Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 95 (2026) 1024–1031

Transportation Research Procedia

www.elsevier.com/locate/procedia

Euro Working Group on Transportation Annual Meeting 2025 - EWGT2025

# Towards a formalisation scale for urban bus transportation system: The case of Bukavu and its global implications

Bwami Kahombera Rupin[a,b], Mehdi Moeinaddini[c], Richa Maheshwari[a], Ismaïl Saadi[d], Mario Cools[a,e,*]

[a]Faulty of Economics and Management, Université Evangélique en Afrique, Bukavu 3323, D.R. Congo
[b] Local Environment Management and Analysis (LEMA), University of Liège, Liège 4000, Belgium
[c]Centre for Public Health, Queen's University Belfast, University Rd, Belfast, BT7 INN, United Kingdom
[d]MRC Epidemiology Unit, Cambridge University, Cambridge CB2 0AH, United Kingdom
[e]Faculty of Business Economics, Hasselt University, Agoralaan Gebouw D, 3590 Diepenbeek, Belgium

**Abstract (July 18, 2025)**

The formalisation of public transport has been widely studied yet lacks a data-driven quantitative assessment. This study addresses this gap by applying a formalisation scale to various aspects of Bukavu's bus transport system based on the Public Transport Formalisation Level (PTFL) model. Formalisation indicators are assessed using a point system inspired by a comprehensive methodology used in a previous study. This approach enabled the derivation of a composite index for Bukavu's public transport system (BPTFL). The composite index indicates a moderate level of formalisation of Bukavu's current public transport system, with a formalisation index of 43.37%. A more detailed analysis reveals slight variations among the formalisation levels of the Ibanda (46.31%), Kadutu (43.10%), and Bagira (46.38%) municipalities. This observation highlights that a city-wide transport formalisation index serves as an overall indicator, which does not necessarily reflect local disparities. Thus, this scale can be utilised in scientific literature to assess the level of formal or informal options in public transport systems.


Peer-review under responsibility of the scientific committee of the Euro Working Group on Transportation Annual Meeting 2025 - EWGT2025.

*Keywords:* level of formalisation; point system; public transport system; urban transport

## 1. Introduction

Public transport is planned and regulated to meet the mobility needs of users (Ashmore and Chandler, 2021). It offers several advantages, including reduced travel times and operating costs, improved urban image and safety, and

* Corresponding author. Tel.: +32-4-366-4813.
*E-mail address:* mario.cools@uliege.be


Peer-review under responsibility of the scientific committee of the Euro Working Group on Transportation Annual Meeting 2025 - EWGT2025.
10.1016/j.trpro.2026.02.129

the integration of new information and communication technologies to enhance services (Hossain et al., 2022; Khadhir et al., 2021; Tonioli Mariotto et al., 2022). However, within this system, a distinction is often made between formal and informal transport. Transport itself is neither illegal nor informal; rather, the conditions under which it operates determine its classification. A legal, economic activity, such as transportation services, is considered informal when it relies on practices that do not comply with commercial, labour, or fiscal regulations (Paget-Seekins and Tironi, 2016; Roca and Simabuko, 2022).

While informal transport is often perceived as a less desirable counterpart to formal transport (Mittal, 2022), it provides key advantages such as last-mile connectivity, accessibility, adaptability, and responsiveness to mobility demands (Amrapala and Choocharukul, 2019; Olowosegun et al., 2021). However, users of formal transportation services also express dissatisfaction, as service quality remains dynamic and perceptions vary (Allen et al., 2020; Calvo-Poyo et al., 2020; Papanikolaou and Zygiaris, 2014; Petrova et al., 2020; Zheng and Kahn, 2013). This complexity is further illustrated by the coexistence of formal and informal elements within transport systems worldwide. While informal transport options, such as jitneys, have emerged in developed cities like New York and Miami (Cervero, 1996), formal public transport structures have also been established in cities across developing countries. This suggests the existence of the same typology of transport systems globally (McLeod et al., 2017). Consequently, transport systems cannot be considered entirely informal, as some operators hold commercial driving licenses, are insured, and respect territorial boundaries (Cervero and Golub, 2007). Likewise, so-called formalised transport is not fully formalised, as its organisation varies across time and space (Nalmpantis et al., 2019).

