A SPATIO-TEMPORAL VISUAL ANALYTICS TOOL FOR SIMULATED TRANSPORT ORIENTED-LAND USE URBAN PLANNING DATA

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ABSTRACT:

This article presents a proposal framed in urban visual analytics, which aims to facilitate the exploration and analysis of zonal spatial indicators over time for a case of a large city-region. The context in which this exploration is carried out is the evaluation of the impact of interventions in land use and transportation, based on data produced by an integrated simulation system. The large amount of data to evaluate a scenario makes urgent the effort to design new interactive analysis environments. The resulting prototype (VIZ-BUS: Visual Analytics for Bogota Urban Simulator) has, for its design, an analyst-centric approach to the analysis task. Our first web deployment has been very well received by urban planning specialists in order to evaluate scenarios for a sustainable and smart city-region.

1. INTRODUCTION

Simulation models oriented to integrate the dynamics of land use, mobility and economic activity in a city region are powerful tools to planning sustainable cities. Decision makers can analyze different alternatives of intervention using estimations of evolution over time of comex city-region, based on a set of indicators located in analysis zones. This paper presents VIZ-BUS: a Urban Visual Analytics toolkit associated with BUS (Bogota Urban Simulator), an integrated simulator of land use, transport and economic activity in a city region of 10 million inhabitants (Guzman, 2018) (Vivas et al., 2021). Different urban intervention alternatives can then be simulated and different scenarios for the city region can be compared over a horizon of years of the simulation period. The challenge is how to explore and compare a significant number of indicators, some of which refer to each zone and others to interactions between pairs of zones. For example, employment in a zone, or number of trips by transport mode (BRT, car, bike, walking) between two zones of interest. The BUS platform (Vivas et al., 2021), as a simulator based on a spatial model based on a partitioning of space into zones and an integrated simulation, allows simulating different intervention scenarios in a city-region environment. A simulation run produces an estimate of the state of each zone over the simulation interval, period by period.

When we have a city-region like Bogota (10 millions inhabitants) with 150 spatial zones, 50 intra-zone indicators - e.g., number of households in the zone -, and 50 inter-zone indicators, between pairs of zones (22,500) - e.g., number of origin-destination trips -, to describe the state of the city-region, this amounts to approximately 130,000 values for a period. If we have this per year over a 30-year horizon, we can very quickly see the analysis challenges and limitations that. (Perveen et al., 2019) (Doraiswamy et al., 2018)

This article is focused on supporting visual analysis with an approach and tools that seeks to make the data resulting from the simulation of a set of scenarios available to the analyst. This is achieved thanks to a Visual Analytics approach, implemented on a web platform in order to generate an "any-time, anywhere" availability. Its results are in the framework of an agreement with the city of Bogota, and its first results are being used by the city's planning department. Our main contribution is our proposal for interactive visualization oriented by expert analysis tasks taking into account the spatio-temporal nature of the analysis.(Doraiswamy et al., 2018)(Andrienko et al., 2003)

The article is structured as follows: first we present a section with the most relevant publications that have influenced this proposal; then we briefly present the characteristics of the data model in BUS, so that in this context the description of VIZ-BUS, the set of visual analysis tools developed, shows its benefits for the analyst, and its adaptability to other models of its type. We then show the results of the first evaluations with experts, and finally our conclusions and vision for future developments.

2. RELATED WORK

The effort to design and develop integrated simulation models for city planning has been very impressive in the last 20 years. Integrated models with mobility, land use and economic activity is a challenge(Batty and Milton, 2021)(Batty et al., 2013)(Lopes, 2010)(Pettit et al., 2018).We find this kind of models developed for several European cities, as well as some developing cities (Alonso et al., 2017)(Fahmi et al., 2014)(Jaensirisak et al., 2015)(Manrique et al., 2020)(Pfaffenbichler et al., 2006)(Guzman et al., 2020) for the analysis of policy combinations at the city level and assessing their impacts over time.

