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Serbian Journal of Management 19 (2) (2024) 275 - 291

Serbian Journal of Management

DESIGNING STREETS FOR PEOPLE: A MULTICRITERIA DECISION-MAKING STUDY

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(Received 15 December 2023; accepted 12 July 2024)

Abstract

Designing Streets for People involves selecting appropriate materials, determining the optimal configuration, and finding the best solution based on technical criteria for urban structures. This paper aims to identify the best solution by comparing two multicriteria decision-making methods: the WISP (Weighted Sum-Product) and AHP-Gaussian, which represents a recent algorithm for the Analytical Hierarchy Process (AHP) decision- making. We created a matrix with eight factors (cost, braking distance, lifetime, sidewalk width, carbon footprint, electricity consumption, and pavement temperature) to choose between four pavement options (concrete and asphalt with different sidewalk widths). The WISP recommended a concrete pavement and 2.0-meter sidewalk. The least viable option was asphalt pavement with a 1.2-meter sidewalk, due to its higher carbon footprint (12%), increased air temperatures (10%), and greater public lighting expenses (11%). WISP allows for assigning weights to criteria with robustness, computational effectiveness, and transparency. Conversely, AHP-Gaussian incorporates a sensitivity feature that lets decision-makers assign weights based on statistical analysis. Despite each method's limitations, both are suitable for urban projects, estimating decisions based on multiple technical aspects, thereby promoting more integrated and efficient choices.

Keywords: Street for People, AHP-Gaussian, WISP method, Urban Pavement, Multicriterial Decision-Making, Case Study.

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DOI: 10.5937/sjm19-48257

1. INTRODUCTION

The city is the core of economic, social, and environmental development, serving as the focal point of public management strategies. The "smart city" paradigm addresses the challenges of sustainable development by implementing new spatial planning schemes (Nesticò & De Mare, 2018). These schemes require the selection of projects based on multi-aspect economic criteria, including both financial and non-financial factors, which adds complexity to the decision-making process.

Furthermore, the recent evolution of cities necessitates effective integrated management of urban services, infrastructure, and communication networks on a metropolitan scale. Therefore, Carli et al. (2018) proposes a study that combines decision-making methods to assess the sustainable development of these cities, considering criteria related to energy, water resources, and environmental factors.

The work carried out by Boix-Cots et al. (2022) highlights that the main studies related to the application of multicriteria methods for decision-making regarding urban infrastructure implementation are associated with three major themes: material and pavement selection, prioritization of maintenance of hydraulic structures, and prioritization of investments in rehabilitation areas.

To select the most suitable solution for Street for People in urban projects, this study applies the Integrated Simple Weighted Sum Product Method (WISP), a decision-making method developed by Stanujkic et al. (2023), which allows the ranking of alternatives based on the decision matrix and the normalized weights of each criterion and the AHP-Gaussian Method, developed by (Santos et al., 2021), that represents a recent algorithm for the Analytical Hierarchy Process (AHP) decision making, where the latter is a general and successful approach developed already in the 1970s. It proposes to determine the weights of each criterion based on a sensitivity factor generated from the normal Gaussian curve.

The focus is on the context of pavement material selection, comparing two consolidate multi-criteria decision making (MCDM) methods, WISP and AHP-Gaussian, to design cities more focused on people. Its relevance lies in the influence of cool pavements on reducing air temperature, improving comfort conditions, and reducing energy demand for cooling. Findings by Aboelata (2021) demonstrate that cool pavements can reduce air temperature by 25% in low-density urban areas. However, due to the reflection of incident shortwave radiation, there is a detriment to thermal comfort in open spaces. To address this, the combination of cool pavements with vegetated masses has shown good performance, particularly in areas with high built density.

Lastly, it is worth noting that the color of pavement surfaces affects the energy balance of cities. Asphalt mixtures, due to their dark color, have a high capacity for absorbing shortwave radiation during the day and releasing heat at night, contributing to the warming of the air in the region near the surface (Li, 2016; Zhu & Mai, 2019). However, they still possess competitive advantages in terms of initial cost, ease of maintenance, and logistics.

Loss (2018) presents 11 criteria considered important by designers and public managers in selecting the most suitable urban road system: a) considering the initial cost of pavement implementation;

b) life cycle maintenance cost; c) promoting integration with the urban environment; d) sustainable use of surface materials; e) sustainable use of subsurface layers such as base, sub-base, and subgrade reinforcement; f) ability to absorb stormwater, reducing floods and waterlogging; g) providing thermal comfort for pedestrians and cyclists; h) providing smooth vehicle ride comfort; i) ensuring road safety; j) being durable; k) aligning with the intended road hierarchy for which it was designed.