Planners and policy implementors in the field of public transport have demonstrated a commitment to enhancing service quality through quality assessment, incorporating user perceptions into the evaluation process (De Aquino et al., 2019; Olivková, 2016; Olowosegun et al., 2021; Sidorchuk and Skorobogatykh, 2015; Ul Abedin et al., 2018). However, despite these efforts, the existing literature does not yet provide a scientific methodology for assessing the degree of formalisation within the public transport system. To date, no study has applied a quantitative measurement model for formalisation indicators weighted using a point system to investigate this issue. From this perspective, the present research examines the level of formalisation in the public transport system of Bukavu, a city in the South Kivu province of the Democratic Republic of Congo.

## 2. Research Design

### *2.1. Indicators, guidelines, and standards*

The present study is based on the estimation of 32 formalisation indicators developed from a systematic review (Bwami Kahombera et al., 2023), complemented by 28 guidelines related to the organisation, planning, and evaluation of public transport systems. During the operationalisation and validation of the index, only 31 indicators were retained. Indicator 9 (on-time performance) could not be estimated due to the absence of scheduled timetables for bus transport in the city of Bukavu. These indicators encompass six key dimensions of a transport system: (i) network infrastructure, (ii) vehicle standards, (iii) institutional frameworks, (iv) operational protocols, (v) equity and inclusiveness, and (vi) workforce development (Bwami Kahombera et al., 2025). The indicators were progressively identified through the analysis of the selected guidelines.

It is important to note that these guidelines did not present a uniform level of detail regarding the indicators: some made no reference to them, others mentioned them without further elaboration, while a few provided more or less developed descriptions, occasionally including one or more reference standards. The 32 indicators, which constitute the first formalisation scale specifically designed to assess public transport systems, are as follows: (1) Span of service, (2) service headway, (3) stop frequency, (4) deviations, (5) service productivity, (6) parallel corridors, (7) circuity, ( 8) vehicle type, (9) on-time performance, (10) crowding, (11) operating cost per passenger trip, (12) cost recovery, (13) transfer locations, (14) accessibility, (15) bus collisions, (16) bus customers injuries, (17) customer complaints, (18) passenger amenities, (19) priority treatments (20) cooperative transit planning, (21) clearances, (22) bus lanes, (23) grades, (24) bus turning radius, (25) bus speed, (26) bus stop, (27) traffic signals, (28) maintenance, (29) monitoring and evaluating service, (30) overall customer satisfaction, (31) fare collection, (32) driver. Each of these indicators includes specific standards that have led to algebraic formulations enabling their estimation through the determination of FIi scores (Bwami Kahombera et al., 2025).

### 2.2. Data collection

Primary data were collected using both qualitative and quantitative methods, while secondary data were sourced from Google Earth and the Center for International Earth Science Information Network (CIESIN) of the Columbia Climate School. Google Earth Engine was employed for the estimation of accessibility, whereas Microsoft Excel was used to calculate the remaining indicators following data cleaning and adjustment of the databases.

The surveys were conducted using a mixed-methods approach, combining both online and offline techniques. Online surveys were conducted using convenience sampling via the KoboCollect tool, resulting in 1,855 fully completed questionnaires from bus users, defined as individuals who had used a minibus for travel within the city of Bukavu at least once during the two weeks preceding the survey. Respondents were primarily users and owners of public transport minibuses operating within the city of Bukavu. Additional field-based (offline) surveys were conducted to collect information on bus frequency during peak and off-peak hours at commonly used stops. Interviews with key stakeholders, conducted either by telephone or using a structured interview guide, included local urban transport authorities, the National Insurance Company (SONAS), and the Congolese Drivers' Associations (ACCO). These interviews served to complement the dataset wherever supplementary information was available and accessible.

The case study of Bukavu was structured around the distribution of its four main public transport routes across the city's three municipalities: two routes in the municipality of Ibanda (one serving the Nyalukemba and Ndendere neighbourhoods, and another in the Panzi area), one in Kadutu, and one in Bagira. The formalisation index for the municipality of Ibanda was calculated as the average of the indices for the neighbourhoods of Nyalukemba, Ndendere, and Nguba, while the indices for Kadutu and Bagira were retained individually. These were then aggregated to compute the composite Bukavu Public Transport Formalisation Level (BPTFL) index.

