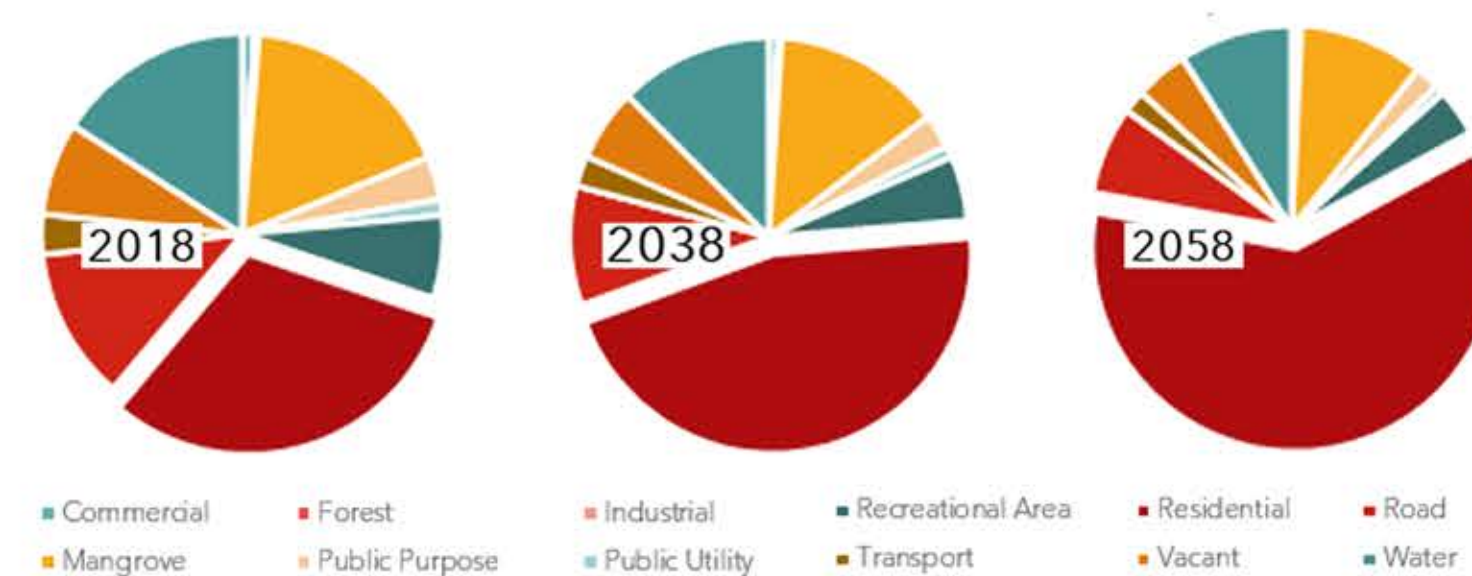


Fig: Predicted Change in Urban Built Up



Fig: Rule Based Generation 2018

METHOD

The parametric translation of building regulations involves identifying key plot-level attributes, including plot geometry, area, abutting road width, designated land use, along with deconstructing the building bye-laws into a spatial program that applies all the necessary controls and generates a permissible built mass for each plot.

A classification algorithm then applies the correct subset algorithm which maximises permissible FAR use in each case based on the building typology to generate the most probable building.

