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Designing a Human-Based Smart Transportation (HBST) pattern, with an emphasize on two concepts of mart transportation and hsuman-based transportation

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ABSTRACT

Urban transport systems are central to contemporary sustainability challenges because rapid urbanization and private-car dependence intensify congestion, energy use, emissions, and public-health burdens. While smart transportation improves efficiency through ICT and intelligent management, it may underweight human well-being and equity; conversely, human-based transportation supports active modes and social interaction but often lacks scalable operational integration. This study aims to formulate a Human-Based Smart Transportation (HBST) pattern that synthesizes these paradigms within the smart-city context and clarifies the leverage points that enable a sustainable and livable mobility transition. Methodologically, indicators were compiled through documentary review and targeted field inquiry, validated via a Delphi panel, structured using Interpretive Structural Modeling (ISM), and evaluated by MICMAC analysis to determine driving and dependence power. Findings yield 12 key HBST indicators and show that “using modern technologies,” “using Information and Communication Technology,” and “viability” operate as the strongest systemic drivers, whereas “increasing productivity,” “promoting security and sustainability,” and “increasing comfort” are the most dependent outcomes. The resulting HBST pattern operationalizes the direct smart transportation–smart city linkage and the indirect pathways through which human-based transportation becomes embedded in smart-city governance. Consequently, the model provides an actionable basis for urban managers to sequence interventions from enabling technologies and institutional viability toward measurable sustainability and quality-of-life gains.

KEYWORDS: Smart City; Smart Transportation; Human-based Transportation; Human-Based Smart Transportation.

INTRODUCTION

In the 21st century, frequently identified as the Century of Cities, a substantial demographic of the global population inhabits urban areas where lifestyles characterized by automobile dependence dominate daily routines. Among the various dimensions of this urbanization trend, the reliance on private vehicles powered by fossil fuels has emerged as a paramount challenge to sustainable urbanism (United Nations, Department of Economic and Social Affairs, Population Division, 2014). The pervasive utilization of such vehicles has exacerbated vehicular congestion, air and noise pollution, and greenhouse gas emissions, causing a deterioration in both urban environmental quality and public health standards. On a global scale, the transportation sector is responsible for approximately 15% of greenhouse gas emissions (OECD, 2010) and nearly 20% of total energy consumption (World Economic Forum, 2011). Notably, data indicates that by 2020, petroleum products satisfied about 94% of total transportation energy demand, highlighting a precarious reliance on nonrenewable resources (IEA, 2012). For instance, in the United States, the transportation sector alone accounted for 26% of total greenhouse gas emissions in 2015 (US Environmental Protection Agency, 2017).

This escalating environmental pressure has compelled urban governance bodies and researchers to pursue innovative strategies for attaining sustainable urban mobility. Two primary paradigms have surfaced as potential solutions: Smart Transportation and Human Based Transportation. While each approach offers significant value, both exhibit intrinsic limitations. Smart Transportation, a cornerstone of the Smart City paradigm, utilizes Information and Communication Technologies (ICT), data analytics, and intelligent systems to optimize mobility efficiency, safety, and energy consumption (Afandizadeh; Rahimi, 2009; Faraji et al., 2019). However, this methodology remains predominantly technocentric, frequently disregarding human well-being, social equity, and behavioral adaptability (Santis et al., 2014). Conversely, Human Based Transportation prioritizes active mobility modes such as walking, cycling, and public transit, placing emphasis on human health and social interaction (Pucher; Dijkstra, 2010). Despite its ecological and social dividends, this approach often lacks technological integration, which restricts its scalability and operational efficacy within complex modern urban systems.

In light of these constraints, the central dilemma addressed in this study is the dichotomy between human centric and technocentric paradigms in urban mobility planning. Contemporary research and policy frameworks frequently approach these two methodologies as isolated or competing domains rather than complementary assets. Consequently, the pivotal research question of this paper is formulated as follows: How can smart and human based transportation paradigms be amalgamated into a synergistic model that augments both technological efficiency and human well-being in urban environments?

The principal objective of this research is to formulate a Human Based Smart Transportation (HBST) framework. This framework aims to integrate the merits of both paradigms by leveraging technological innovations to enhance human mobility while upholding human health, social cohesion, and environmental sustainability. The proposed integrated model seeks to construct a balanced ecosystem where technology caters to human necessities and fosters a sustainable urban future instead of merely automating transport infrastructure.

The rationale for this research is grounded in the urgent necessity to align the rapid technological progression of smart cities with the fundamental tenets of human oriented urbanism. The HBST approach not only mitigates environmental imperatives such as carbon reduction and energy efficiency but also reinforces social inclusion, physical activity, and mental well-being. Furthermore, by bridging the existing theoretical and practical gap between smart and human based transportation, this study contributes to the evolution of sustainable urban management models that are simultaneously intelligent and humane. Ultimately, the development of an HBST framework provides a novel trajectory for cities to transition into genuinely sustainable smart cities where technological advancement and human values coexist in harmony.

RESEARCH LITERATURE

The Evolution of Urban Mobility and Smart City Paradigms

The rapid proliferation of technology in contemporary societies has compelled scholars to scrutinize urban development through multidimensional lenses and examine its pervasive role in daily urban systems. However, the domain of Human-Based Smart Transportation remains a critical yet underexplored area within the academic discourse. This study bridges this lacuna by analyzing the subject from a sociotechnical perspective, positing that the advancement of this transportation mode is a prerequisite for the realization of sustainable and viable smart cities. In particular, the nascent literature on the Strategic Digital City (SDC) emphasizes the integration of human-centric approaches into mobility infrastructures, thereby aligning smart transportation with the macro-level objectives of sustainable urban management and the Sustainable Development Goals (Rezende et al., 2023; Rezende et al., 2024; Rezende et al., 2025).

The Smart City paradigm has undergone a significant evolutionary trajectory over recent decades, shifting from technocentric definitions toward holistic urban ecosystems. Early conceptualizations, such as those propounded by Toppeta (2010), characterized the smart city as a spatial entity integrating ICT and web technologies with organizational utilities to enhance participatory governance and identify innovative solutions for urban management. However, subsequent scholarships have significantly expanded this discursive framework. Nam and Pardo (2011) argued that a smart city transcends mere technological development and must actively catalyze economic and social imperatives. Similarly, Chourabi et al. (2012) and Colldahi et al. (2013) conceptualized the smart city through the dimensions of technology, people, and institutions, defining it as an ecosystem where intelligence in economy, governance, mobility, and living fosters sustainable growth and quality of life. This evolutionary path culminates in the recent SDC model, which distinguishes itself from conventional digital cities by prioritizing the strategic application of IT in urban services and management, explicitly aligned with city strategies that center on the citizen's lived experience (Rezende, 2023).

Smart Transportation

Smart transportation constitutes a core pillar of the smart city, characterized by the coordinated integration of software, hardware, and telecommunication technologies designed to enhance the efficiency, safety, and sustainability of urban mobility (Giffinger et al., 2007; Afandizadeh; Rahimi, 2009). Fundamentally, these systems rely on ICT-powered infrastructures and online services to optimize vehicle efficiency, traffic control, and discipline (Colldahi et al., 2013; Miles; Kanchen, 2004). The literature consistently highlights that beyond operational metrics, such as cost reduction and energy conservation (IEA, 2012; Xylia et al., 2017), smart transportation must address critical social and environmental dimensions, including safety, stress reduction, and pollution mitigation (Bilodeau, 2010; U.S. Department of Transportation, 2000). Recent scholarship has further expanded this scope, emphasizing that smart transportation is deeply intertwined with strategic digital city models and governance outcomes, necessitating a focus on effective fuel management and digital public services (Rezende et al., 2024; Modarelli et al., 2024; Xu, 2025).