### 2.3. Methods

To quantify the level of formalisation of public transport in Bukavu, we adopted a points-based model referred to as the Public Transport Formalisation Level (PTFL). The estimation of the indicator scores ($FI_i$) is based on various algebraic formulations, while Equation 3 determines the weights ($w_i$) assigned to each indicator. These two components, the $FI_i$ scores and their corresponding weights $w_i$, are incorporated into the calculation of the composite formalisation index, as defined by Equation 1. Our original contribution thus lies in the structured application of this weighting system to measure the degree of formalisation in public transport. It is also worth noting that some previous studies have employed approaches based on a point system.

For instance, Jaskiewicz et al. (1999) evaluated pedestrian systems in Winter Park, Florida, by integrating nine innovative factors that identify qualities contributing to a positive walking experience beyond volumes and capacities. The author argued that to encourage walking as a viable alternative mode of transport, pedestrian comfort and safety should be improved, in addition to paying particular attention to the two traditional factors (volume and capacity). These qualitative factors would thus lead to specific improvements in specific areas of the studied zone.

Similarly, Khisty (1994) focused on the Illinois Institute of Technology (IIT) campus, incorporating environmental factors as suggested by the 1985 Highway Capacity Manual (HCM), despite the absence of guidelines. This was done to complement the quantitative level of service of pedestrian facilities for monitoring and comparing their performance, as well as for allocating the necessary budget for changes and improvements.

Sarkar (1993) examined pedestrian environments in Munich and Rome to provide adequate travel conditions for the elderly, physically disabled, and children, considered "captive pedestrians" (Braun and Roddin, 1978) because they rely more on walking than other pedestrian groups, particularly the young. Mozer (1994) proposed a combined method with the traditional level of service method for pedestrians, bicycles, and public transport while encouraging transport systems that increase access to these modes, which are alternatives to private cars. Additionally, three studies by Asadi-Shekari et al. (2013, 2014, 2015) respectively evaluated the level of service for disabled pedestrians (DPLOS) in urban areas, the level of service for pedestrians (PLOS) on university campus streets, and the pedestrian safety index (PSI) in urban areas.

The Public Transport Formalisation Level (PTFL) model can thus be expressed as follows:

$$PTFL = \sum_{i=1}^{32} w_i FI_i \tag{1}$$

The PTFL model enabled us to weight the contribution of each indicator within the overall formalisation index of Bukavu's public transport system. To assign these weights, it was first necessary to determine the level of detail (coefficient $k_i$) attributed to each indicator in each guideline. The coefficient $k_i$ was assigned a value of 0 when the indicator was not mentioned, 1 when it was merely cited, 2 when it was cited and briefly detailed, and 3 when it was cited, described, and accompanied by at least one associated standard. Since not all indicators were described with the same level of detail across the guidelines, this approach highlighted differences in weights ($w_i$), reflecting the varying importance of these indicators according to the reference documents. Given that this analysis includes four roads in the model, Equation 1 is therefore adapted as follows:

$$BPTFL = \frac{1}{4}\sum_{j=1}^{4}\sum_{i=1}^{32} w_{i,j} FI_{i,j} \tag{2}$$

where, BPTFL is Bukavu Public Transport Formalisation Level (mean of the PTFL index); i is the formalisation indicator index, i= 1,2,3,4, …, 32; j represents the road index, with j=1 for Nyalukemba and Ndendere road, j=2 for Panzi road, j=3 for Bagira road, j=4 for Kadutu road; $w_{i,j}$ is the weight (coefficient) of indicator i for road j; $FI_{i,j}$ is the score of the public transport formalisation indicator i for road j.

Then, to determine the weight of each indicator, Equation 3 was utilised:

$$w_i = \sum_{j=1}^{3} Q_j N_{i,j} \tag{3}$$

where wi is the coefficient of the formalisation indicator i; i is the indicator number; j is the evaluation depth number; $Q_j$ is the value of the evaluation depth j; $N_{ij}$ is the number of guidelines associated with indicator i at evaluation depth j.