The contributions in simulation models for urban planning are extensive. For the context of this work we highlight those proposed around MARS (Emberger et al., 2010)(Pfaffenbichler et al., 2010), UrbanSim (Waddell, 2002), and LUTI (Torrens, 2000). Recently we proposed BUS(Bogota Urban Simulator)

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(Guzman, 2018)(Vivas et al., 2021) to integrate in a platform a Bogotá-LUTI model using Vensim(Eberlein and Peterson, 1992), with two other models (Economic general equilibrium, and urban structure) using a SOA approach for the deployment.

The issue of what to evaluate and how to compare scenarios, is a challenge that has been recently addressed (Perveen et al., 2019). VIZ-BUS intends to contribute to address that challenge, following an approach based on Visual Analytics and expert user- centered interaction (Munzner, 2014)(Emberger et al., 2006)(Andrienko et al., 2017)

Regarding the challenges of interactive visualization of urban data, we highlight the work of Andrienko et al. (Andrienko et al., 2017)(Andrienko et al., 2003) and a previous prototype of this project (SPLOR-T) (Alfonso Feijóo-García and Tiberio Hernández-Peñalosa, 2021) that have served as references for the design and construction of VIZ-BUS. In particular, the typology of spatio-temporal data visualization (Andrienko et al., 2003), and different approaches for its visualization. (Andrienko et al., 2017).

3. DATA MODEL IN BUS AND BOGOTA AS USE CASE

BUS: THE LAND USE TRANSPORTATION INTERACTION MODEL FOR BOGOTÁ

The Bogotá Urban Simulator (BUS) is integration between land-use and transport models at a spatial aggregation level defined as obeying data availability. It was developed as a completely open platform using causal loop diagramming (CLD) and subsystem diagrams allowing adaptation and modification of the conditions of analysis according to specific needs. It has characteristics intended to address multiple weaknesses of the conventional transport planning approach in Bogotá, the Colombian capital. The traditional four-step transport modeling approach is a static simulation, given that no dynamic interactions between land use and transport system performance are encompassed. In addition, traditional models are intended for analyzing the network performance during peak times. Therefore, the BUS was developed as an alternative to the traditional four-stage transport model with marked differences such as the inclusion of data from a general equilibrium model, urban structure model, and an accessibility model. The BUS can simulate outcomes from the implementation of land use policies, as well as new transport infrastructures. Results are obtained faster in comparison to traditional approaches given that the route assignment stage works with volume-delay relationships between aggregated zones rather than a complete network. All of the BUS components were tested statistically and calibrated for the base year (2019), unfortunately, currently there is not enough official information to make a complete model validation in two different timestamps.

This decision support tool is essential in trying to mitigate the risk of uncoordinated planning decisions among public administration offices, for instance, housing and transport, but at the same time among Bogotá and 17 neighboring municipalities, given that the capital has not contained its growth within its existing boundaries. That situation implies that more frequently that not decisions need to be made as for an interconnected urban area(Guzman et al., 2017).

As mentioned above, the BUS (Bogota Urban Simulation) platform supports the period-by-period simulation of the evolution of an urban system taking into account land use, economic activity and transportation based on the respective simulation models and a spatio-temporal data model described below.

3.1 Spatial data

The spatial model, based on the partition of the large city into zones (114) and of each of the region's municipalities (17) into urban and rural zones, provides a structure for representing and calculating the indicators referring to the zones (148) and to the relationships between pairs of zones (148x148). In this way, it is possible to obtain data on the evolution of the state of the city-region over the simulation periods as a result of the analysis of an analyzed intervention alternative. The initial state of the alternative is expressed based on the values of the indicators for each of the zones in the base period of analysis.

3.2 Simulation time modelling

The time management of the integrated simulator (BUS) will produce for each simulation period a set of values for the indicators representing the status of each zone. Also the values of the relationships between pairs of zones and those of the global indicators of the city-region.