However, despite the technological sophistication of Smart Transportation Systems (STS), which integrate Artificial Intelligence (AI) and automation to improve service quality (Nikitas et al., 2020), purely technocentric approaches often fail to fully account for human variability, behavioral adaptability, and cultural context. To bridge this gap, the concept of Human-Based Smart Transportation (HBST) has emerged as a holistic synthesis of smart mobility technologies and human-centered design (HCD). HBST aims to create systems that are not only efficient but also inclusive and adaptive, leveraging digital innovation while prioritizing the social and psychological dimensions of mobility (Mitchell et al., 2016).

The human-based perspective within the HBST framework extends beyond traditional ergonomics to integrate broader socio-environmental dimensions, ensuring that mobility systems respond to the diverse needs of all citizens, including vulnerable populations such as the elderly or mobility-impaired (Fakhimi; Hughes, 2025). This approach emphasizes participatory design and inclusivity, allowing citizens to actively shape the mobility systems that affect their daily lives (Gall et al., 2021). Through data-driven models like agent-based simulations and crowdsourcing, urban planners can evaluate the effects of human decision-making on transport efficiency and optimize public transport scheduling to enhance livability (Fourie et al., 2020; Saravanan; Kumar, 2019).

Ultimately, the HBST framework seeks to establish a human-technology symbiosis where technological intelligence serves human empathy. This model represents a necessary paradigm shift from a technology-first approach toward a system where AI and IoT are employed to embed human values, such as equity, inclusivity, and accessibility, into every layer of design. By adapting dynamically to changing behavioral patterns and community feedback, HBST positions human experience as both the starting point and the ultimate goal of smart mobility innovation (Mirović et al., 2024).

Human-Based Transportation

Parallel to the technological revolution, Human Based Transportation has emerged as a vital paradigm aimed at mitigating the adverse effects of car dependent urban planning. This approach defines transportation systems designed for general public usage with the ultimate goal of a sustainable life by prioritizing the well-being of human communities over vehicular dominance (Hsu, 2003; Tibbalds, 2012). It emphasizes modes such as cycling, walking, and public transportation which align with the principles of cost effectiveness, energy conservation, and pollution reduction (Amirazodi, 2012; Pucher; Dijkstra, 2010). Recent studies increasingly view the integration of human based design with smart mobility infrastructures as essential for the resilience of future urban systems (Kotur; Radović, 2024; Rezende et al., 2025).

The literature extensively documents the benefits of human based transportation across health, environmental, and social domains. From a public health perspective, Bauman (2007) and the Transit Capacity and Quality of Service Manual (2013) note its role in reducing obesity, sudden deaths, and chronic diseases while promoting vitality. Environmentally, it is associated with reduced carbon emissions, lower reliance on motor vehicles, and the promotion of friendly fuels (Chandrappa; Chandra Kulshrestha, 2016; Popham, 2018). Economically and socially, this model is lauded for requiring cheaper infrastructure and less space than vehicular systems while simultaneously improving social justice and access to public spaces (Tsenkova; Mahlek, 2014; Pucher; Buhler, 2012). Key indicators for evaluating this transport mode include safety, comfort, cleanliness, and convenient access (Ebolli; Mazulla, 2012) alongside broader metrics such as social equity, community development, and the efficient use of roads to reduce congestion (Allen et al., 2001; Handy; Xing, 2011).

In the contemporary era of urban transformation, Human Based Smart Transportation (HBST) has emerged as a framework integrating the intelligence of digital systems with the social and behavioral dimensions of human mobility. HBST envisions cities as ecosystems where technology does not merely automate movement but enhances human well-being, equity, and sustainability. Recent studies indicate that human centered design is crucial in building intelligent transportation systems that reflect the diversity and complexity of urban life. For instance, the integration of smart card data has enabled researchers to decode human mobility patterns and reveal variations in urban travel behaviors (Cats, 2022). Similarly, mobility knowledge graphs offer a sophisticated data structure to model the hidden dependencies of human movement which enables personalized and adaptive transit recommendations (Zhang et al., 2023).

The human based transportation dimension extends beyond data analysis to integrate social inclusion and accessibility into the smart city narrative. Studies such as those by Kang et al. (2023) on autonomous shuttles for elderly populations highlight how transportation technologies can address demographic shifts by customizing mobility services. Likewise, decentralized and participatory management systems underscore how community driven decision making can strengthen transport governance and responsiveness to human needs (Zhao et al., 2023). From a technological standpoint, the HBST paradigm leverages smart sensors, AI algorithms, and data fusion to enhance safety and adaptability. Advanced cyber physical systems create real time interactions between digital platforms and human activity to ensure data informed decision making (Rathore et al., 2021). Furthermore, technologies such as triboelectric nanogenerators are being incorporated into smart transport systems to enable self-powered sensors and minimize dependency on external energy sources (Nguyen et al., 2024).

Ultimately, the HBST model integrates human cognition, digital intelligence, and ecological awareness. By embedding human values such as inclusivity, adaptability, and safety within smart transportation infrastructures, cities can evolve into truly human centric environments. The convergence of human based and smart transportation paradigms fosters a transition from technology dominated urbanism toward empathetic and data driven mobility ecosystems. Consequently, the HBST framework signifies a pivotal advancement in urban mobility planning by establishing a future where technological innovation is fundamentally harnessed to serve the needs of humanity.

Theoretical Framework

To rigorously address the integration of technological efficiency and human well-being, this research is grounded in the Strategic Digital City (SDC) framework, reinforced by Sociotechnical Systems (STS) theory. The SDC framework, as propounded by Rezende (2023), moves beyond the traditional technocentric view of smart cities to emphasize the alignment of Information Technology (IT) resources with long-term city strategies explicitly targeting citizens' quality of life. This framework is instrumental to this research as it posits that urban intelligence is not merely an attribute of hardware infrastructure but a strategic outcome of governance that connects city public thematics, such as mobility, to digital public services (Rezende et al., 2024). Furthermore, by adopting an STS lens, this study treats urban transportation not as a mechanical assembly of vehicles and sensors but as an interacting system of social requirements, including human behavior, health, and equity, and technical capabilities such as ICT and automation. This theoretical dualism guides the proposed Human-Based Smart Transportation (HBST) pattern, suggesting that sustainable urban management is achieved only when the optimization of the technical subsystem serves to reinforce and elevate the objectives of the social subsystem.