For a detailed presentation of the weighting method and the algebraic formulations used for indicator calculation, the reader is referred to the supplementary documentation, which demonstrates that the score ranges lie between 0 and 1, or between 0% and 100% (Bwami Kahombera et al., 2025).

To facilitate interpretation, we classified the PTFL% values into predefined categories, assigning qualitative labels ('Highly Formalised,' 'Moderately Formalised') as seen in Table 1. The categories are assigned based on logical understanding. These classifications help distinguish different levels of formalisation. While these thresholds are not derived from a specific theoretical framework, they provide a structured way to compare formalisation levels across different contexts.

Table 1. PTFL% interpretation

| PTFL% rating | Model score | Interpretation |
|---|---|---|
| A | [80-100] | Public transport system is highly formalised |
| B | [60-80[ | Public transport system is well formalised |
| C | [40-60[ | Public transport system is moderately formalised |
| D | [20-40[ | Public transport system is somewhat informal |
| E | [1-20[ | Public transport system is very informal |
| F | [0-1[ | Public transport system is completely informal |

## 3. Results

Table 2 has 12 columns. Columns 1 and 2 list the order and the names of the indicators $FI_i$,. Columns 3, 4, 5, and 6 then present the scores of the individual indicators $FI_{i,j}$ for each analysed route, district, or municipality. Column 7 represents the weighted score for each indicator after applying the weights from the methodology. Finally, columns 8, 9, 10, 11, and 12 present the estimated formalisation levels of each indicator in the municipalities of Ibanda, Bagira, Kadutu, and the entire city of Bukavu.

Considering the results of the indicator estimates in Table 2, it is observed that the studied municipalities generally share the same characteristics. This means that when the estimated value of an indicator i is close to or equal to 1 (or close to or equal to 0, or even close to the average) in one municipality, the estimated values for the other municipalities are generally equal, with the estimated value of the city being the average of the estimated values from the municipalities.

In this section, it should be noted that the estimation of indicator 9 was not feasible due to the absence of scheduled timetables allowing for the assessment of whether a minibus was late or not. However, survey results showed that the average headway between two buses was less than two minutes, indicating a frequency slightly exceeding one bus per minute. Nonetheless, due to the absence of official timetable references, this indicator (on-time performance) was excluded. To maintain consistency and facilitate interpretation, indicator 9 was skipped, while the numbering of the remaining indicators in Table 2 and Figure 1 was retained as defined in the original formalisation scale.