The following is a brief description of the data that characterizes a BUS scenario analysis:

Input:

Scenario identifier: for future reference

Responsible analyst: useful for collaborative environments

Objective: A paragraph referring to the intervention under analysis

Simulation interval: Start year, end year

Indicators of focus: set of indicators of particular interest

Areas of interest: Set of areas of particular interest

Initial state data in the base period: The values describing the state of the city-region that are going to BUS for the simulation.

Output:

For each simulation period we will have a dataset with the state of the analyzed urban system:

- For each zone , intra-zone indicators
  - For each simple indicator (scalar value). Examples of these indicators: number of ”new low-income households by zone”
  - For each composite indicator (set of scalar values). Examples of these indicators: number of ”trips by mode from one zone” (BRT, car, Bike, walking)
- For each pair of zones, inter-zone indicators
  - For each simple indicator (scalar value). Examples of these indicators: “accessibility rate” between zones

    * For each composite indicator (set of scalar values) Examples of these indicators: number of "trips by mode between zones" (BRT, car, Bike, walking)

- Global indicators (reference to all the city-region)
    * For each indicator (scalar value). Examples of these indicators: "global housing deficit"

4. OUR PROPOSAL: VIZ-BUS

The focus of this proposal is on the analyst's vision and his need to explore in order to identify trends, behaviors and thus generate/confirm hypotheses about the impact of an intervention in the city both in space (its model is key) and in time: An analysis scenario.

The main features of the VIZ-BUS design are described below:

4.1 The analysis tasks

The analysis tasks identified are formulated as follows: Identify one or more areas in which relevant changes occur in the analyzed indicators (e.g., employment, number of households at the poverty level,....).

Identify one or more periods in which relevant changes in the analyzed indicators occur. (e.g., year in which the trend of an indicator changes).

For a set of focus zones, how do focus indicators evolve over time (e.g., in which year can we observe a qualitative change in the number of jobs generated)?

For a focus zone, how does it relate to the other zones over time and how do the other zones relate to it (e.g., number of trips by one mode of transport, trip length).

Compare two analysis scenarios to identify the zones in which the focus indicators differ and over what period these differences occur.

Compare two analysis scenarios to identify the differences in a focus zone: how it relates to the other zones over time and how the other zones relate to it (e.g., number of trips on a mode of transportation when a new transportation facility is or is not built).

Guided by these analysis tasks, we designed our interactive tools to support the analyst's journey.

The classic dimensions of WHERE/WHEN/WHAT (Andrienko et al., 2003) are clearly visible for the analyst to look for trends, changes, hotspots for focus indicators, critical years for focus indicators, indicators changing in focus zones, etc. .

The requirements for VIZ-BUS are to support interactive exploration and navigation over indicator sets, with focus on zone sets, and to have access to accurate data when deemed necessary.

Thus, marks and channels were defined to build our visual analytics tools for the experts:

4.2 Space (Where)

zones: the classic interactive map(provide orientation and build user confidence).

each zone has a line to express values over time

a selected zone has an associated column to show the values over time

a selected zone is highlighted on the map

pairs of zones:

Origin zone-on is highlighted on the map

A Line graph (from it to all others zones)

Destination is highlighted on the map

A Line graph (from all others zones to it)

4.3 Time(When):

The simulation period interval is the abscissa in the line chart of an indicator for the selected zones and the unit is the period (usually the year).

The simulation period interval is the dimension of the table of values of an indicator for a selected zone where there is one row per simulated period.

A selected period is shown on the map (as the values shown correspond to that period), in the line charts by highlighting the abscissa value, and in the tables, the corresponding row.

4.4 The indicators (What):

In the Line graphs there is a line for each selected zone, with the indicators values on the ordinate and the time period on the abscissa

For the selected period, a colorphlet map is displayed with the colors proportional to the values of the indicator.

In the tables, a column is displayed with the values of the selected indicator, for the selected zone over time.