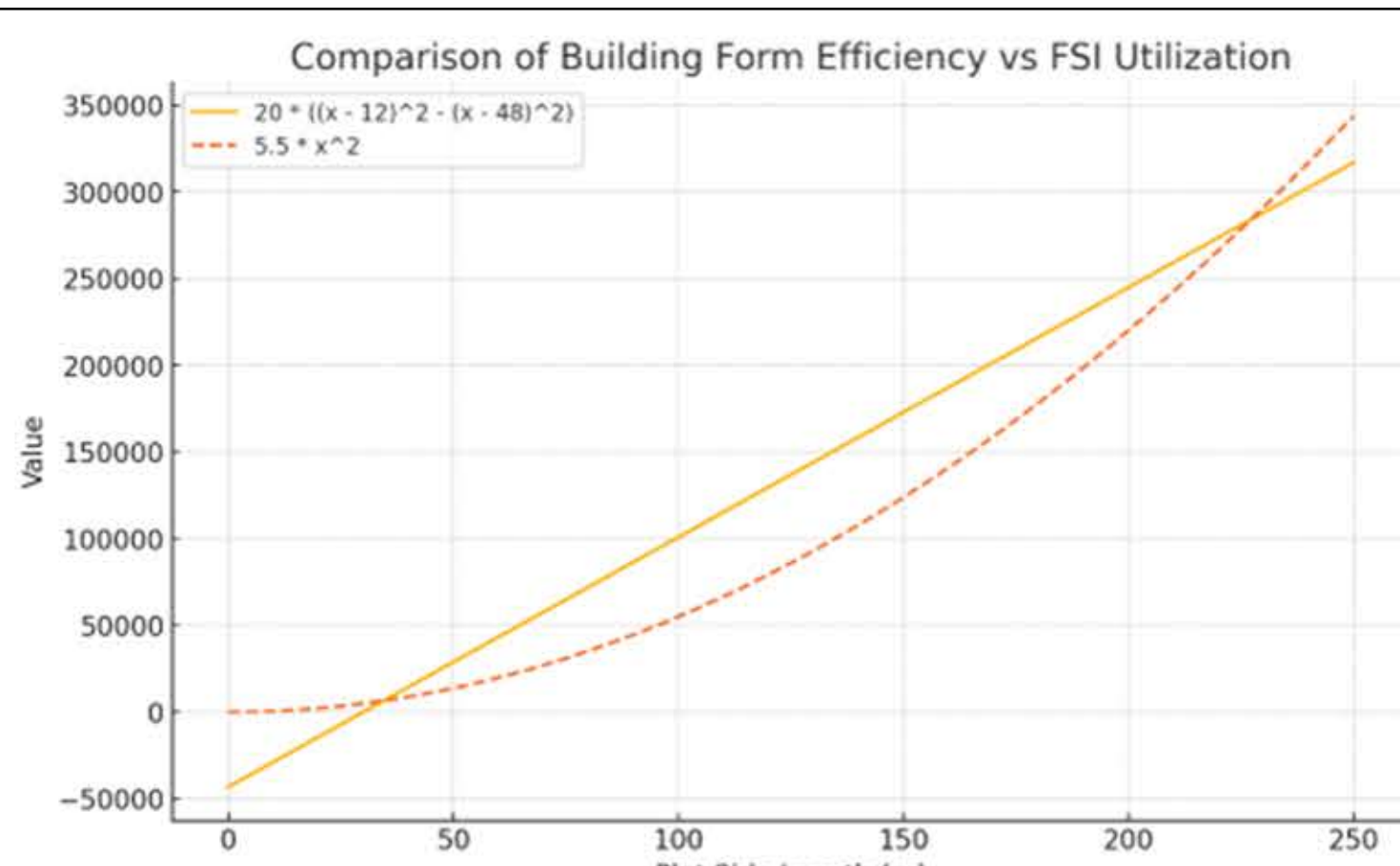


Fig: Classification