Table 2. Calculation and scoring of formalisation indicators

| N° | Service Indicator | Ndendere and Nyalukemba Districts | Panzi District | Bagira municipality | Kadutu municipality | $W_{i,j}$ | $w_i$*$FI_i$, Ndendere and Nyalukemba districts | $w_i$*$FI_i$, Panzi district | $w_i$*$FI_i$, Bagira municipality | wi*$FI_i$,Kadutu municipality | $w_i$*$FI_i$, city of Bukavu |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Span of service | 0.6 | 0.6 | 0.6 | 0.6 | 60 | 36 | 36 | 36 | 36 | 36 |
| 2 | Service Headway | 1 | 1 | 1 | 1 | 68 | 68 | 68 | 68 | 68 | 68 |
| 3 | Stop Frequency | 1 | 1 | 1 | 1 | 73 | 73 | 73 | 73 | 73 | 73 |
| 4 | Deviations | 0 | 1 | 1 | 0 | 54 | 0 | 54 | 54 | 0 | 27 |
| 5 | Service productivity | 0.2 | 0.2 | 0.2 | 0.2 | 51 | 10.2 | 10.2 | 10.2 | 10.2 | 10.2 |
| 6 | Parallel corridors | 1 | 1 | 1 | 1 | 45 | 45 | 45 | 45 | 45 | 45 |
| 7 | Circuity | 1 | 1 | 1 | 1 | 50 | 50 | 50 | 50 | 50 | 50 |
| 8 | Vehicle type | 0.5 | 0.5 | 0.5 | 0.5 | 56 | 28 | 28 | 28 | 28 | 28 |
| 10 | Crowding | 0.4 | 0.4 | 0.4 | 0.4 | 63 | 25.2 | 25.2 | 25.2 | 25.2 | 25.2 |
| 11 | Operating Cost per Passenger Trip | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 0 |
| 12 | Cost Recovery | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| 13 | Transfer Locations | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 0 |
| 14 | Accessibility | 1 | 0.5 | 0.5 | 0.5 | 74 | 74 | 37 | 37 | 37 | 46.25 |
| 15 | Bus Collisions | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 |
| 16 | Bus Customers injuries | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 |
| 17 | Customers complaints | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 |
| 18 | Passenger amenities | 0 | 0 | 0 | 0 | 61 | 0 | 0 | 0 | 0 | 0 |
| 19 | Priority | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 | 0 |
| 20 | Cooperative transit planning | 0.7 | 0.7 | 0.7 | 0.7 | 42 | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 |
| 21 | Clearances | 1 | 1 | 1 | 0.94 | 22 | 22 | 22 | 22 | 20.68 | 21.67 |
| 22 | Bus lanes | 0 | 0 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 0 |
| 23 | Grades | 0.88 | 1 | 0.76 | 0.6 | 18 | 15.84 | 18 | 13.68 | 10.8 | 14.58 |
| 24 | Bus turning | 0.8 | 0 | 0.08 | 0.22 | 23 | 18.4 | 0 | 1.84 | 5.06 | 6.33 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | radius | | | | | | | | | | |
| 25 | Bus speed | 1 | 1 | 1 | 1 | 53 | 53 | 53 | 53 | 53 | 53 |
| 26 | Bus stop | 0 | 0 | 0 | 0 | 57 | 0 | 0 | 0 | 0 | 0 |
| 27 | Traffic Signals | 0 | 0 | 0 | 0 | 45 | 0 | 0 | 0 | 0 | 0 |
| 28 | Maintenance | 0.33 | 0.33 | 0.33 | 0.33 | 37 | 12.21 | 12.21 | 12.21 | 12.21 | 12.21 |
| 29 | Monitoring and Evaluating service | 0.25 | 0.25 | 0.29 | 0.43 | 68 | 17 | 17 | 19.72 | 29.24 | 20.74 |
| 30 | Overall customer satisfaction | 0.75 | 0.75 | 0.75 | 0.75 | 39 | 29.25 | 29.25 | 29.25 | 29.25 | 29.25 |
| 31 | Fare collection | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 |
| 32 | Driver | 0.48 | 0.48 | 0.49 | 0.52 | 38 | 18.24 | 18.24 | 18.62 | 19.76 | 18.72 |
| **Sum** | | **12.89** | **12.71** | **12.60** | **11.69** | **1350** | **624.74** | **625.50** | **626.12** | **581.80** | **614.54** |

Drawing on the results presented above, we then estimated the formalisation levels of the public transport system in the municipalities of Ibanda ($PTFL_i$), Bagira ($PTFL_b$), Kadutu ($PTFL_k$), and an overall index for the city of Bukavu (BPTFL) as shown in Table 3.

Table 3. Formalisation indicators calculation in Bukavu City

| N° | Municipalities/Bukavu | Levels of Formalisation | |
|---|---|---|---|
| | | Formalisation index | Index values |
| 1 | Ibanda | $PTFL_i$ | 46.31% |
| 2 | Bagira | $PTFL_b$ | 46.38% |
| 3 | Kadutu | $PTFL_k$ | 43.10% |
| 4 | Bukavu | BPTFL | 45.52% |

These results are illustrated in Fig. 1 for an overall visualisation of the findings of the 31 indicators:

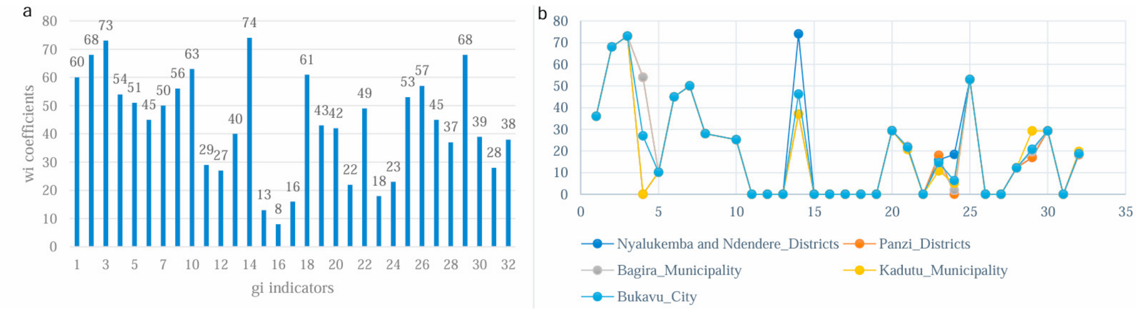


Fig. 1. (a) fluctuations in the weighting scores of the formalisation indicators ; (b) The weighted indicators in Bukavu City.

The curves in Fig. 1 (b) overlap for certain indicators in Bukavu and its three studied municipalities. This convergence is explained by the nearly similar levels of formalisation resulting from the uniform application of public transport policies across the city. Additionally, the operational practices in the sector remain homogeneous, as these three municipalities are contiguous and form the urban unit of Bukavu, which promotes a contagion effect. Furthermore, the differences in the levels of formalisation between Ibanda, Kadutu, and Bagira are relatively minor, indicating a generally homogeneous degree of public transport formalisation across Bukavu. Although Bagira exhibits a slightly higher index, likely due to the absence of route deviations and the presence of gentle grades, the variations are not substantial enough to suggest significant disparities.

Considering all these results (Tables 2 and 3, and Fig. 1), the public transport system of Bukavu is moderately formalised (according to the interpretation in Table 1), as is the case in the municipalities of Ibanda, Bagira, and Kadutu. This indicates that several key components require significant improvement across all three municipalities of the city of Bukavu, including operating cost per passenger trip, cost recovery, transfer locations and bus stops, service productivity, fare collection, traffic signalling, dedicated bus lanes, and passenger amenities, all of which received a score of zero. The type of vehicle also requires improvement, having received a score of 0.5. Although the municipalities and the city of Bukavu exhibit broadly similar formalisation indices, they are not perfectly identical. This implies that the formalisation index of a given city does not necessarily correspond to the formalisation indices of its constituent areas.

## 4. Conclusion

This study aimed to assess the public transport system's formalisation level in Bukavu, South Kivu, Democratic Republic of Congo, where existing literature lacks a clear methodology for measuring formalisation. Public transport systems in the Global South are often subjectively classified as informal without a comprehensive analysis. This research demonstrates that formal elements exist in these systems, using Bukavu as a case study. The PTFL (Public Transport Formalisation Level) model was applied, using weighted coefficients derived from guidelines for transport systems in cities with established formal networks. Data collected from observations, surveys, secondary data, and interviews showed that Bukavu's transport system is moderately formal. It also revealed that the formalisation index varies by municipality, though the overall level remains relatively uniform.

The PTFL model contributes significantly to the concept of sustainable mobility by evaluating public transport formalisation across accessibility, equity, and inclusivity; economic equity, considering state subsidies for vulnerable populations; and environmental sustainability, particularly energy consumption. These aspects of sustainability are crucial for promoting inclusive, equitable, and environmentally friendly transport systems.

From an urban planning perspective, the PTFL model serves as a relevant tool for integrating public transport into territorial planning decisions. By quantifying the level of formalisation, it highlights the structuring role of transport systems in the implementation of sustainable mobility strategies. This framework thus promotes urban designs where public transport occupies a central position in the coherent organisation and development of the city. Furthermore, given that one indicator, namely on-time performance, was not estimated, its corresponding weight was excluded from the calculation of the overall formalisation index to minimise potential bias. Nonetheless, it is important to emphasise that estimating this indicator would have provided a better understanding of the reliability level of Bukavu's public transport system.

Future research could explore the weight of each indicator and scale the model to other types of public transport (e.g., trains, metros). Additionally, the PTFL model could be extended to assess the formalisation of public transport systems in cities worldwide, as well as in non-urban areas, as it was developed using guidelines drawn from a variety of urban contexts across the globe. By incorporating new, updated indicators, and being programmed into software for easier data collection, the model could be used across various platforms, contributing to more efficient data processing and decision-making.