The values of the indicators are displayed in the interaction at the user's request

4.5 The VIZ-BUS tools:

In the BUS environment, the analyst can have various scenarios simulated. For example: with or without a new BRT line, in order to enhance activities in some specific zones.

For one scenario, the analyst finds a visual analysis environment with tools for one simulated scenario (tools i and ii) and (tools iii and iv) to compare two simulated scenarios :

4.5.1 A tool to explore intra-zone indicators over time. Main features

Give an overview of two focus indicators over simulation periods, with the possibility to select a specific period.

Allow an overview and try to provide easy identification of trend changes over time for specific zones.

- Make available to the analyst the detail of the focus indicators (on values and trends in a specific area).
- Offer the possibility to focus on one area while visualizing all areas of interest allows the analyst to have a more complete view of the impact of the intervention studied.

In Figure 1. we show our implementation of this interactive idiom in the Intra-zone indicator Tool (A) Map with colorphlet map focused on the selected period data. (B) Line graph with one line per zone for the selected *intra-zone* indicator with the selected period highlighted (C) A second focus *intra-zone* indicator with the selected period highlighted. (D) Value table for the two focus *intra-zone* indicators and the values for the selected period highlighted.

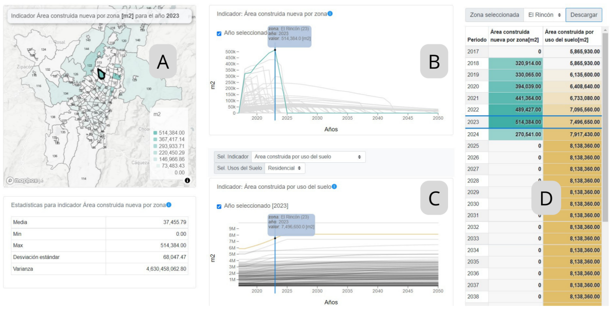

Figure 1. Intra-zone explorer tool

4.5.2 Tool for inter-zone indicator exploration over simulation periods. Main features:

Provide an overview of a cross-zone indicator over simulation periods, focusing on a specific period. Allows an overview of how one zone relates to all other zones, and vice versa (example: Origin-Destination trips). This provides the analyst with detailed focus indicators (on values and trends to and from a particular zone).

Allow to focus on one zone while viewing its relationships to all zones of interest. This feature allows the analyst to have a more complete view of the impact of the intervention under study.

In Figure 2 *Inter-zone* explorer tool: (A) Map with colorphlet map focused on the selected period data. The Origin zone is highlighted (B) Line graph with one line per zone for the selected zone with the“inter-zone” indicator (origin to destination) with the selected period highlighted (C) Line graph with one line per zone for the selected zon with the “inter-zone”indicator (destination to origin) with the selected period highlighted. (D) Value Table for the values from the selected zone to the others and from all the others zones to the selected zone, and the selected period highlighted.

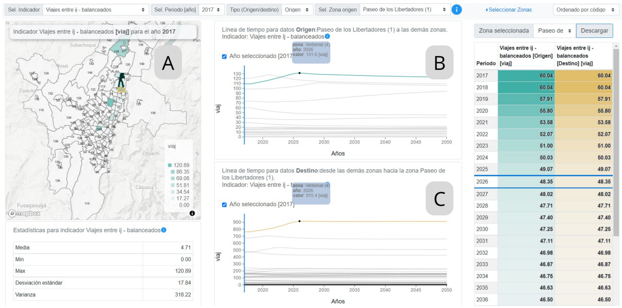

Figure 2. Inter-zone explorer tool

In order to assist the analyst in comparing two scenarios of interest, the emphasis is on being able to compare them on specific zones, and to offer the difference of indicators over time.

Three synchronized views are offered in the interaction: Scenario1, Scenario2, and the difference Scenario1-Scenario2.

We find two different comparison tools: for intra-zone indicators and for inter-zone indicators

4.5.3 Tools for comparison of two scenarios on intra-zone indicators Main features

Allow to visualize the behavior of an indicator over time, in two scenarios simultaneously along with the difference of the two.