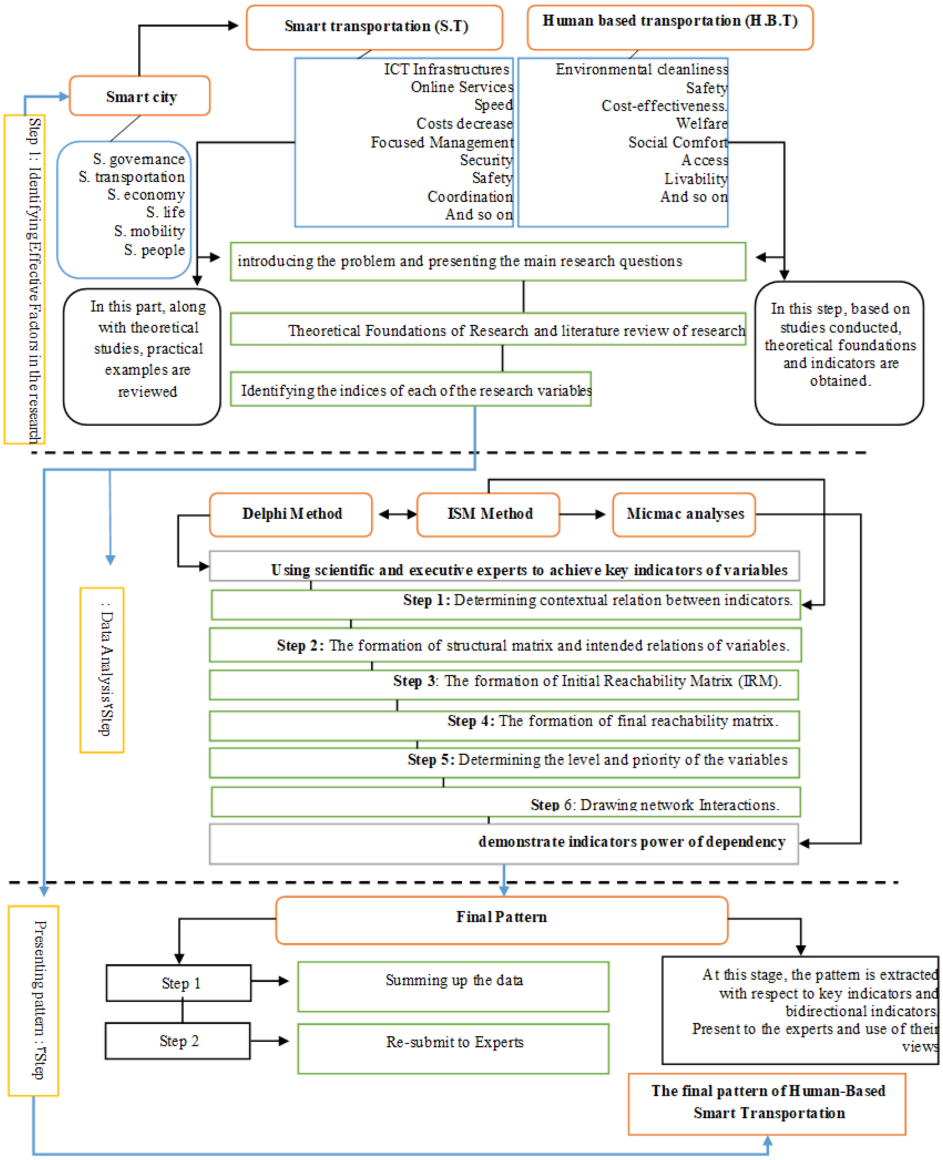
RESEARCH METHODOLOGY

Reviewing the research literature and studying the experts’ comments, the indicators of the two main variables of the research - namely, urban smart Transportation and human-based transportation – was extracted and adjusted in Tables (3) and (5). Then, they were formulated as questions to clarify the relationships between these indices and presented to the expert team (selected through the snowball method) for final confirmation through the Delphi method. In the next step, using the ISM method, the relationship between selected indices is investigated and the necessary prioritization is made. Then, the relationship between the severity and impact of the indices is analyzed using the MICMAC analysis. Finally, the final pattern is extracted and presented by the researchers according to all the research data. With regard to the research in general, the research framework is arranged as follows.

The Pattern of Doing Research

Considering all the steps of research, a Framework is set out as below (Figure 1).

Figure 1 - Research framework



Source: Authors

RESEARCH FINDINGS

In the first step, after collecting the studies and discussing the theoretical issues on smart Transportation and human-based transportation, we tried to extract the indices of each of these variables (Table 6). In the meantime, due to the multiplicity of indicators, it was important to identify the key vital indicators that can fulfill the purpose of the research. Delphi method was used for two purposes: 1) extracting key indicators from multiple domains of smart transportation and human-based indicators, and 2) reaching a common point of view among experts on the relationship between smart transportation and human-based transportation.

Data collection was done by distributing a researcher-made questionnaire package to the panel members. The questionnaire consists of 33 questions made based on a five-point Likert scale, using scores of 5, 4, 3, 2, and 1 (left to right, respectively). In this study, the validity of the questionnaire was assessed using face validity, and Cronbach's alpha coefficient was used to assess the reliability of the questionnaire - which was 76%. It is said that if the alpha coefficient is greater than 0.7, the test has acceptable reliability (Faraji et al., 2019).

The questionnaire was presented to 14 experts (consisting of 8 scientific experts active in the field of smart city and 6 executive experts of urban transportation) in three consecutive periods. At the first round, 7 questions (of total 31 questions) didn’t reach favorable points and were eliminated. In the second round, the experts did not reach consensus on the remaining 11 questions, and finally in the third round, they reached consensus on 10 questions, the following indicators have been extracted from. Meanwhile, due to the level of statistical significance (p<= 0.05) it was necessary to have CVR>=0.75 to accept each item. Results are presented in Table 1.

Table 1 - Key Indicators of Smart Transportation and Human-based Transportation

Item	Code	Indicator	Source	CVR
Human-based Transportation	HT1	Peoples’ more Mobility	Transit Capacity and Quality of Service Manual, 2013 Pucherj and Dijkastra, 2010 Chmiel et al, 2016	0.82
	HT2	Being Economical	Ebolli; Mazulla, 2012; Tsenkova; Mahlek, 2014; Pucher; Buhler, 2012; Kelly blue book, 2016; Popham, 2018	0.87
	HT3	Fossil Fuels Consumption	Popham, 2018	1
	HT4	Development of Human Relations and Civil Life	Velleman, 1997; Allen et al, 2001	1
	HT5	Livability	Ebolli; Mazulla, 2012; Pucherj; Dijkastra, 2010; Chmiel et al, 2016	0.85
	HT6	Increase of Convenience	Ebolli; Mazulla, 2012	1
Smart Transportation	ST1	Using Modern Technologies	Shi; Wu, 2018; Aboudina; Abdulhai 2017; Jimenez, 2018; An et al ,2011	0.95
	ST2	Using IT	Aboudina; Abdulhai 2017; Jimenez, 2018; An et al ,2011; Quezada, 2009; Miles, 2004; Afandizadeh; Rahimi, 2009	1

Item	Code	Indicator	Source	CVR
	ST3	Reducing Traffic	Miles, 2004; Mengyao Wang et al, 2014; Shi; Wu, 2018; Aboudina; Abdulhai 2017	1
	ST4	Increasing Air Quality	Maiti et al. (2017); Jimenez, 2018; Bilodeau, 2010; Litman, 2005	1
	ST5	Increasing Productivity	Wei et al, 2012; Jimenez, 2018,	0.85
	ST6	Increasing Security and Sustainability	Bilodeau, 2010; Shi; Wu, 2018	0.90

Source: Authors (2025)

Defining final indices, a review matrix was prepared for experts to examine the relationships among indices and their impact on each other for achieving Human-Based Smart Transportation and the following steps were set out.