Algorithm

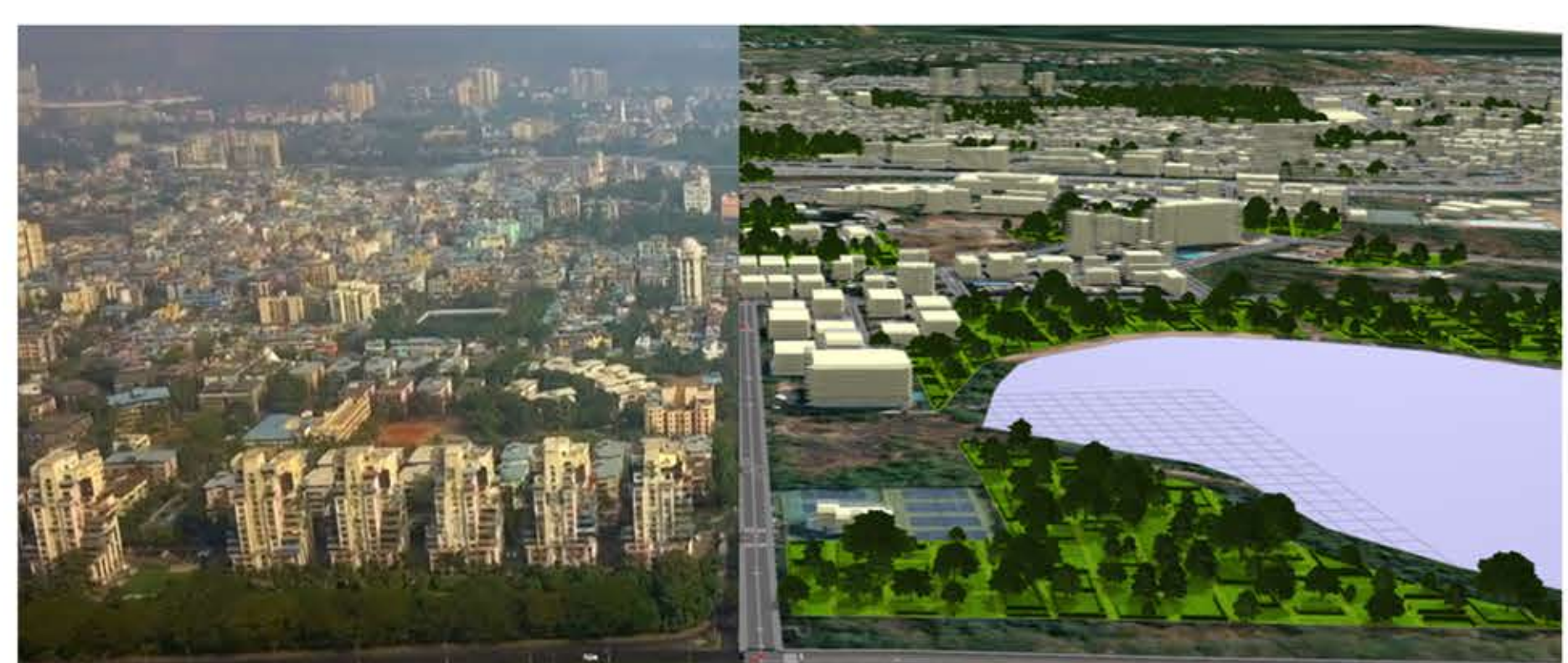
