A Multivariate Sensitivity approach for urban densification modelling

Anasua Chakraborty[1]; Ahmed Mustafa[2], Hichem Omrani[3]; Jacques Teller[1]

[1]LEMA, University of Liege, Belgium, A.chakraborty@uliege.be (corresponding author)
Jacques.teller@uliege.be
[2]Urban Systems Lab, The New School, New York, NY, United States
a.mustafa.eg@gmail.com

[3]Urban Development and Mobility, Luxembourg Institute of Socio-Economic Research, Luxembourg.
Hichem.omrani@liser.lu

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Urban land use planning plays a critical role in sustainable urban development, requiring accurate prediction models to inform decision-making processes(Razavi et al., 2021). This study employs sensitivity analysis to investigate the robustness and reliability of a multi-logistic regression models in predicting urban land use patterns. Sensitivity analysis enables the exploration of the influence of input variables on model outputs, thus providing insights into the model's performance and potential uncertainties(Li et al., 2019).

Several studies have employed sensitivity analysis techniques to evaluate the performance of various predictive models in urban planning and land use studies. For example, used SA for land use and land cover probability assessment for Lake Balaton watershed in Hungary. Brändle et al., 2015 used SA to investigate the impact of land use policy to assess land abandonment in Swiss Mountain Region. (Stickler et al., 2009)used SA to investigate the impact of climate change on urban land use change in the Amazon rainforest. The results of these studies have shown that SA can be a valuable tool for understanding the factors that influence urban land use change. However, there are a number of gaps in the literature on SA and urban land use change. First, most studies have focused on a single factor, such as population growth, economic development, or climate change. Second, most studies have used simple SA methods, such as univariate sensitivity analysis.

This study addresses the gaps in the literature by suggesting a comprehensive multilogistic-multivariate sensitivity analysis [MLR_MVSA] method to investigate the factors that influence urban densification in Belgium. The study uses a set of geophysical and socioeconomic variables to train a logistic regression model. The analysis is being done for three areas of Belgium, namely Brussels capital region and its associated Brabant of Flanders and Walloon for the year of 2010. This is because of availability of census based data with accurate precision. Earlier, a multinomial logistic regression was employed to evaluate the impact of variables on the urban built up densification with four level of density class at a scale of 100*100m. However, it is crucial to understand the nature of model outcome, if there is a change in terms of spatial resolution, density classes and neighbourhood size simultaneously.

Therefore, our study considers the various combination of spatial resolution at 50m, 100m, 300m and 500m.Alongside, the spatial resolution, the density classes were classified into 3,7,9 number of classes.

Interestingly , in our study a changing moving windows were also employed in three different combinations of 3×3, 5×5 , 7×7 and 9×9 cells. In order to evaluate the model's outcome, three different metrices were used to confirm the best possible combination. Receiver operating characteristics (ROC) curve was used to evaluate the model's outcome based on the same evaluation process used for reference model. Other than that, metrices like producers accuracy, overall accuracy, figure of merit (FoM) were also calculated. This shows that even if the accuracy does not vividly vary over density classes and neighbourhood size, but change in spatial resolution shows significant differences in accuracy of model resulting into the best result with combination of a raster cell at 50m with 4 density class and 3×3 neighbourhood cells. It is imperative to understand the behaviour of model parameters for simulating a near realistic scenarios through modelling which is why study like this will help the data analyst, urban modellers and environmentalist to have an in depth understanding of data and their interactions(Wu et al., 2019).

References

Brändle, J.M., Langendijk, G., Peter, S., Brunner, S.H., Huber, R., 2015. Sensitivity Analysis of a Land-Use Change Model with and without Agents to Assess Land Abandonment and Long-Term Re-Forestation in a Swiss Mountain Region. Land (Basel) 4, 475–512. https://doi.org/10.3390/LAND4020475

Li, Z., Sun, Z., Tian, Y., Zhong, J., Yang, W., 2019. Impact of land use/cover change on yangtze river delta urban agglomeration ecosystem services value: Temporal-spatial patterns and cold/hot spots ecosystem services value change brought by urbanization. Int J Environ Res Public Health 16. https://doi.org/10.3390/IJERPH16010123

Razavi, S., Jakeman, A., Saltelli, A., Prieur, C., Iooss, B., Borgonovo, E., Plischke, E., Lo Piano, S., Iwanaga, T., Becker, W., Tarantola, S., Guillaume, J.H.A., Jakeman, J., Gupta, H., Melillo, N., Rabitti, G., Chabridon, V., Duan, Q., Sun, X., Smith, S., Sheikholeslami, R., Hosseini, N., Asadzadeh, M., Puy, A., Kucherenko, S., Maier, H.R., 2021. The Future of Sensitivity Analysis: An essential discipline for systems modeling and policy support. Environmental Modelling & Software 137, 104954. https://doi.org/10.1016/J.ENVSOFT.2020.104954

Stickler, C.M., Nepstad, D.C., Coe, M.T., McGrath, D.G., Rodrigues, H.O., Walker, W.S., Soares-Filho, B.S., Davidson, E.A., 2009. The potential ecological costs and cobenefits of REDD: a critical review and case study from the Amazon region. Glob Chang Biol 15, 2803–2824. https://doi.org/10.1111/J.1365-2486.2009.02109.X

Wu, H., Li, Z., Clarke, K.C., Shi, W., Fang, L., Lin, A., Zhou, J., 2019. Examining the sensitivity of spatial scale in cellular automata Markov chain simulation of land use change. https://doi.org/10.1080/13658816.2019.156844133,1040–1061. https://doi.org/10.1080/13658816.2019.1568441