Step 1: Determining the type of Contextual Relationship among Indicators

The contextual relationship among factors can be of priority and delay, or a kind of effectiveness relation. Meanwhile, each of identified indicators may influence the probability or severity of the effects of variables. So, the question in the questionnaire was that: What is the relationship between index i and index j?

Step 2: Formulating Structural Self-Interaction Matrix of Variables

At this stage, the identified variables are entered into the SSIM. Therefore, all experts in the research with necessary research and executive experiences in the field of urban smart transportation and human-based transportation were asked to comment on the relevance of these variables using the following four symbols (Table 2).

Table 2 - Conceptual Relationships in Matrix Formation (SSIM)

Symbol	Meaning
V	i leads to j (the factor of i row leads to column j)
A	j leads to i (the factor of column j leads to I row)
X	There is a two-way relationship between i and j (both of them form the basis of each other)
O	There is no relationship between two elements of i and j.

Source: Authors (2025)

In the meantime, due to the limitation of the article, the expert opinion summary table has not been included. However, the results can be identified through the initial access matrix.

Table 3 - Structural Self-Interaction Matrix of Variables

	HT1	HT2	HT3	HT4	HT5	HT6	ST1	ST2	ST3	ST4	ST5	ST6
HT1	🟥	V	X	X	X	O	O	O	V	X	O	O
HT2	🟩	🟥	A	O	O	V	A	A	X	O	O	O
HT3	🟩	🟩	🟥	O	X	V	A	A	A	V	V	O
HT4	🟩	🟩	🟩	🟥	V	O	O	A	X	A	O	X
HT5	🟩	🟩	🟩	🟩	🟥	V	A	A	A	X	O	V
HT6	🟩	🟩	🟩	🟩	🟩	🟥	A	A	A	A	X	X
ST1	🟩	🟩	🟩	🟩	🟩	🟩	🟥	X	V	V	V	V
ST2	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	V	V	V	V
ST3	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	V	V	O
ST4	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	V	O
ST5	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	A
ST6	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥

Source: Authors (2025)

Step 3: Formulating Reachability Matrix

At this point, the RM matrix can be obtained through converting the symbols of the SSIM matrix to zero and one, according to the rules of Table 4.

Table 4 - Standardization Table for Formulating Reachability Matrix

	Symbol Chosen by Experts	The number of corresponding Cell at Matrix	The number of analog Cell at Matrix (I,j)
(j, i) Cell at SSIM Matrix	V	1	0
	A	0	1
	X	1	1
	O	0	0

Source: Authors (2025)

For example, if (j, i) cell in the SSIM matrix has the symbol V. The corresponding cell in reachability matrix will have 1, and its analog Cell, (I, j), will have 0 (Table 5) (Warfield, 1974).

Table 5 - Primary Reachability Matrix

	HT1	HT2	HT3	HT4	HT5	HT6	ST1	ST2	ST3	ST4	ST5	ST6
HT1	🟥	1	1	1	1	0	0	0	1	1	0	0
HT2	0	🟥	0	0	0	1	0	0	1	0	0	0
HT3	1	1	🟥	0	1	1	0	0	0	1	1	0
HT4	1	0	0	🟥	1	0	0	0	1	0	0	1
HT5	1	0	1	0	🟥	1	0	0	0	1	0	1
HT6	0	0	0	0	0	🟥	0	0	0	0	1	1
ST1	0	1	1	0	1	1	🟥	1	1	1	1	1
ST2	0	1	1	1	1	1	1	🟥	1	1	1	1
ST3	0	1	1	1	1	1	0	0	🟥	1	1	0
ST4	1	0	0	1	1	1	0	0	0	🟥	1	0
ST5	0	0	0	0	0	1	0	0	0	0	🟥	0
ST6	0	0	0	1	0	1	0	0	0	0	1	🟥

Source: Authors (2025)

Step 4: Formulating Final Reachability Matrix

Once the primary reachability matrix is obtained, its internal consistency must be checked, i.e., according to a violation quality in mathematical logic: if (I, j) = 1 and (j, k) = 1, then (I, k) = 1. In this study, the initial reachability matrix is in stable state after 2 iterations based on the Bullen rule (Table 6).

Table 6 - Final Reachability Matrix

	HT1	HT2	HT3	HT4	HT5	HT6	ST1	ST2	ST3	ST4	ST5	ST6
HT1	1	1	1	1	1	1	0	0	1	1	1	1
HT2	0	1	1	1	1	1	0	0	1	1	1	1
HT3	1	1	1	1	1	1	0	0	1	1	1	1
HT4	1	1	1	1	1	1	0	0	1	1	1	1
HT5	1	1	1	1	1	1	0	0	1	1	1	1
HT6	0	0	0	0	0	1	0	0	0	0	1	1
ST1	1	1	1	1	1	1	1	1	1	1	1	1
ST2	1	1	1	1	1	1	1	1	1	1	1	1

ST3	1	1	1	1	1	1	0	0	1	1	1	1
ST4	1	1	1	1	1	1	0	0	1	1	1	1
ST5	0	0	0	0	0	1	0	0	0	0	1	1
ST6	1	0	0	1	1	1	0	0	1	0	1	1

Source: Authors (2025)

Based on the obtained numbers, we calculate influence and dependence of each index and put it in the graph.

Table 7 - Influence and Dependency of each Indicator

	HT1	HT2	HT3	HT4	HT5	HT6	ST1	ST2	ST3	ST4	ST5	ST6	نفوذ
HT1	1	1	1	1	1	1	0	0	1	1	1	1	10
HT2	0	1	1	1	1	1	0	0	1	1	1	1	9
HT3	1	1	1	1	1	1	0	0	1	1	1	1	10
HT4	1	1	1	1	1	1	0	0	1	1	1	1	10
HT5	1	1	1	1	1	1	0	0	1	1	1	1	10
HT6	0	0	0	0	0	1	0	0	0	0	1	1	3
ST1	1	1	1	1	1	1	1	1	1	1	1	1	12
ST2	1	1	1	1	1	1	1	1	1	1	1	1	12
ST3	1	1	1	1	1	1	0	0	1	1	1	1	10
ST4	1	1	1	1	1	1	0	0	1	1	1	1	10
ST5	0	0	0	0	0	1	0	0	0	0	1	1	3
ST6	1	0	0	1	1	1	0	0	1	0	1	1	7
Dependency	9	9	9	10	10	12	2	2	10	9	12	12	

Source: Authors (2025)

Step 5: Determining the Level and Priority of the Variables

In this step, we calculate the set of input (prerequisite) and output (access) criteria for each criterion, and then identify the common factors. The criterion with the highest level of ISM is the one in which output set (access) is equal to common set. After identifying these variable or variables, we remove their rows and columns from the table, and repeat the operation for other criteria.