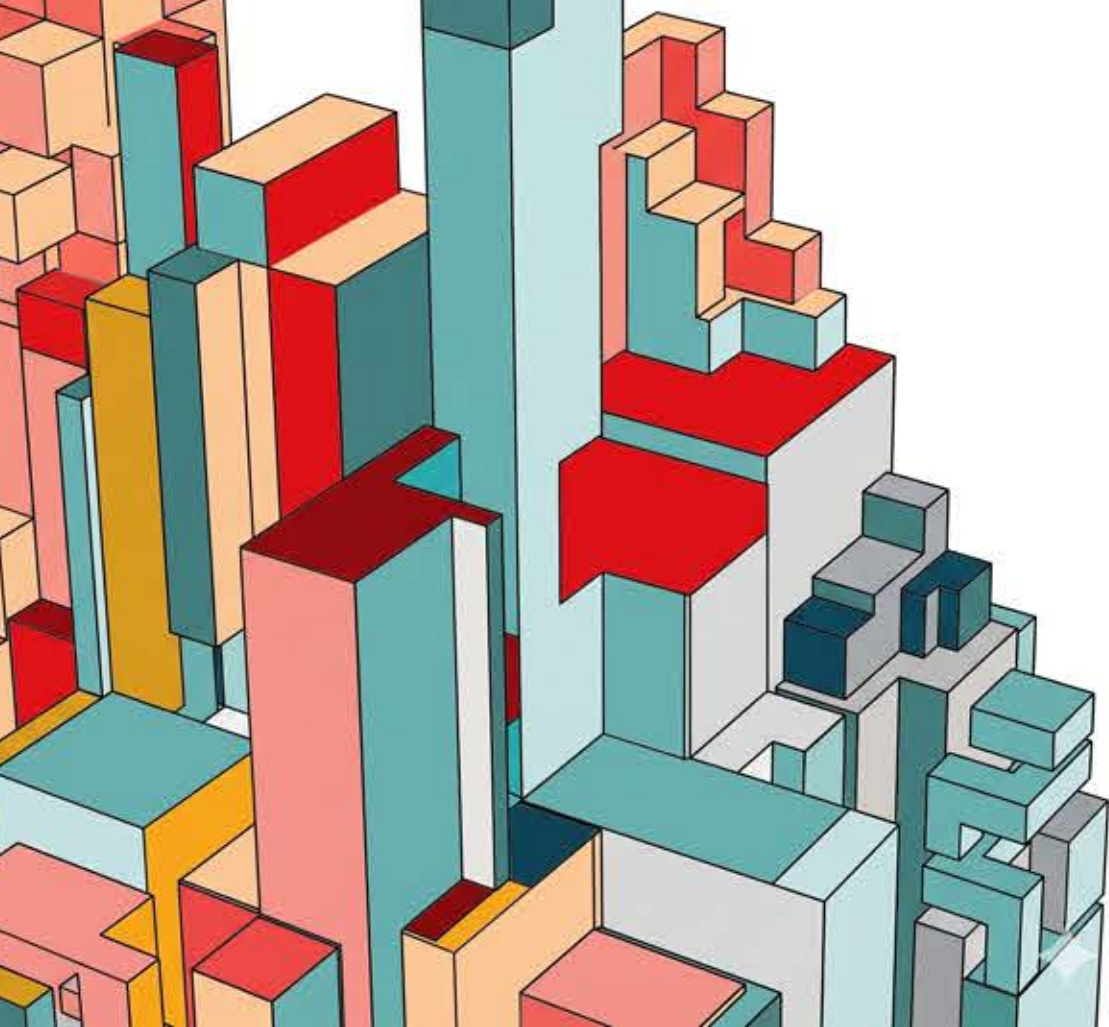
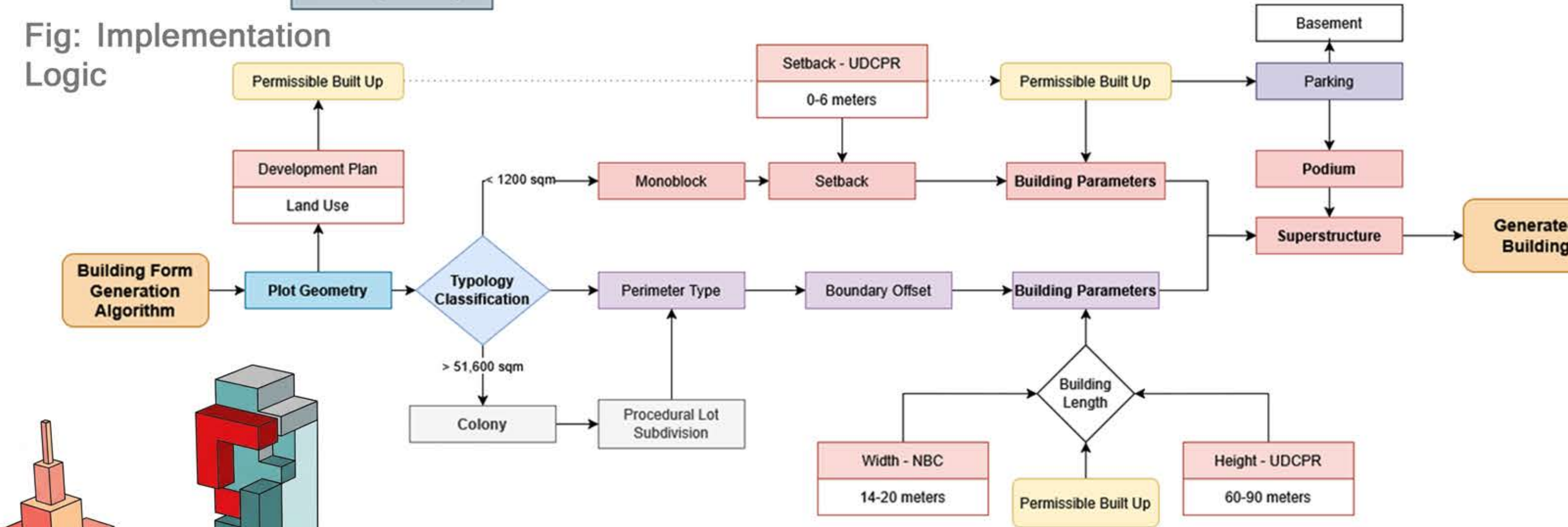
