

Monitoring Urban Growth in Informal Settlements Using Deep Learning: A Spatial Analysis of Khayelitsha (2013-2022)

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SUMMARY

The quick pace of global urbanization causes standard mapping techniques to become instantly irrelevant, creating a critical temporal lag that severely hinders effective urban governance. This study addresses this fundamental deficit by implementing and validating a Deep Learning-based geospatial methodology to accurately measure informal dwelling expansion and quantify the resulting increase in hazard exposure in Khayelitsha, Cape Town, between 2013 and 2022. The methodology proved highly efficient and reliable. It was successfully validated with an F1-Score of 74.8% (Recall:85.6%), confirming its robust suitability for generating large-scale, object-level inventories in the complex, high density environment. The application of this validated approach revealed an overwhelming 282.4% dwelling increase (an addition of 2,895 structures) over the nine-year period. Crucially, the Nearest Neighbor Index (NNI) analysis corrected the initial assumption of densification, proving the massive growth was achieved through outward sprawl (NNI shift from 0.58 to 0.94). This sprawl directly translated into a systemic increase in environmental vulnerability. The final Proximity Risk Analysis quantifies the risk precisely: the average informal dwelling moved a calculated 45.81 meters closer to the Flood Susceptible Area boundary between 2013 and 2022. This substantial reduction in the safety margin provides definitive proof that uncontrolled expansion systematically consumes the protective geographic space. In conclusion, the research validates the use of cost-effective Deep Learning to overcome critical data deficits. The evidence produces a severe finding—a 45.81 meter erosion of the community's safety margin. This highlights the urgent need for data-driven disaster risk reduction strategies to protect vulnerable populations from the spatial consequences of unmitigated growth. This work demonstrates the crucial utility of geospatial innovation in delivering timely, object-level intelligence necessary for addressing rapidly evolving humanitarian and urban development challenges.

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