2. LITERATURE REVIEW

2.1. Multicriteria Decision-Making Methods applied in urban studies

In urban studies, there are numerous variables that contribute to evaluations in the decision-making process. Therefore, multicriteria decision-making (MCDM) methods have been widely used in operational research to assist project managers in selection processes (Santos et al., 2021).

Decision-making and multicriteria analysis methods are applied when there is a need to select, rank, or describe alternatives in complex decision processes with multiple criteria and conflicting objectives (Singh & Pant, 2021).

Bellman and Zadeh (1970) initiated the discussion by using decision-making methods in a fuzzy environment. Subsequently, the Analytic Hierarchy Process (AHP) method, conceived by Saaty (1980), was published. It is an additive linear model that converts subjective evaluations of relative importance into a set of scores and weights based on pairwise comparisons. Only the indicators are evaluated using input variables, which can be qualitative or quantitative, including different scales and units. Finally, the evaluation is performed by applying a value function to the indicators.

However, these tools are still underexplored in the field of city planning. When selecting the best option for urban pavement, for example, there are still a series of constraints and attributes that qualify each of the construction systems, which complicates the decision-making process.

Jato-Espino et al. (2019) conducted a case study considering a decision-making model for the selection of permeable pavements. The method used was the Integrated Value Model for Sustainable Assessment (MIVES). Due to the lack of precise information for modeling the behavior of alternatives, a stochastic simulation process based on the Monte Carlo model was decided upon. In addition, ten experts from various sectors related to water management were interviewed to provide their opinions on the importance of the selected criteria according to the levels of comparison in the Analytic Hierarchy Process (AHP).

Gupta et al. (2021) evaluated the influence of aramid fiber, aramid pulp, hybrid glass fiber, and cellulose fiber to improve the abrasion resistance and strength of porous asphalt mixtures while maintaining their functional characteristics. The multicriteria decision-making method used was the Weighted Aggregated Sum Product Assessment (WASPAS) in combination with the Criteria Importance Through Inter-criteria Correlation (CRITIC) method for weighting.

The facade and pavement are the two main structures that form the urban canyons. However, the facade also has a decisive contribution to the building's performance and the comfort conditions of the street.

Being one of the largest construction components, choosing the ideal surfaces can be a challenge for designers, especially when considering facades with multiple materials. However, it is important to consider that urban geometry can greatly influence the urban climate, so it is not enough to know only the thermal properties of surface materials, but rather the interaction between them based on different geometric configurations, such as width-to-height ratios or the sky view factor of urban canyons, for example.

In this context, Gupta et al. (2021) set out to select the best facade material in the city of Barcelona to meet the requirements of cost, energy performance, aesthetics, and maintenance capacity. These criteria were determined by stakeholders, including clients, authorities, and designers. The significant contribution of this research was working in a scenario with multiple variables, many of which were subjective and uncertain.

Due to the complexity of urban networks, the wide variety of materials (concrete, rock, asphalt, soil), and their different functions (traffic, pedestrians, or both), there are few methods that can be used to evaluate the conditions of urban pavement use. Therefore, Pujadas et al. (2018) proposed an approach to pavement management using a multicriteria method adaptable to various urban environments. The concepts used combine multicriteria decision-making and the Multi-Attribute Utility Theory.

After applying the methodology, sensitivity was evaluated through a case study in the city of Barcelona. The workflow sequence started with determining the pavement quality index and identifying problems. Then, a systematic categorization of pavements in the urban network was performed to make the method precise, consistent, and repeatable.

Finally, Boix-Cots et al. (2022) conducted a systematic review using the Integrated Value Model for Sustainable Assessment (MIVES). The studies essentially relate multicriteria decision-making methods to urban planning.

Demircan and Yetilmezsoy (2023) proposed an approach for implementing smarter and more sustainable waste management strategies using a hybrid fuzzy approach with AHP-TOPSIS.

Kutty et al. (2023) measured the sustainability, resilience, and quality of life performance of European smart cities using a multicriteria decision-making method.

Da Silva et al. (2022) proposed a new approach for selecting urban mobility projects in medium-sized cities, considering the challenges of smart cities. The focus is on intelligence and sustainability issues, using multicriteria decision-making methods such as TOPSIS and AHP.

Stanujkic et al. (2023) and Stanujkić et al. (2021) propose a new method for ranking alternatives in a given problem, called Simple Weighted Sum-Product (WISP). This approach requires the inclusion of weights and utility measure calculations. The proposal is based on integrating utility frames that assign the impact of cost and benefit criteria, based on the use of Weighted Sum (WS) and Weighted Product (WP) methods.