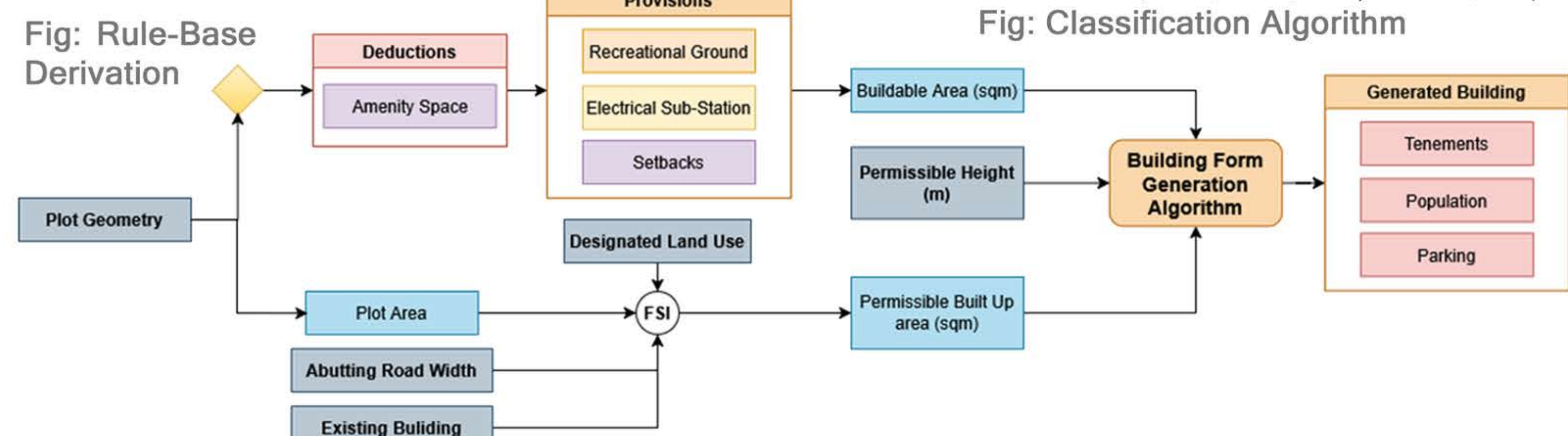