Provide flexible navigation and selection of indicators, periods and zones.

Offer a homogeneous visualization and interaction with the analysis tools of a scenario.

In Figure 3: Intra-zone comparator explorer tool (A) Map with colorphlet map focused on the selected period data, line graph with one line per zone for the selected “intra-zone” indicator with the selected period highlighted in a specific simulation (B)Map and line graph that show the difference between the first scenario”A” and the second scenario”C”. (C) Map and line graph focused on the selected period data ,selected”inrazone” indicator in a specific simulation.

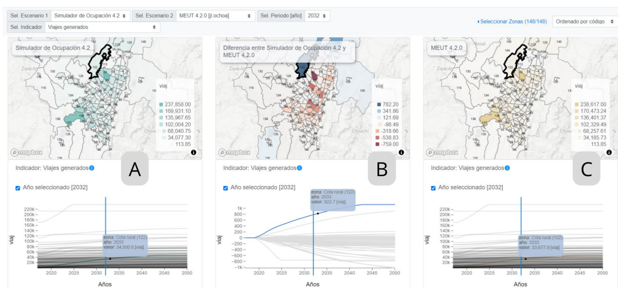

Figure 3. Intra-zone comparator explorer tool

4.5.4 Tools for comparison of two scenarios on inter-zone indicators Main features

Allows to visualize the behavior of an inter-zone indicator, taking into account whether we want to visualize the Origin-Destination or Destination-Origin values over time, in both scenarios simultaneously with the difference between them over time.

Provide flexible navigation and selection of indicators, periods and zones.

Offer a homogeneous visualization and interaction with the analysis tools of a scenario

In Figure 4: Inter-zone comparator explorer tool: (A) Map with colorphlet map focused on the selected period data. The Origin zone is highlighted, line graph with one line per zone for the selected zone with the"inter-zone" indicator (origin to destination) with the selected period highlighted in a specific simulation (B)Map and line graph that show the difference between the first scenario"A" and the second scenario"C". (C) Map and line graph focused on the selected period data ‚selected"inter-zone" indicator in a specific simulation.

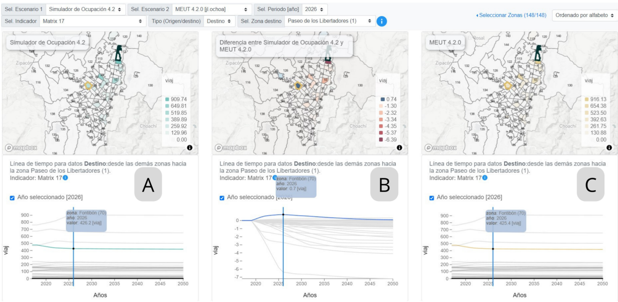

Figure 4. Inter-zone comparator explorer tool

5. RESULTS AND EVALUATION

In order to have a first feedback on the relevance and usability of the tools presented above, a session with experts was conducted based on a group of specific tasks. It is important to highlight that the number of subjects is very small, due to the fact that the target population is also very small (urban planning departments). In our case the session had 5 experts, and in some cases 2. Although this does not allow general statements to be made, it was very important in the process of fine-tuning the tools, given the use of non-conventional idioms (for this type of users).

The proposed tasks are in the context of the analysis tasks listed above.

The results were registered by the number of responses, the time spent by the experts, and the most used component to solve the task.

In table 1. We show some data from the testing session.

The deployment of the VIZ-BUS platform was done in integration with BUS, in a SOA architecture, and with availability of web clients with at least 4GB of RAM.

According to the results, the analysis of the scenario simulation results had a positive response, as well as the ability to access them in a flexible way and to share the simulations among the experts.

Although it requires a short training to handle the interactivity with the visualizations, the quality of the analysis information was highlighted. The quality of the interaction, the speed of responses, and the flexibility of the tools have been privileged.