Table 8 - Determination of Level and Priority of Variables

Variable	Input Set	Output Set	Common Set	Level
HT1	1,3,4,5,7,8,9,10,12	1,2,3,4,5,6,9,10,11,12	1,3,4,5,9,10,12	
HT2	1,2,3,4,5,7,8,9,10	2,3,4,5,6,9,10,11,12	2,3,4,5,9,10	
HT3	1,2,3,4,5,7,8,9,10	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,9,10	
HT4	1,2,3,4,5,7,8,9,10,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,9,10,12	
HT5	1,2,3,4,5,7,8,9,10,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,9,10,12	
HT6	1,2,3,4,5,6,7,8,9,10,11,12	6,10,11	6,10,11	1
ST1	7,8	1,2,3,4,5,6,7,8,9,10,11,12	7,8	
ST2	7,8	1,2,3,4,5,6,7,8,9,10,11,12	7,8	
ST3	1,2,3,4,5,7,8,9,10,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,9,10,12	
ST4	1,2,3,4,5,7,8,9,10	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,9,10	
ST5	1,2,3,4,5,6,7,8,9,10,11,12	6,11,12	6,11,12	1
ST6	1,2,3,4,5,6,7,8,9,10,11,12	1,4,5,6,9,11,12	1,4,5,6,9,11,12	1

Source: Authors (2025)

To determine the second level, we will remove the indices of level 1.

Table 9 - Determination of Level and Priority of Variables

Variable	Input Set	Output Set	Common Set	Level
HT1	1,3,4,5,7,8,9,10	1,2,3,4,5,9,10	1,3,4,5,9,10	
HT2	1,2,3,4,5,7,8,9,10	2,3,4,5,9,10	2,3,4,5,9,10	2
HT3	1,2,3,4,5,7,8,9,10	1,2,3,4,5,9,10	1,2,3,4,5,9,10	2
HT4	1,2,3,4,5,7,8,9,10	1,2,3,4,5,9,10	1,2,3,4,5,9,10	2
HT5	1,2,3,4,5,7,8,9,10,	1,2,3,4,5,9,10	1,2,3,4,5,9,10	2
ST1	7,8	1,2,3,4,5,7,8,9,10	7,8	
ST2	7,8	1,2,3,4,5,7,8,9,10	7,8	
ST3	1,2,3,4,5,7,8,9,10	1,2,3,4,5,9,10	1,2,3,4,5,9,10	2
ST4	1,2,3,4,5,7,8,9,10	1,2,3,4,5,9,10	1,2,3,4,5,9,10	2

Source: Authors (2025)

To determine the third level indices, we will remove the indices related to level 2.

Table 10 - Determination of Level and Priority of Variables

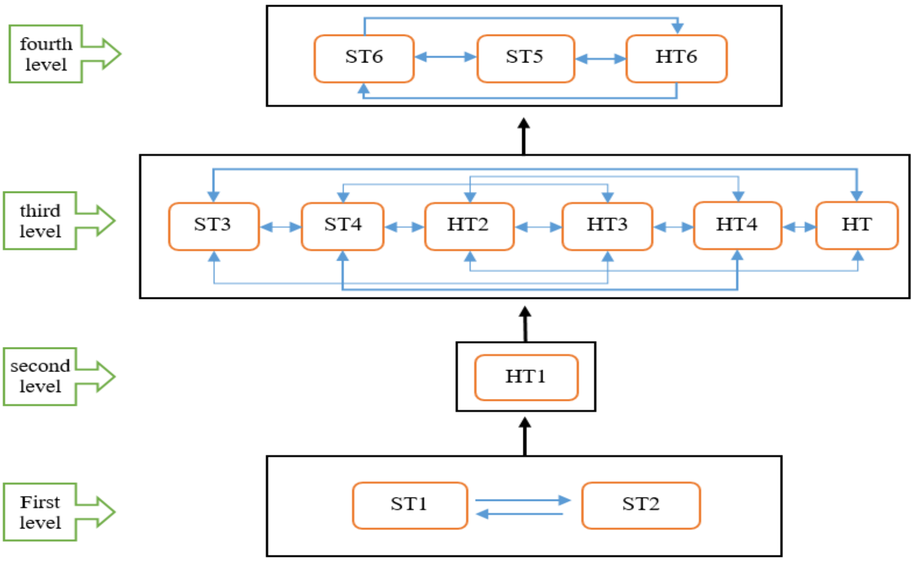
Variable	Input Set	Output Set	Common Set	Level
HT1	1,7,8	1	1	3
ST1	7,8	1,7,8	7,8	4
ST3	7,8	1,7,8	7,8	4

Source: Authors (2025)

In fact, the indices of level 1 show the highest dependency and indices of level 4 show the highest influence and lowest dependency.

Step 6: Drawing the Interactions Grid:

Figure 2 - Pattern of Interactions between the Research Indices



Source: Authors (2025)

Figure 2 illustrates the relationships and interactions between indices after final data analysis. In this figure, the indicators with highest influence are displayed at level 1 and indicators with highest dependency are shown at level 4. Based on obtained data, the indices that are set at same level affect each other. However, the relationship between the layers occurs unilaterally so that each lower layer effects on its top layer. The results show that two indicators of "using modern technologies" and "using IT" have the highest influence, and the three indicators of "increasing productivity", "increasing security and stability", and "increasing comfort and convenience" have the highest dependency and impact; and as a result, all indicators have influence each other. The other indices are in a position between these indices.

In the meantime, in order to evaluate the results, MICMAC analysis is also used to refer to the results more accurately.

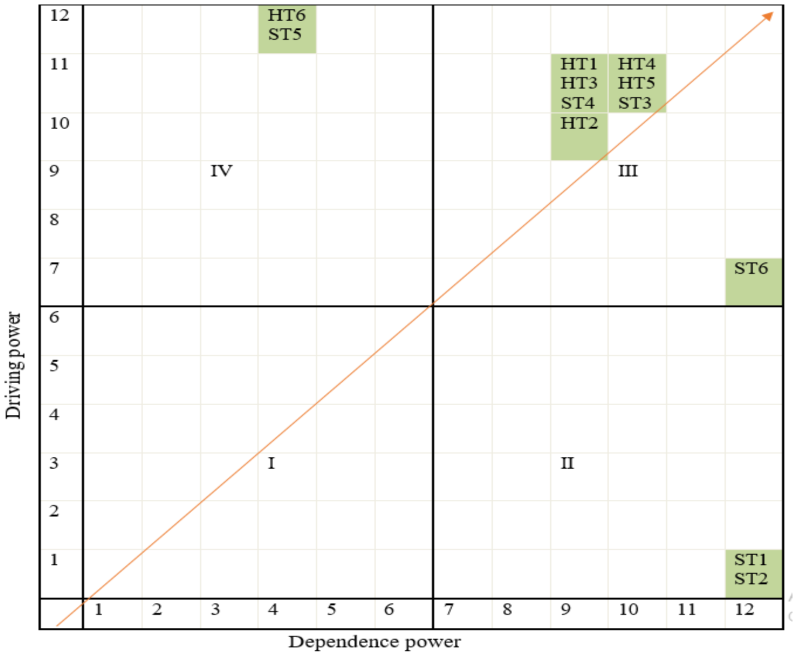
MICMAC Analysis

MICMAC analysis is based on the influence power and dependency rate of each variable and allows further investigation of the position and role of each variable. In this method the importance of variables is further measured by the indirect relationships between them, and the variables are divided into four groups of influential, dependent, bidirectional (connector), and independent.