Fig: Preliminary Model Generation

CONCLUSION

The work demonstrates the potential of regulation-sensitive procedural modelling to spatially translate urban planning norms into three-dimensional, scalable representations of city form.

By parameterising the building codes and simulating urban morphology for 2018, 2038, and 2058, the geo-spatial, semantic, attribute rich 3D model bridges the gap between static regulations and dynamic city growth.

It offers planners a visual and analytical framework to assess redevelopment potential, test alternative futures, and simulate environmental impacts.

The approach moves beyond conventional master planning by enabling scenario-based evaluation rooted in regulatory logic—thereby contributing to more transparent, data-driven, and adaptive urban decision-making.

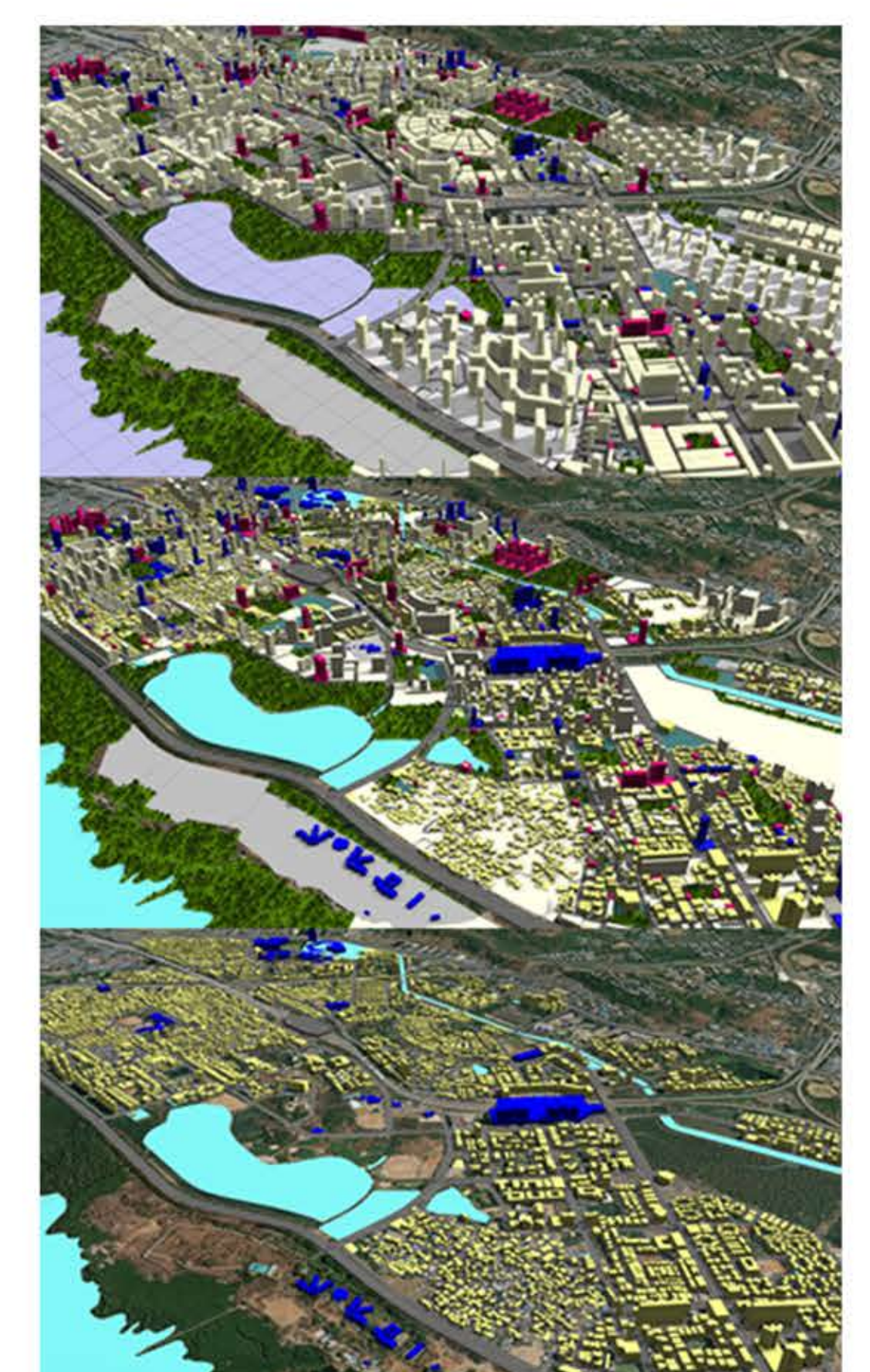


Fig: (Bottom to Top) 2018, 2038 and 2058 scenarios

FUTURE WORK/REFERENCES

The base model offers the potential to integrate a wide range of 3D urban applications—such as ventilation, heat island, and wind comfort simulations—supporting multipurpose analysis from a single spatial framework.