In recent decades, sustainability has been seen as a solution to deal with resource scarcity and growing environmental and social problems. In this regard, Ulutaş et al. (2022) proposed the application of the Weighted Sum-Product (WISP) method in sustainable supplier selection. However, this methodology could be extended to territorial and resource management in the public sector.

Furthermore, since the WISP method is relatively new, there is still limited research on its application in urban planning and city design, as well as on the use of the AHP-Gaussian method in these areas. Thus, this paper aims to determine the best solution for Streets for People by comparing two multicriteria decision-making methods: the WISP (Integrated Simple Weighted Sum Product Method) and the AHP-Gaussian and highlight the potential application of this tool in urban system management and planning.

3. METHODOLOGY

This study is classified as explanatory as it aims to structure systems, theoretical models, and relate hypotheses in a more integrated view, seeking to identify factors that contribute to the occurrence of a phenomenon. Finally, in terms of methodological procedures, it is an operational research as mathematical models will be constructed to solve the decision-making process. Additionally, it is subdivided into five main stages:

a) Identification and systematization of the problem.

b) Definition of alternatives and study criteria.

c) Proposal of a solution and application of the WISP method for decision-making.

d) Application of the AHP-Gaussian method for decision-making.

e) Ranking comparison between WISP and AHP-Gaussian methods.

3.1. Systematization of the problem

According to Rodrigues et al. (2023), the lack of consensus on the factors influencing the development of sustainable cities hinders the creation of better urban ecosystems. To enhance quality of life and drive economic growth in metropolises, it is necessary to understand the dynamics and challenges of urban ecosystems, as well as identify initiatives that promote their development.

However, given the increasing complexities of cities, it is crucial to assess urban life based on multiple conflicting criteria. Multiple-criteria evaluations have been an approach to measuring the overall performance of various decision-making entities Kutty et al. (2023).

Simjanović et al. (2023) applied the Analytic Hierarchy Process (AHP) method for a study on smart city development with a focus on mobility, public health, and education. These sectors are fundamental and involve highly complex decision-making processes, especially when seeking integration between them. Kutty et al. (2023) proposed measuring the sustainability performance, resilience, and quality of life of European smart cities using a multicriteria decision support method.

Recognizing that urban projects centered on people involve multiple dimensions of study, the selection of materials for the urban landscape becomes a complex task. In order to structure and understand the problem of this paper, a strategic decision-making framework is used in this context.

This methodology proposes the organization and systematization of the problem, considering aspects such as: a) reward, meaning what is expected from the implementation of this project; b) the scenario in which the problem is embedded;

c) the strategies used to achieve the objective in the described scenario; d) the rules for problem resolution; e) the challenges faced during the process; f) the sources of resources; g) the stakeholders involved; h) alternatives; and i) performance indicators for monitoring. Finally, it identifies the j) decisions to be made and k) those that should not be made to achieve satisfactory performance in problem resolution. The entire organization is presented in Table 1.

Thus, if key actors, such as technical teams in engineering, architecture, geography, and urban planning, are aligned and sufficiently skilled, coupled with the application of multicriteria decision-making tools, they can generate increasingly precise performance indicators that support public territorial management. The relevance of this research is based on the arguments presented and guided by three perspectives:

- Why is the choice of urban pavements a problem? Because currently, this issue is not addressed with a multi and interdisciplinary perspective by public management.

Table 1. Framework for strategic decision-making to select the best urban pavement

<table>
<tr>
<td>Rules

Seek reliable data sources for creating the decision matrix.</td>
<td>Challenge

Always have up-to-date data sources. Additionally, the tools and methodologies for data acquisition have a certain level of complexity.

Another challenge is to find the best technical solution with the lowest implementation cost.</td>
<td rowspan="2">Reward

Reduction of costs for public funds, increased durability, and delivering the best solution for society.

The return on investment is achieved through the satisfaction of the population, the adequacy of sidewalk accessibility, promoting greater social inclusion, and optimizing the public budget.</td>
<td>Alternatives

Concrete pavements or asphalt pavements.

Wider or narrower sidewalks.

More sustainable pavements with a smaller carbon footprint and better comfort and safety conditions.