In sum, the PTFL model offers a unique tool for quantifying the formalisation of public transport systems. It provides evidence that helps public authorities and researchers make informed decisions, thereby contributing to the development of sustainable, efficient, and equitable urban transport systems worldwide.

## Acknowledgements

The authors would like to express their sincere gratitude to the Université Evangélique en Afrique (UEA/Bukavu) for its financial support, which made it possible to attend and present this work at the conference. This support has been instrumental in fostering academic exchange and advancing our research.

## References

Allen, J., Muñoz, J.C., de Dios Ortúzar, J., 2020. On the effect of operational service attributes on transit satisfaction. Transportation (Amst) 47, 2307–2336. https://doi.org/10.1007/s11116-019-10016-8

Amrapala, C., Choocharukul, K., 2019. Comparative study of travel behavior between Thai and Japanese informal transport users: A case study of silor services in the Sukhumvit area. Engineering and Applied Science Research 46, 349–359. https://doi.org/10.14456/easr.2019.39

Asadi-Shekari, Z., Moeinaddini, M., Zaly Shah, M., 2015. Pedestrian safety index for evaluating street facilities in urban areas. Saf Sci 74, 1–14. https://doi.org/10.1016/j.ssci.2014.11.014

Asadi-Shekari, Z., Moeinaddini, M., Zaly Shah, M., 2014. A pedestrian level of service method for evaluating and promoting walking facilities on campus streets. Land use policy 38, 175–193. https://doi.org/10.1016/j.landusepol.2013.11.007

Asadi-Shekari, Z., Moeinaddini, M., Zaly Shah, M., 2013. Disabled Pedestrian Level of Service Method for Evaluating and Promoting Inclusive Walking Facilities on Urban Streets. J Transp Eng 139, 181–192. https://doi.org/10.1061/(ASCE)TE.1943-5436.0000492

Ashmore, D., Chandler, P., 2021. Research issues arising from a review of themes at the formal-informal transport interface in developing countries, in: Australian Transport Research Forum. pp. 1–11.

Braun, R.R., Roddin, M.F., 1978. Quantifying the Benefits of Separating Pedestrians and Vehicles (No. 78–66422), Transportation Research Board National Research Council, 189. Washington, D.C.

Bwami Kahombera, R., Moeinaddini, M., Maheshwari, R., Saadi, I., Cools, M., 2025. A Quantitative Framework for Estimating Levels of Formalisation in Urban Public Transport. Working paper, University of Liège, Liège.

Bwami Kahombera, R., Moeinaddini, M., Saadi, I., Cools, M., 2023. Levels of Formalisation in Urban Public Transport Systems, in: Tampere, C.M.J., Cools, Mario, Proost, S. (Eds.), Proceedings of the BIVEC‐GIBET Transport Research Days 2023. BIVEC, Leuven, pp. 513–521.

Calvo-Poyo, F., Medialdea, A., Ferri-García, R., 2020. Citizens' opinion about investment in public transport projects in cities. Int J Sustain Transp 14, 806–818. https://doi.org/10.1080/15568318.2019.1630529

Cervero, R., 1996. Commercial Paratransit in the United States: Service Options, Markets, and Performance (No. 299), UCTC. Berkelye.

Cervero, R., Golub, A., 2007. Informal transport: A global perspective. Transp Policy (Oxf) 14, 445–457. https://doi.org/10.1016/j.tranpol.2007.04.011

De Aquino, J.T., de Melo, F.J.C., Jerônimo, T. de B., de Medeiros, D.D., 2019. Evaluation of Quality in Public Transport Services: The Use of Quality Dimensions as an Input for Fuzzy TOPSIS. International Journal of Fuzzy Systems 21, 176–193. https://doi.org/10.1007/s40815-018-0524-1

Hossain, S., Shaikh, F., Kumar, L., Soomro, R., Memon, I.A., Faisal, A., Pathan, H., Mahar, W.A., Sahito, N., Lashari, Z.A., 2022. Factors That Influence Travelers' Willingness to Adopt Bus Rapid Transit (Green Line) Service in Karachi. https://doi.org/10.3390/su141610184

Jaskiewicz, F., Jackson, G., Anglin, K., Rinehart, L., 1999. Pedestrian Level of Service Based on Trip Quality, in: Urban Street Symposium (TRB). Dallas, TX.