With further development, the model could evolve into a critical decision-support tool for urban planners, enabling dynamic policy testing, visualisation of redevelopment outcomes, and scenario-based evaluations.

The framework could also serve as the foundation for participatory digital planning platforms, facilitating collaboration among planning authorities, infrastructure agencies, and citizens through a shared spatial data environment.

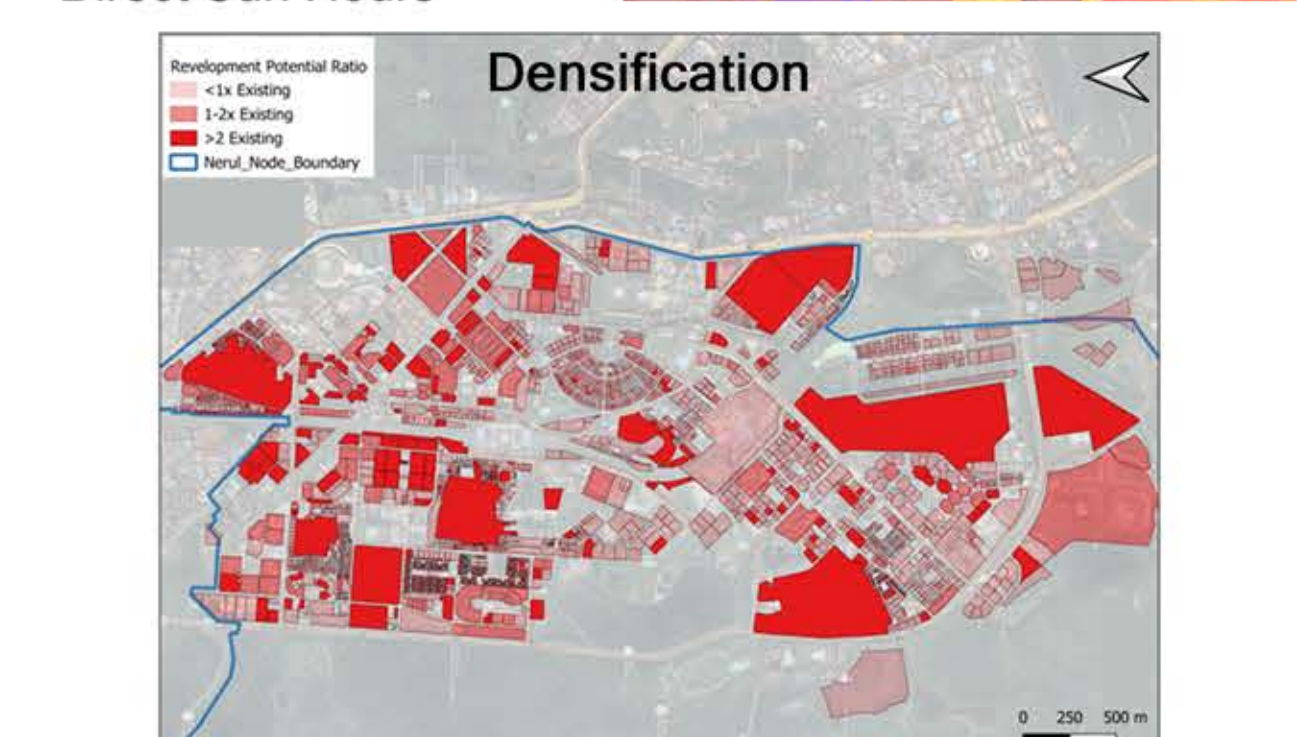
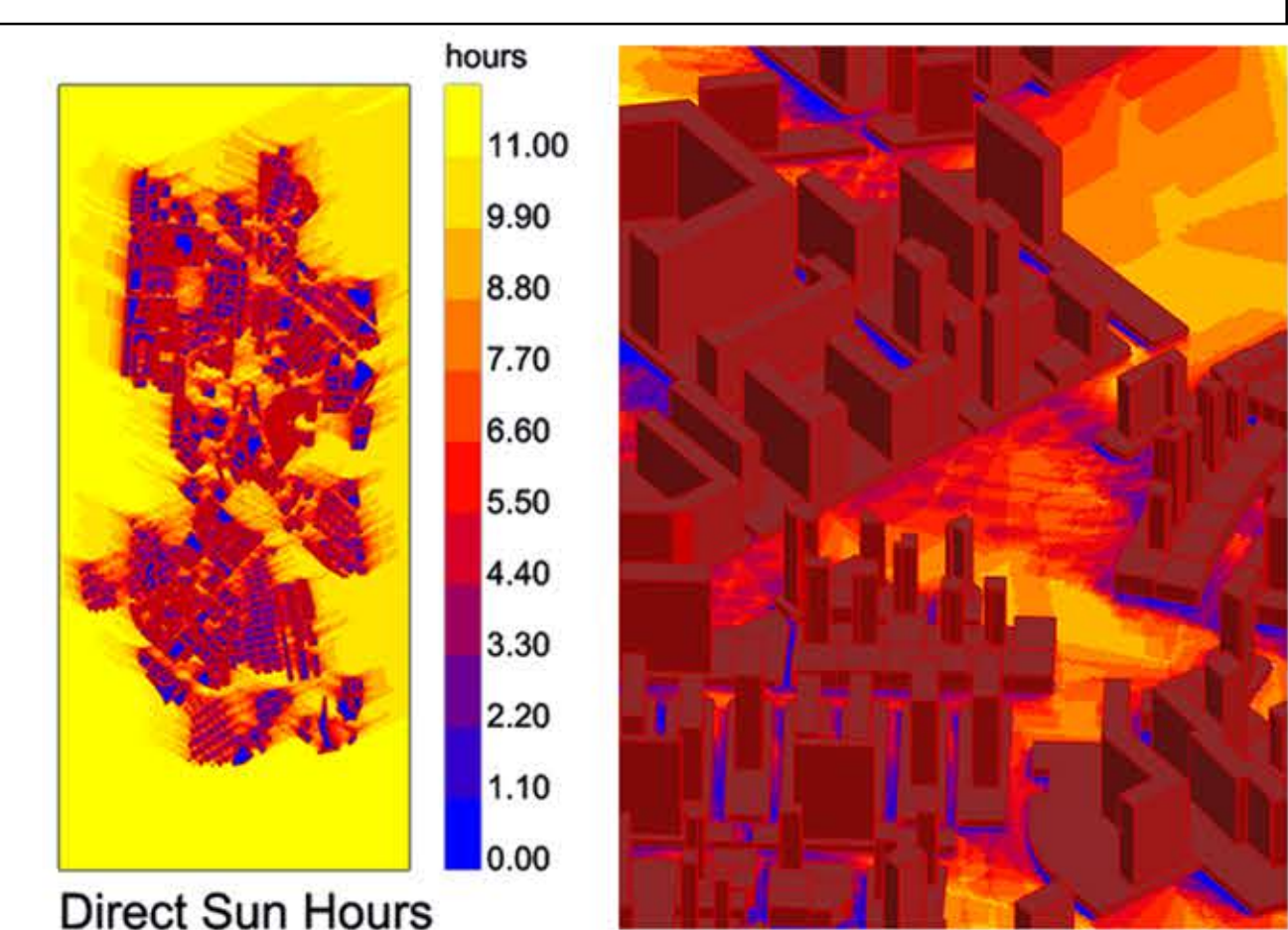


Fig: Model based Applications