Task proposed	Answers	Time (minutes)	More used tool/component
Which zone did the largest number of "new low-income households by zone" arrive in 2017? How many households arrived?	5/5	1:00	Intra-zone tool Line Graphs
In what year does the Los Cedros zone (zone 8) reach its maximum value in "new low-income households by zone"and what happens after that year?	5/5	1:07	Itra-zone tool Value Table
What is the relationship between the indicators "New low-income households by zone" and "Built-up area by zone" for the Los Cedros zone (zone 8)?	5/5	2:04	Intra-zone Tool Line Graph, Value Table
To which zone were the most trips generated from the Bolivia zone (zone 67) in 2017? How many trips were generated?	4/5	3:03	Inter-zone Tool Line Graphs
How many trips are generated from the "Bolivia" zone (zone 67) to the "Chicó Lago" zone (zone 92) in the year 2025?	4/5	1:13	Inter-zone Tool Value Table
List the 2 zones in which the highest speed is recorded.	5/5	1:59	Intra-zone Tool Line Graph Value Table
In which area does the greatest change in the number of trips occur?	2/2	00:47	Intra-zone Tool Line Graph
By what proportion does the "built-up area" of the RNorth zone (113) increase or decrease in the year 2025?	2/2	00:49	Intra-zone Tool Map Line Graph
Which of the two scenarios presents the largest amount of "built-up area" for the RNorth zone (113) in the year 2025?	2/2	00:58	Intra-zone Comparison Tool Maps
If the aim is to maximize the number of "trips by mode between zones" whose mode of transport is bike from the "Apogeo" zone to the other zones, which of the two scenarios generates more trips to the other zones overall?	2/2	00:58	Inter-zone Comparison Tool Zone fintering Maps

Table 1. Summary of expert session: Task and results

6. CONCLUSIONS

A set of urban visual analytics tools oriented to the exploration of simulation scenarios of complex urban systems has been presented in this paper.

The flexible access to scenario simulations, and the ability to analyze and compare them, effectively supports decision making for a more sustainable city-region

Although a platform such as VIZ-BUS does not guarantee the quality of decisions, we believe that complex urban systems require this type of analysis tools to support decisions and achieve cities that are integrated with their region in a smart way.

The computational architecture used in VIZ-BUS allows it to be integrated with other simulation systems that have a spatio-temporal model with the same structure. This proposal, which we could call VIZ-*US, for other urban systems (modeled with zones, intra-zone and inter-zone indicators) can be enriched with more analysis modules (example: clustering of zones by behavior over time) and thus consolidate this approach of Urban Visual Analytics, focused on scenario management of decision alternatives and their comparison.

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REFERENCES

Alfonso Feijóo-García, M., Tiberio Hernández-Peñalosa, J., 2021. Splort: Evaluation of a web-based approach for descriptive and exploratory analysis of multivariate spatio-temporal data. *The 14th International Symposium on Visual Information Communication and Interaction*, 1–5.

Alonso, A., Monzón, A., Wang, Y., 2017. Modelling land use and transport policies to measure their contribution to urban challenges: the case of Madrid. *Sustainability*, 9(3), 378.

Andrienko, G., Andrienko, N., Chen, W., Maciejewski, R., Zhao, Y., 2017. Visual analytics of mobility and transportation: State of the art and further research directions. *IEEE Transactions on Intelligent Transportation Systems*, 18(8), 2232–2249.

Andrienko, N., Andrienko, G., Gatalsky, P., 2003. Exploratory spatio-temporal visualization: an analytical review. *Journal of Visual Languages & Computing*, 14(6), 503–541.

Batty, M., Milton, R., 2021. A new framework for very large-scale urban modelling. *Urban Studies*, 58(15), 3071–3094.

Batty, M., Vargas, C., Smith, D., Serras, J., Reades, J., Johansson, A., 2013. SIMULACRA: Fast land-use—transportation models for the rapid assessment of urban futures. *Environment and Planning B: Planning and Design*, 40(6), 987–1002.