Always associated with the lowest cost.</td>
<td>Decision to make

Prioritize the selection of pavements with lower implementation costs, longer lifespan, wider sidewalks, and a smaller carbon footprint.</td>
</tr>
<tr>
<td>Stakeholders

Civil society is the end customer; public managers are responsible for funding; civil engineers and infrastructure secretaries promote project approval; construction investors enable execution; architects and urban planners are responsible for data collection and structuring the best technical solutions.</td>
<td>Resources

The resources are primarily from the public sector. However, public-private partnerships or consortium operations may be a possibility.</td>
<td>Indicators

The metrics for monitoring and evaluating performance in this study are the multicriteria methods of operations research. It uses an information base that should preferably be primary. Data is collected through market studies, computational simulations, and interviews with managers.</td>
<td>Decision not to make

Do not disregard aspects such as energy consumption for public lighting, air and pavement temperature for thermal comfort evaluation, and pedestrian safety in terms of braking distance.</td>
</tr>
<tr>
<td colspan="3">Scenarios

In the Brazilian context, the topic of sustainable cities is still underexplored. Additionally, decisions regarding material selection in urban systems are rarely based on technical considerations.</td>
<td colspan="2">Strategies

The process to achieve the objective in the proposed scenario is to initially present a well-founded proposal to public management. Highlight the financial benefits of these selection projects and how the population benefits from this investment.</td>
</tr>
</table>

- Who is it a problem for? For society in general and for populations with reduced mobility who do not have adequate urban road infrastructure.
- What evidence shows that it is a problem? A significant portion of the streets and sidewalks in Brazilian cities are still not accessible to the most vulnerable public. Additionally, expenditures on road pavement infrastructure are high and often lack technical optimization.

3.2. Definition of alternatives and study criteria

Figure 1 presents the criteria, alternatives, and the methodological sequence of the research.

The methods used in this study was the Weighted Sum-Product (WISP) method, proposed by Stanujkic et al. (2023) and AHP-Gaussian, proposed by (Santos et al., 2021), as they are new methods with few applications focused on urban planning. Furthermore, the choice of WISP method

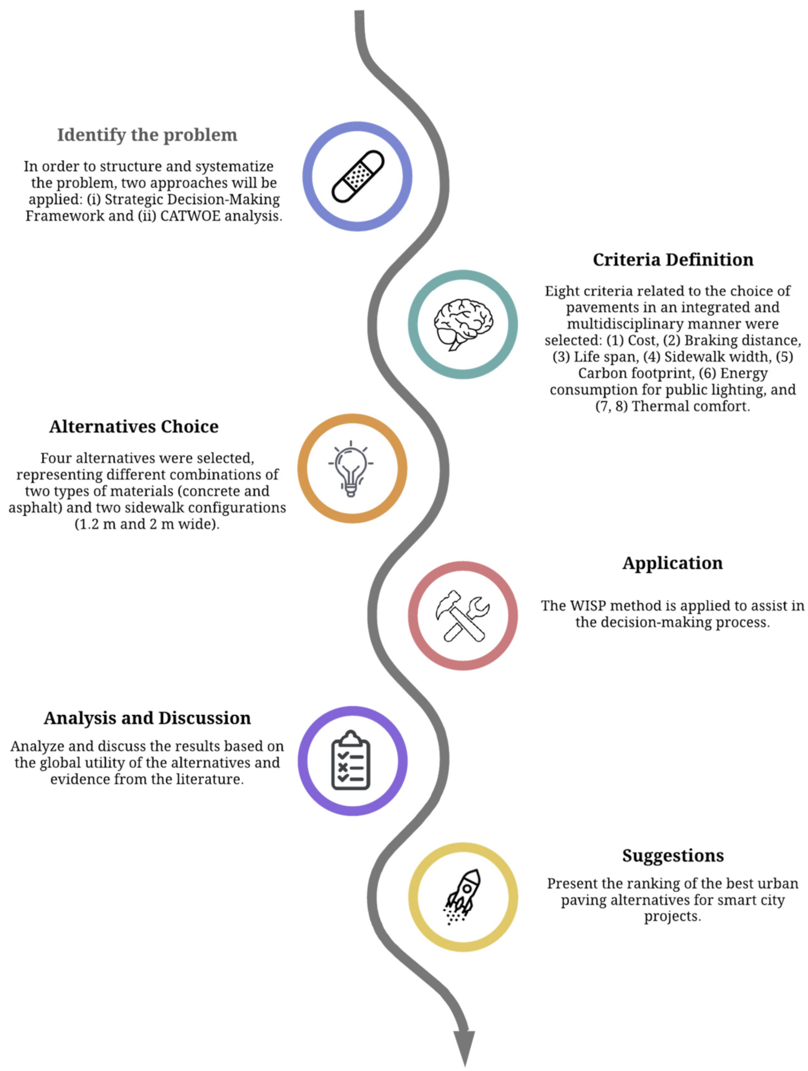

Figure 1. Flowchart with the methodological sequence of the research

was due to its ability to weigh the criteria according to a weight (which, in this context, was determined by public managers and complemented by designers) and the AHP-Gaussian, because it proposes to determine the weights of each criterion based on a sensitivity factor generated from the normal Gaussian curve.