As the figure of MICMAC analysis shows, the results of ISM are also highly reliable – i.e., some indicators are effective, some are influential, and some are bi-directional.

The results of the structural analysis of MICMAC can be described as below.

Figure 3 - Power-Dependency Chart, MICMAC Figure



Source: Authors (2025)

Effective variables are variables that are more effective than influential. These variables are the most critical variables and cannot be controlled by the system. They are also called environmental variables shown in 2nd area of the graph, including the use of IT technology and modern technologies.

The dependent variables, shown in the 4th region of the graph, have the lowest and the highest impact. These variables are very sensitive to effective and bi-directional variables and are actually the output of the system. These variables include increased comfort and convenience and also increased productivity.

Independent variables are not affected by other system variables and do not have much influence on them. These variables are set in the 3rd area of the graph and have very little to do with the system. In fact, these variables do not stop the main variable from evolving, and don't complete it, either. The graph of the present study lacks independent variables.

Bidirectional variables are highly effective and influential. Therefore, they are mixed with instability and are set the 1st region of graph. These include: greater mobility of people, cost-effectiveness, reduced use of fossil fuels, development of social interactions and civic life, environmental sustainability, reduced traffic, improved air quality, and increased security and sustainability. Bidirectional variables are divided into two types of variables:

- Risk Variables: are located around the diagonal line of the Northeast and have a high capacity to become key players in the system. Because of their unstable nature, they have the potential to become system breakpoints. These include: greater mobility of people, cost-effectiveness, reduced use of fossil fuels, development of social interactions and civic life, environmental sustainability, reduced traffic, and improved air quality.
- Target variables: are located below the diagonal line of the northeast region and are most influential. These variables are identified as the results of system evolution. In fact, manipulating these variables, one can achieve changes in system evolution. These variables represent the goals of the system, rather than being its result and predetermined. The variable of "increased security and stability" can be set into this group.
- Regulatory variables: are variables set in the middle of the graph. They do not have a regulatory variable.

The results from MICMAC strongly support the results of ISM.

According to the ISM, two indicators of “using modern technologies” and “using IT technology” have had the highest impact on the other indicators. According to the MICMAC, these two variables are set as effective variables, confirmed by the ISM result.

According to ISM, people's mobility, cost-effectiveness, reduced use of fossil fuels, development of social interactions and civic life, environmental sustainability, reduced traffic, and improved air quality are both effective and influential. According to MICMAC chart, these indices are bi-directional variables and confirmed by ISM [results].

According to the ISM, three variables (increasing comfort and efficiency, increase of productivity, and increase of security and sustainability) only affect one another and do not affect other indicators. According to the obtained MICMAC chart, increasing 1) comfort, and 2) productivity are dependent variables, so the ISM result is confirmed. The index of increasing security and stability in MICMAC chart is among bidirectional variables but because of its proximity to the 4th region of the axis (which is related to the dependent variables), only the target variable is set as of bidirectional variables. It means that it is more influential than effective. So, the ISM result is confirmed.

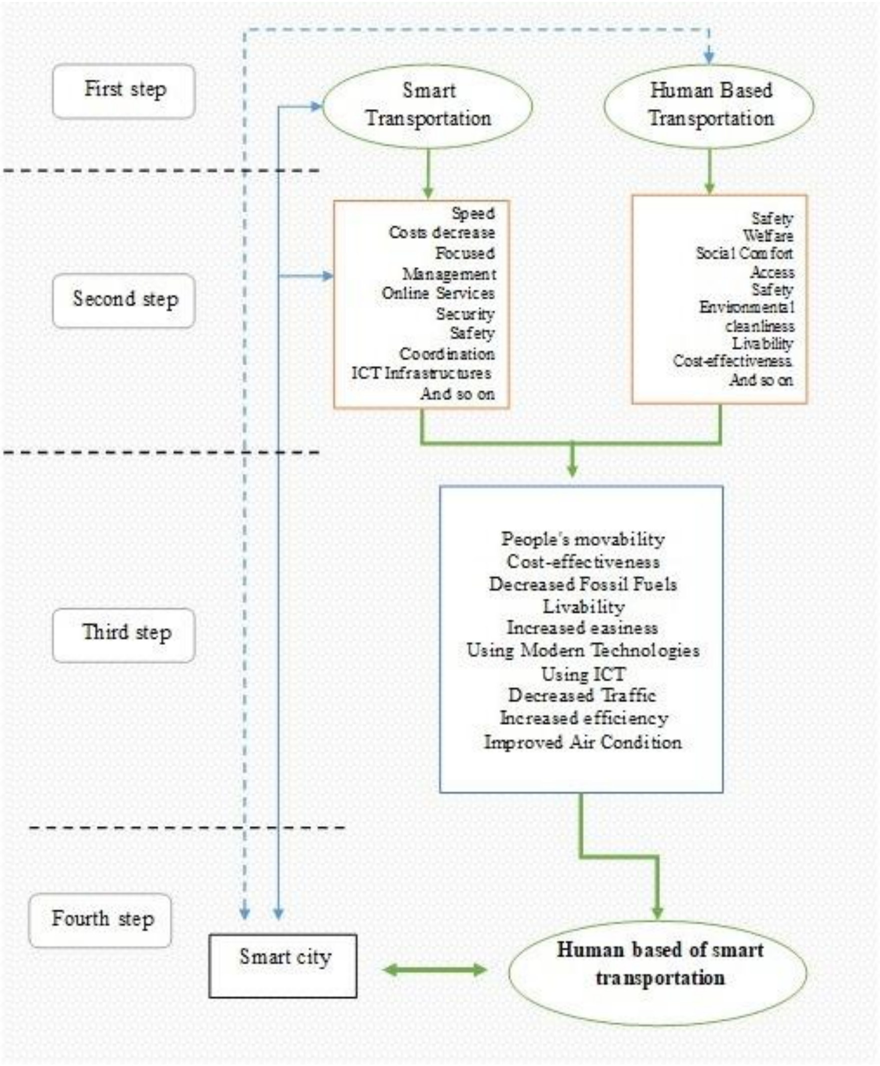
The Final Pattern Extracted from the Research

In order to increase the capability of urban authorities in urban transport management, focusing on the two components of smart urban transportation and human-based transport, we can present the following pattern (Figure 4).

Based on the proposed pattern, four steps must be considered in order to achieve an intelligent human-based transportation. In the first step, the main variables of the research should be identified. Therefore, in this study, two variables of smart Transportation and human-based transportation were identified as the main variables of the research.

Secondly, using library studies and field research (if necessary), the key indicators of each variable should be extracted. Finally, the key indicators would be chosen based on experts’ opinion to continue the study. In this study, after reviewing various sources, several indicators representing each of the research variables were identified and arranged in tables 2 and 4.

Figure 4 - Intelligent Human-based Transportation Pattern



Source: Authors (2025)

In the third stage, key indicators for each of the research variables are extracted based on the experts' viewpoints in order to clarify the context of the research goal. Accordingly, in this study, six key indicators for smart Transportation (table) and six key indicators for human-based transportation (table) were extracted in order to achieve Human-Based Smart Transportation. The next step is to investigate the relationship between key indicators and their effects using the ISM method and MICMAC analysis.