Doraiswamy, H., Freire, J., Lage, M., Miranda, F., Silva, C., 2018. Spatio-temporal urban data analysis: a visual analytics perspective. *IEEE computer graphics and applications*, 38(5), 26–35.

Eberlein, R. L., Peterson, D. W., 1992. Understanding models with Vensim™. *European journal of operational research*, 59(1), 216–219.

Emberger, G., Ibesich, N., Pfaffenbichler, P., 2006. Can decision making processes benefit from a user friendly land use and transport interaction model? *Innovations in Design & Decision Support Systems in Architecture and Urban Planning*, Springer, 3–17.

Emberger, G., Pfaffenbichler, P., Riedl, L., 2010. MARS meets ANIMAP: Interlinking the Model MARS with dynamic Internet Cartography. *Journal of Maps*, 6(1), 240–249.

Fahmi, F., Timms, P., Shepherd, S., 2014. Integrating disaster mitigation strategies in land use and transport plan interaction. *Procedia-Social and Behavioral Sciences*, 111, 488–497.

Guzman, L. A., 2018. A strategic and dynamic land-use transport interaction model for Bogotá and its region. *Transportmetrica B: Transport Dynamics*.

Guzman, L. A., Escobar, F., Peña, J., Cardona, R., 2020. A cellular automata-based land-use model as an integrated spatial decision support system for urban planning in developing cities: The case of the Bogotá region. *Land use policy*, 92, 104445.

Guzman, L. A., Oviedo, D., Bocarejo, J. P., 2017. City profile: the Bogotá metropolitan area that never was. *Cities*, 60, 202–215.

Jaensirisak, S., Jittrapirom, P., Emberger, G., Thiengburanathum, P., Fukuda, T., 2015. Metropolitan activity relocation simulator (mars) model for chiang mai city. *New Binh Duong City, International Conference on Modeling the Future of Ho Chi Minh City Metropolitan Area (HCMCFuture 2015)*, 09–24.

Lopes, S. B., 2010. Uma ferramenta para planejamento da mobilidade sustentável com base em modelo de uso do solo e transportes. PhD thesis, Universidade de São Paulo.

Manrique, J., Cordera, R., Moreno, E. G., Oreña, B. A., 2020. Equity analysis in access to Public Transport through a Land Use Transport Interaction Model. Application to Bucaramanga Metropolitan Area-Colombia. *Research in Transportation Business & Management*, 100561.

Munzner, T., 2014. *Visualization analysis and design*. CRC press.

Perveen, S., Kamruzzaman, M., Yigitcanlar, T., 2019. What to assess to model the transport impacts of urban growth? A Delphi approach to examine the space–time suitability of transport indicators. *International Journal of Sustainable Transportation*, 13(8), 597–613.

Pettit, C., Bakelmun, A., Lieske, S. N., Glackin, S., 2018. Karlson ‘Charlie’Hargroves, Giles Thomson, Heather Shearer, Hussein Dia, Peter Newman. *Planning support systems for smart cities*.

Pfaffenbichler, P., Emberger, G., Ibesich, N., 2006. Simulation of co-operative strategies in the cross-border region Vienna–Bratislava.

Pfaffenbichler, P., Emberger, G., Shepherd, S., 2010. A system dynamics approach to land use transport interaction modelling: the strategic model MARS and its application. *System Dynamics Review*, 26(3), 262–282.

Torrens, P. M., 2000. How land-use-transportation models work.

Vivas, A., Castro, H., Bautista, D., Merchan, L., Hernandez, J., Peña, J., Guzman, L. A., 2021. Improving exploratory analysis in land-use transportation interaction models. *2021 XLVII Latin American Computing Conference (CLEI)*, IEEE, 1–10.

Waddell, P., 2002. UrbanSim: Modeling urban development for land use, transportation, and environmental planning. *Journal of the American planning association*, 68(3), 297–314.