The selected alternatives for the application of the WISP and AHP-Gaussian methods are generic solutions that should be adapted according to the project's specific needs in each location. The aim was to explore materials with completely contrasting costs, thermal and mechanical properties, execution techniques, and performance, based on the literature, such as asphalt and concrete.

The criteria considered important for the efficient selection of urban pavements were based on the research data of Loss (2018). The main motivation for the selection of the criteria proposed by the author was the fact that the research was carried out in the same urban context, a medium-sized city with approximately 250,000 inhabitants, named São Carlos, located in the State of São Paulo.

The pavement designs are recommendations from [ABCP - Brazilian Portland Cement Association] and [DNIT - National Department of Infrastructure and Transport], two reference institutions in infrastructure management and technical standards in the Brazilian context.

In addition, asphalt pavements make up almost all of the paved surface in the city of São Carlos, representing an average of 30% of the urbanized area. Concrete pavements, on the other hand, are proposed by ABCP as a more sustainable and durable alternative. For this reason, we were motivated to study both.

The thermal energy simulation data were processed in ENVI-met software, a sophisticated numerical modeling tool for urban microclimates. The output data from this modeling were the air temperature above the sidewalk and the surface temperature, two important variables for determining the thermal stress conditions that pedestrians face when walking on the sidewalk.

The data on the construction costs of sidewalks come from a reference table called SINAP (National System for Researching Construction Costs and Indices). CAIXA is responsible for the entire technical engineering base, the processing of the data and the publication of the price and cost reports, while IBGE carries out the price research, processes the data and creates and publishes the indices.

The other data come from the results of technical and scientific materials applied in similar urban contexts.

The computational tool used for the WISP calculation procedure was developed by Silva (2023) and the code implementation followed the methodology of Stanujkic et al. (2023) and the equation proposed by Stanujkić et al. (2021).

The tool proposed by Moreira et al. (2021) was used to apply the AHP-Gaussian method, following the same criteria and alternatives as the WISP method. The only difference is that in this methodology the weights are not predetermined. They are generated from the mean and standard deviation of the data, as a sensitivity factor.

Table 2 presents the eight criteria of this study, along with their information sources, and Table 3 presents the four urban pavement alternatives.

Table 2. Relationship of studied criteria

ID	Criteria	Data Source
C1	Cost/km (US$)	SINAP table (data march/2023, São Paulo)
C2	Braking distance (m)	ABCP (considering a car at 95km/h)
C3	Lifespan (years)	ABCP
C4	Sidewalk width (m)	Project data
C5	Carbon footprint/km (CO2eq)	ADB method (2010)
C6	Electric energy consumption index for public lighting	Pomerantz et al. (2000)
C7	Air temperature above pavement (°C)	ENVI-met
C8	Surface temperature (°C)	ENVI-met

Table 3. Urban pavements alternatives

Alternatives	Scheme	Description
Pavement A		Concrete pavement 4.0 m and 2.0 meters width sidewalk
Pavement B		Concrete pavement 8.0 m and 1.2 meters width sidewalk
Pavement C		Asphalt pavement 8.0 m and 2.0 meters width sidewalk
Pavement D		Asphalt pavement 8.0 m and 1.2 meters width sidewalk

4. SOLUTION PROPOSAL

4.1. WISP Method

The six steps for applying WISP are as follows:

-Step 1. Define the decision matrix.

-Step 2. Normalize the decision matrix (r_{ij}) by the maximum value of each criterion.

-Step 3. Determine the four utility measures u_i^{wsd}, u_i^{wpd}, u_i^{wsr} and u_i^{wpr} considering whether the criteria are cost-monotonic or benefit-monotonic.

-Step 4. Recalculate the utilities

$\left(\overline{u}_i^{wsd}, \overline{u}_i^{wpd}, \overline{u}_i^{wsr} \text{ and } \overline{u}_i^{wpr}\right)$.

-Step 5. Calculate the global utility (u_i) for each alternative.

-Step 6. Obtain the ranking.

Based on the criteria and alternatives, Table 4 presents the decision matrix for this problem.

Finally, the calculation procedure of the new approach, applied to an MCDM problem involving *m* alternatives and *n* criteria. The normalization results are then presented in Table 5.

The utility matrix for each alternative is presented in Table 6.