Finally, the fourth layer focuses on research output. In this layer, alongside the research output, special attention should be paid to the smart city as the context in which Human-Based Smart Transportation should take place. Therefore, the type of relationship between smart city and research variables will play an important role in shaping this type of transportation. Since smart transportation is recognized as one of the key components of smart city, there is a direct and reciprocal relationship between the two. While the type of relationship between smart city and human-based transportation is not clearly understood, it’s vital to understand this relationship. Therefore, based on research results and necessity of finding the severity of effectiveness and influential capacity of the indicators, we can define an indirect interaction between these two variables using the ISM method. In fact, using the ISM-based logic (a violation quality in mathematical logic: if (I, j) = 1 and (j, k) = 1, then (i, k) = 1), the indirect relationships between the components were identified. Based on this logic, the relationship between smart Transportation and human-based transportation has been confirmed in the research; on the other hand, the direct and mutual relationship between smart Transportation and smart city was also confirmed. Therefore, according to the relationships between the obtained variables, the relationship between smart Transportation and human-based transportation has been confirmed. Therefore, due to the violation quality in mathematical logic, the relationship between human-based transportation and smart city can also be proved, but the type of relationship must be considered as a kind of indirect relationship - as indicated by the dotted arrow in the figure.

Finally, the output of the research leads to Human-Based Smart Transportation, which is the result of two types of intelligent and human-based transportation, having direct relationship with two. On the other hand, as it grows in the context of the smart city, this type of transportation establishes a bidirectional relationship with the smart city. Analyzing the results and exploring the relationships between the research variables, the pattern of formulating Human-Based Smart Transportation would be finally extracted – it plays an important role in achieving sustainable smart city and smart management of urban spaces.

CONCLUSION

Due to the rapid growth of cities and the use of personal cars, along with the increasing development of IT technology, the focus on new concepts in urban management has further increased. In this regard, this research has been focused on Human-Based Smart Transportation based on two components of urban smart Transportation (as one of the most important indicators of the appearing smart cities) and the human-based transportation. In fact, this study aims to design a Human-Based Smart Transportation pattern to achieve a sustainable and livable intelligent city.

The results of the study indicate that development of Human-Based Smart Transportation is achievable and can help smart cities become more sustainable. In the meantime, the formation of this type of transportation needs patterns that make it possible to theorize and provide its operational basis. Accordingly, using library and field studies, the research has developed an early conceptual pattern for the implementation of Human-Based Smart Transportation, helping managers and researchers achieve this type of transportation.

In order to achieve this goal, Delphi method was performed to determine the relationship among research variables. In the next step, the key indicators of each of these variables are extracted, including six key indicators for human-based transportation and six important indicators for urban smart transport.

In the next step, Structural-Interpretive model (ISM) was used to analyze the relationships among indicators defining Human-Based Smart Transportation. The results of the pattern classify the indices related to this type of transportation, and

using MICMAC software, the severity of impact among these indices is investigated. Finally, considering all these dimensions, the research final pattern for human-based intelligent transport has been extracted.

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Desenvolvendo um padrão de Transporte Inteligente Centrado no Humano (HBST), com ênfase em dois conceitos: Transporte Inteligente e Transporte Centrado no Humano

RESUMO

Os sistemas de transporte urbano são fundamentais para os desafios contemporâneos da sustentabilidade, pois a rápida urbanização e a dependência de carros particulares intensificam o congestionamento, o consumo de energia, as emissões e os impactos na saúde pública. Embora o transporte inteligente melhore a eficiência por meio das TIC e da gestão inteligente, ele pode negligenciar o bem-estar humano e a equidade; por outro lado, o transporte centrado no ser humano apoia modos ativos e a interação social, mas frequentemente carece de integração operacional escalável. Este estudo visa formular um modelo de Transporte Inteligente Centrado no Ser Humano (TICS) que sintetize esses paradigmas no contexto das cidades inteligentes e esclareça os pontos de alavancagem que possibilitam uma transição para a mobilidade sustentável e habitável. Metodologicamente, os indicadores foram compilados por meio de revisão documental e pesquisa de campo direcionada, validados por um painel Delphi, estruturados utilizando a Modelagem Estrutural Interpretativa (MEI) e avaliados pela análise MICMAC para determinar o poder de condução e dependência. Os resultados revelam 12 indicadores-chave do HBST e mostram que “utilizar tecnologias modernas”, “utilizar Tecnologias de Informação e Comunicação” e “viabilidade” operam como os principais impulsionadores sistêmicos, enquanto “aumentar a produtividade”, “promover a segurança e a sustentabilidade” e “aumentar o conforto” são os resultados mais dependentes. O padrão HBST resultante operacionaliza a ligação direta entre transporte inteligente e cidade inteligente, bem como os caminhos indiretos pelos quais o transporte baseado em pessoas se integra à governança da cidade inteligente. Consequentemente, o modelo fornece uma base prática para que os gestores urbanos sequenciem intervenções, desde tecnologias habilitadoras e viabilidade institucional até ganhos mensuráveis em sustentabilidade e qualidade de vida.

PALAVRAS-CHAVE: Cidade Inteligente. Transporte Inteligente. Transporte Centrado no Ser Humano. Transporte Inteligente Centrado no Ser Humano.

REFERENCES

ABOUDINA, A.; ABDULHAI, B. A bi-level distributed approach for optimizing time-dependent congestion pricing in large networks: a simulation-based case study in the Greater Toronto Area. **Transportation Research Part C: Emerging Technologies**, v. 85, p. 684–710, 2017.

AFANDIZADEH, S.; RAHIMI, A. M. **Transportation engineering: planning and design.** Iran: University of Science and Technology, 2009.

ALEXANDER, D. W.; TOMALTY, R. Smart Growth and Sustainable Development: challenges, solutions and policy directions. **EconomicsPublished**, 2002. DOI: 10.1080/1354983022000027578.

ALLEN, J. C.; VOGT, R. J.; CORDES, S. The dynamics of community life in rural Nebraska. **Publications from the Center for Applied Rural Innovation (CARI)**, Paper 31, 2001.

AMIRZODI, T. Sustainable urban transport management and ITS strategies. International Journal of Business, **Human and Social Sciences**, v. 5, n. 5, 2012.

AN, S.; LEE, B. H.; SHIN, D. R. A survey of intelligent transportation systems. In: INTERNATIONAL CONFERENCE ON COMPUTATIONAL INTELLIGENCE, COMMUNICATION SYSTEMS AND NETWORKS (CICSyn), 3., 2011. **Proceedings** […]. IEEE, 2011. p. 332–337.

BASTANIFAR, S.; SAMETI, M. An inquiry of green tax effect on decreasing of air pollution of Isfahan Products in Isfahan Province. In: **GIAN INTERNATIONAL SYMPOSIUM ; WORKSHOP**. Anais […]. Isfahan: Isfahan University, 2004.

BAUMAN, A. E.; BULL, F. C. **Environmental correlates of physical activity and walking in adults and children:** a review of reviews. London: National Institute of Health and Clinical Excellence, 2007.

BILODEAU, V. P. **Intelligent parking technology adoption.** Administrative Sciences Association of Canada, 2010. p. 1-222.