Khadhir, A., Anil Kumar, B., Vanajakshi, L.D., 2021. Analysis of global positioning system based bus travel time data and its use for advanced public transportation system applications. Journal of Intelligent Transportation Systems: Technology, Planning, and Operations 25, 58–76. https://doi.org/10.1080/15472450.2020.1754818

Khisty, C.J., 1994. Evaluation of Pedestrian Facilities: Beyond the Level-of-Service Concept. Transp Res Rec 1438, 45–50.

McLeod, S., Scheurer, J., Curtis, C., 2017. Urban Public Transport: Planning Principles and Emerging Practice. J Plan Lit 32, 223–239. https://doi.org/10.1177/0885412217693570

Mittal, G., 2022. The state and the production of informalities in urban transport: Vikrams in Dehradun, India. Geoforum 136, 273–282. https://doi.org/10.1016/J.GEOFORUM.2020.10.003

Mozer, D., 1994. Calculating Multi-Mode Levels-Of-Service, International Bicycle Fund, WA. Seattle.

Nalmpantis, D., Roukouni, A., Genitsaris, E., Stamelou, A., Naniopoulos, A., 2019. Evaluation of innovative ideas for Public Transport proposed by citizens using Multi-Criteria Decision Analysis (MCDA). European Transport Research Review 11. https://doi.org/10.1186/s12544-019-0356-6

Olivková, I., 2016. Evaluation of Quality Public Transport Criteria in Terms of Passenger Satisfaction. Transport and Telecommunication 17, 18–27. https://doi.org/10.1515/ttj-2016-0003

Olowosegun, A., Moyo, D., Gopinath, D., 2021. Multicriteria evaluation of the quality of service of informal public transport: An empirical evidence from Ibadan, Nigeria. Case Stud Transp Policy 9, 1518–1530. https://doi.org/10.1016/j.cstp.2021.08.002

Paget-Seekins, L., Tironi, M., 2016. The publicness of public transport: The changing nature of public transport in Latin American cities. Transp Policy (Oxf) 49, 176–183. https://doi.org/10.1016/j.tranpol.2016.05.003

Papanikolaou, V., Zygiaris, S., 2014. Service quality perceptions in primary health care centres in Greece. Health Expectations 17, 197–207. https://doi.org/10.1111/j.1369-7625.2011.00747.x

Petrova, T., Grunin, A., Shakhbazyan, A., 2020. Integral Index of Traffic Planning: Case-Study of Moscow City's Transportation System. Sustainability 12, 7395. https://doi.org/10.3390/su12187395

Roca, S., Simabuko, L., 2022. Informality and Tax Refund in Peru's Intercity Passenger Ground Transport Market: An Empirical Appraisal. Transportation (Amst). https://doi.org/10.1007/s11116-022-10273-0

Sarkar, S., 1993. Determination of Service Levels for Pedestrians, with European Examples. Transp Res Rec 1405, 35–42.

Sidorchuk, R., Skorobogatykh, I., 2015. Marketing evaluation of public transport quality attributes: Review of two waves of research. Volume 6, Issue 3S3, Pages 275 - 282 6, 275–282. https://doi.org/10.5901/mjss.2015.v6n3s3p275

Tonioli Mariotto, F., Ugarte, L.F., Alves Lima Zaneti, L., Lacusta, E., Cortes de Almeida, M., 2022. A Visual Analytics Approach for Inferring Passenger Demand in Public Transport System Based on Bus Trajectory. Journal of Control, Automation and Electrical Systems 33, 1711–1723. https://doi.org/10.1007/s40313-022-00908-z

Ul Abedin, Z., Busch, F., Wang, D.Z.W., Rau, A., Du, B., 2018. Comparison of Public Transport Network Design Methodologies Using Solution-Quality Evaluation. J Transp Eng A Syst 144, 04018036. https://doi.org/10.1061/jtepbs.0000159

Zheng, S., Kahn, M.E., 2013. Understanding China's Urban Pollution Dynamics. J Econ Lit 51, 731–772. https://doi.org/10.1257/jel.51.3.731