The recalculated utility matrix the values of the four utility measures are presented in Table 7.

Then, the overall utility u_i and the ranking for each alternative are shown in Table 8.

Finally, applying WISP method, the overall ranking indicated that concrete pavements were the best solution, with Pavement A (concrete pavement with wider sidewalk) being the most suitable alternative, with a global utility value of 1.00. It was

Table 4. Decision matrix

Criteria	Cost/ km (US$)	Braking distance (m)	Lifespan (years)	Sidewalk width (m)	Carbon footprint/ km (CO2eq)	Electric energy consum.	Air temp. above pavement (°C)	Surface temp. (°C)
Optimization	min	min	max	max	min	min	min	min
Weight	0.204	0.071	0.184	0.143	0.122	0.112	0.102	0.062
Pavement A	1882000	96	20	2	1200	0.2	34	57
Pavement B	1870000	96	25	1.2	1100	0.4	32	54
Pavement C	1712000	109	10	2	2300	0.6	28	74
Pavement D	1700000	109	15	1.2	2200	0.8	29	72
Maximum val.	1870000	109	25	2	2300	0.8	34	74

Table 5. Normalized data (Authors' calculations)

	Cost/ km (US$)	Braking distance (m)	Lifespan (years)	Sidewalk width (m)	Carbon footprint/km (CO2eq)	Electric energy consum.	Air temp. above pavement (°C)	Surface temp. (°C)
Pavement A	1.000	0.881	0.800	1.000	0.522	0.250	1.000	0.770
Pavement B	0.994	0.881	1.000	0.600	0.478	0.500	0.941	0.730
Pavement C	0.910	1.000	0.400	1.000	1.000	0.750	0.824	1.000
Pavement D	0.903	1.000	0.600	0.600	0.957	1.000	0.853	0.973

Table 6. Utility matrix (Authors' calculations)

	u_i^{wsd}	u_i^{wpd}	u_i^{wsr}	u_i^{wpr}
Pavement A	-0.21770	0.0210500	0.5713	190100
Pavement B	-0.25100	0.0157900	0.5180	87760
Pavement C	-0.39200	0.0105200	0.3559	14790
Pavement D	-0.43510	0.0094710	0.3108	10550
Maximum	-0.21770	0.0210500	0.5713	190100

Table 7. Recalculated utility matrix (Authors' calculations)

	$\bar{\boldsymbol{u}}_i^{wsd}$	$\bar{\boldsymbol{u}}_i^{wpd}$	$\bar{\boldsymbol{u}}_i^{wsr}$	$\bar{\boldsymbol{u}}_i^{wpr}$
Pavement A	1.0000	1.0000	1.0000	1.0000
Pavement B	0.9570	0.9948	0.9661	0.4618
Pavement C	0.7773	0.9897	0.8629	0.0788
Pavement D	0.7221	0.9887	0.8342	0.0555

Table 8. WISP Ranking (Authors' calculations)

	Position	$\boldsymbol{u}_i$	Scheme
Pavement A	1	1.000	
Pavement B	2	0.845	
Pavement C	3	0.677	
Pavement D	4	0.650	

followed by Pavement B (concrete pavement with narrower sidewalk) with a value of 0.84. The last position was occupied by Pavement D (asphalt pavement with narrow sidewalk) with a value of 0.650.

4.2 AHP-Gaussian Method

The seven steps for applying AHP-Gaussian are as follows and the also presented in Figure 2.

-Step 1. Define the decision matrix.

-Step 2. Normalize the decision matrix.

-Step 3. Calculate the mean of the alternatives.

-Step 4. Calculate the standard deviation of the alternatives for each criterion.

-Step 5. Calculate the Gaussian factor for each criterion.

-Step 6. Multiply the Gaussian factor by the decision matrix.

-Step 7. Obtain the ranking.

After applying the method, the Table 9 shows the AHP-Gaussian Weights.

It can be seen that the highest weights in AHP-Gaussian Method were for Electricity Consumption for Lighting (0.268), Carbon footprint (0.194) and Lifespan (0.1915). In the WISP methodology, the criteria scored with the highest value were not coident, and the final ranking did not converge. Because, the highest weights were given to Cost/km (0.204), Lifespan (0.184) and Sidewalk width (0.143).

Thus, the AHP-Gaussian Global Ranking was completely opposite to the WISP method, as can be seen in Table 10, because the weights were either predetermined by the decision maker or mathematically generated.

5. RESULTS AND DISCUSSION

The approach of this research stands out for two main aspects that differentiate it from previous models in the literature: (i) the use of multicriteria decision-making tools in the selection of urban pavements, and (ii) the application of the WISP method or AHP-Gaussian in urban planning and territorial management.

Da Silva et al. (2022) proposed a new approach focused on intelligence and sustainability issues in selecting mobility systems. They also used methods such as TOPSIS and AHP, along with a predefined set of evaluation criteria, to allow decision-makers to select a smaller and more suitable set of criteria for the problem alternatives,

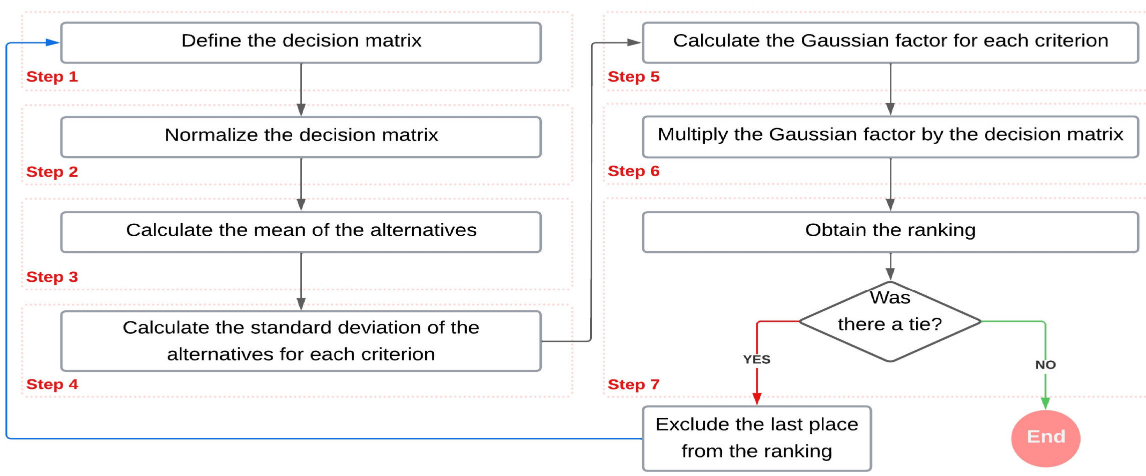

Figure 2. Flowchart with the AHP-Gaussian Method. Source: Apolinário and Kowalski (2023)

Table 9. AHP-Gaussian Weights (Authors' calculations)

	Means	Standard Deviation	Gaussian Factor	Weights
Cost/km (US$)	0.25	0.01373447	0.05493789	0.02852908
Braking distance (m)	0.25	0.01830623	0.07322491	0.03802548
Lifespan (years)	0.25	0.09221389	0.36885556	0.19154557
Sidewalk width (m)	0.25	0.07216878	0.28867513	0.14990812
Carbon footprint/km (CO2eq)	0.25	0.09378003	0.37512013	0.19479875
Electric energy consum.	0.25	0.12909944	0.51639778	0.26816380
Air temp. above pavement (°C)	0.25	0.02238850	0.08955399	0.04650512
Surface temp. (°C)	0.25	0.03972875	0.15891500	0.08252408

Table 10. AHP-Gaussian Ranking (Authors' calculations)

	Position	Score	Scheme
Pavement A	4	0.2103225	
Pavement B	3	0.2274502	
Pavement C	2	0.2718221	
Pavement D	1	0.2904052	

which could be incorporated in future studies. It should be noted that in this study, stakeholders only assigned weights to the criteria and did not suggest them directly. Furthermore, Puška et al. (2018) and Pamučar et al. (2017) proposed a model for result consistency evaluation and sensitivity analysis between different multicriterial decision-making methods, which may represent an important aspect to consider.

On the other hand, Ulutaş et al. (2022) applied the Weighted Sum-Product (WISP) method in the sustainable supplier selection, which could be easily integrated into territorial and resource management of the public sector. The authors highlighted that the adaptation of the WISP method was sensitive to changes in criterion weights. The same could be observed in this paper.

On the other hand, in AHP-Gaussian, the decision maker does not have to determine the weights for each criterion, which seems to be an extremely complex step for such subjective variables in the urban context. The sensitivity factor comes from the mean and standard deviation of the data in the matrix.

Furthermore, the study by Ulutaş et al. (2022) did not use objective weighting techniques such as CRITIC, Entropy, or MEREC. One of these methods could be used in future studies with the same thematic as this article to create a more robust model.

Finally, the main findings regarding the benefits of using multicriteria methods in public management were also highlighted by (Carli et al., 2018). This result has relevant implications for managers, as they have the opportunity to identify and implement targeted actions specifically designed to improve specific areas based on the current situation of the city. This allows for maximizing the efficiency and effectiveness of actions taken for the sustainable development of energy, water, and environmental systems throughout the metropolitan city. This perfectly reflects an integrated, multi and interdisciplinary management throughout the decision-making process.

Regarding the eleven criteria, both methods (AHP-Gaussian and WISP) proved to be satisfactory, in selecting the most suitable urban road system. The main difference between them is that the WISP allows the decision maker to determine the weights in the decision process. On the other hand, if the decision maker doesn't feel comfortable thinking about the weights, the mathematical model of AHP-Gaussian can help.

However, it should be mentioned that this methodology can be extended and optimized in future research for other pavement typologies and configurations. This includes elements such as water bodies, vegetation, shading elements, and incorporating peripheral aspects (such as sociodemographic indicators, legal and regulatory aspects) to adjust the weights of stakeholders, promoting a clearer and more robust procedure, as suggested by (Gilani et al., 2022).

6. CONCLUSIONS

This research has achieved its purpose by determining the best methodology to determine solution for Streets for People by comparing two multicriteria decision-making methods: the WISP (Integrated Simple Weighted Sum Product Method) and the AHP-Gaussian and highlight the potential application of this tool in urban system management and planning.

However, using AHP-Gaussian, the decision maker is spared from having to figure out the weights for every criterion. The mean and standard deviation of the data in the matrix provide the sensitivity factor. Desta forma,

The WISP pointed the concrete pavement and sidewalk width of 2.0 meters. Despite being one of the more expensive alternatives, with a weight of approximately 20% in the evaluation criteria. However, it is understood that the lifespan (the second criteria with the highest weight) favored this convergence.

The least viable alternative was the asphalt pavement, with a sidewalk width of 1.2 meters. This result can be explained by the fact that it has a higher carbon footprint (weight of 12%), promotes higher air temperatures (weight of 10%), and generates higher expenses for public lighting (weight of approximately 11%).

Although both methods are robust and computationally efficient, the WISP approach proved in this study to be more suitable for the selection of pavement materials by public decision makers. However, the “negative” aspect is that decision-maker must have expertise to determine the weights for each criterion.

Conversely, AHP-Gaussian incorporates a sensitivity feature, that allows the decision-maker to assign weights to each criterion derived from statistical analysis, even if they are not comfortable doing so.

This study represents an interesting illustration of a situation with contradictory results obtained by different MCDM methods. In practice, the user may make a more informed and robust decision by a systematic and data-driven analysis of the results. This may include e.g. sensitivity analysis on the weights, discussion of the criteria and conflicting results with the stakeholders, using some hybrid approach, or aggregating the results of different methods by voting.

The use of multi-criteria methods can help build better cities through a more integrated decision-making process across different domains, promoting a more optimized infrastructure project and people-centered solutions.

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ПРОЈЕКТОВАЊЕ УЛИЦА ЗА ЉУДЕ: СТУДИЈА О ДОНОШЕЊУ ОДЛУКА

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Извод

Пројектовање улица за људе подразумева одабир одговарајућих материјала, одређивање оптималне конфигурације и проналажење најбољег решења на основу техничких критеријума за урбане структуре. Овај рад има за циљ да идентификује најбоље решење упоређивањем две вишекритеријумске методе одлучивања: ВИСП (ен. *Weighted Sum-Product*) и АХП-Гауссиан, који представља новији алгоритам за доношење одлука аналитичким хијерархијским процесом (АХП). Направили смо матрицу са осам фактора (цена, пут кочења, животни век, ширина тротоара, угљенични отисак, потрошња електричне енергије и температура коловоза) да бисмо изабрали између четири опције коловоза (бетон и асфалт са различитим ширинама тротоара). ВИСП је препоручио бетонски тротоар и тротоар од 2,0 метара. Најмање исплатива опција је асфалтни коловоз са тротоаром од 1,2 метра, због већег угљичног отиска (12%), повишене температуре ваздуха (10%) и већих трошкова јавне расвете (11%). ВИСП омогућава додељивање пондера критеријумима са робусношћу, рачунарском ефикасношћу и транспарентношћу. Насупрот томе, АХП-Гауссиан укључује функцију осетљивости која омогућава доносиоцима одлука да додељују тежине на основу статистичке анализе. Упркос ограничењима сваке методе, обе су погодне за урбане пројекте, процењујући одлуке засноване на више техничких аспеката, чиме се промовишу интегрисанији и ефикаснији избори.

Кључне речи: улица за људе, АХП-Гаусов метод, ВИСП метода, урбани коловоз, вишекритеријско одлучивање, студија случаја.

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