CANTILLO, V.; ARELLANA, J.; ROLONG, M. Modelling pedestrian crossing behaviour in urban roads: a latent variable approach. **Transportation Research Part F: Traffic Psychology and Behaviour**, v. 32, p. 56-67, 2015.

CATS, O. Identifying human mobility patterns using smart card data. **Transport Reviews**, v. 44, n. 1, p. 213–243, 2024. DOI: 10.1080/01441647.2023.2251688.

CHANDRAPPA, R.; KULSHRESTHA, U. C. Sustainable air pollution management in transportation sector. **Switzerland: Springer International Publishing**, 2016. (Environmental Science and Engineering). DOI: 10.1007/978-3-319-21596-9_6.

CHENG, H. Y.; HUANG, C. W.; HWANG, J. N. Advanced formation and delivery of traffic information in intelligent transportation systems. **Expert Systems with Applications**, v. 39, p. 8356–8368, 2012.

CHERRETT, T. et al. Logistics impacts of student online shopping – evaluating delivery consolidation to halls of residence. **Transportation Research Part C: Emerging Technologies**, v. 78, p. 111–128, 2017.

CHMIEL, W. et al. INSIGMA: An intelligent transportation system for urban mobility enhancement. **Multimedia Tools and Applications**, 2016. DOI: 10.1007/s11042-016-3367-5.

CHOURABI, H. et al. Understanding smart Cities: An integrative framework. In: **HAWAII INTERNATIONAL CONFERENCE ON SYSTEM SCIENCE (HICSS)**, 45., 2012. Proceedings [...]. 2012.

COLLDAHL, C.; FREY, S.; KELEMEN, J. **Smart cities:** Strategic sustainable development for an urban world. Karlskrona: School of Engineering Blekinge Institute of Technology, 2013.

COWAN, R. **The dictionary of urbanism.** [S.l.]: Streetwise Press, 2005.

EBOLI, L.; MAZULLA, G. Performance indicators for an objective measure of public transport service quality. **European Transport/Trasporti Europei**, v. 51, p. 7-16, 2012.

EREMIA, M.; TOMA, L.; SANDULEAC, M. The Smart City Concept in the 21st Century. In: **INTERNATIONAL CONFERENCE INTERDISCIPLINARITY IN ENGINEERING (INTER-ENG)**, 10., 2016. Proceedings [...]. 2016.

FAKHIMI, M. M.; HUGHES, A.; GUSTAVSON, A. M. Human-centered design for smart home technologies: a framework for aging and mental health. **Frontiers in Digital Health**, v. 7, 2025. DOI: 10.3389/fdgth.2025.1555569.

FARAJI, S. J.; JAFARI NOZAR, M.; ARASH, M. The analysis of smart governance scenarios of the urban culture in multicultural cities based on two concepts of cultural intelligence and smart governance. **GeoJournal**, 2019. Available at: https://doi.org/10.1007/s10708-019-10074-6.

FOURIE, P. J. et al. Modeling and design of smart mobility systems. In: **Urban systems design**. [S.l.]: Elsevier, 2020. p. 163–197. DOI: 10.1016/B978-0-12-816055-8.00006-3.

GALL, T. et al. Re-defining the system boundaries of human-centred design. **Proceedings of the Design Society**, v. 1, p. 2521–2530, 2021. DOI: 10.1017/pds.2021.513.

GALYCHYN, O.; USTUNDAG, K. Organic urbanism: Human-oriented design for metropolisies. In: **INTERNATIONAL CONFERENCE-GREEN URBANISM (GU)**, 2017. Anais [...]. 2017.

GANIN, A. A. et al. Resilience in Intelligent Transportation Systems (ITS). **Transportation Research Journal, Part C**, v. 100, p. 318-329, 2019. DOI: 10.1016/j.trc.2019.01.014.

GIFFINGER, R. et al. **Smart Cities:** Ranking of European medium-sized cities. Vienna: Centre of Regional Science (SRF), 2007. Available at: http://www.smart-cities.eu/download/smart_cities_final_report.pdf.

HANDY, S.; XING, Y. Factors correlated with bicycle commuting: A study in six small US cities. **International Journal of Sustainable Transportation**, v. 5, p. 91–110, 2011.

HSU, T. P. Development Concept of Human Oriented Traffic and Greenly Traffic. **Urban Traffic**, v. 18, n. 3, p. 41-52, 2003.

IEA. **Policies and measures database**. Paris: International Energy Agency, 2012.

INTELLIGENT TRANSPORT SYSTEM. **European Commission**, 2014. Available at: http://ec.europa.eu/transport/themes/its/index_en.htm.

JIANWEI, H.; ZHENXIANG, Z.; ZHIHENG, L. Benefit evaluation framework of intelligent transportation systems. **Journal of Transportation System Engineering and Information Technology**, v. 10, n. 1, 2010.

JIMENEZ, J. A. Smart transportation systems. In: MCCLELLAN, S. et al. (eds.). **Smart Cities.** Switzerland: Springer International Publishing AG, 2018. DOI: 10.1007/978-3-319-59381-4_8.

KANG, E. et al. Introducing autonomous shuttle services based on travel patterns for the elderly. **Journal of Advanced Transportation**, v. 2023, n. 1, 2023. DOI: 10.1155/2023/2206625.

KELLY BLUE BOOK. **New car transaction prices up 2 percent**. 2016. Available at: http://mediaroom.kbb.com/new-car-transaction-prices-up-2-percent-March-2016.

KOGAN, N. **Exploratory research on success factors and challenges of Smart City Projects.** Kyung Hee University: Department of Business Administration, 2014.

KOTUR, M.; RADOVIĆ, V. Importance of safe smart airports as a decisive subsystem of the smart cities. In: **URBANA BEZBEDNOST I URBANI RAZVOJ** (Globalizacija, urbani razvij i transformacija gradova). Zbornik radova [...]. 2024. p. 261-270.

LITMAN, T. **Evaluating public transit benefits and costs.** Victoria: Victoria Transport Policy Institute, 2015.

LITMAN, T. **Evaluating criticism of smart growth.** Victoria: Victoria Transport Policy Institute, 2005. Available at: www.vtpi.org.

MADAKAM, S.; RAMASWAMY, R. Smart Cities - Six Dimensions (A Scholarstical Articles Review). In: INTERNATIONAL CONFERENCE ON ADVANCES IN COMPUTING AND INFORMATION TECHNOLOGY (ACIT). **Proceedings [...].** 2014. DOI: 10.3850/978-981-07-8859-9_09.

MAITI, S.; WINTER, S.; KULIK, L. A conceptualization of vehicle platoons and platoon operations. **Transportation Research Part C: Emerging Technologies**, v. 80, p. 1–19, 2017.

MILES, C. J.; CHEN, K. **The intelligent transport system handbook.** UK: [s.n.], 2004. p. 34-38.

MIROVIĆ, V. et al. Smart Mobility in Smart Cities. **JTTTP - Journal of Traffic and Transport Theory and Practice**, 2024. DOI: 10.7251/JTTTP2402083M.

MITCHELL, D.; CLARIS, S.; EDGE, D. Human-centered mobility: A new approach to designing and improving our urban transport infrastructure. **Engineering**, v. 2, n. 1, p. 33–36, 2016. DOI: 10.1016/J.ENG.2016.01.030.

MODARELLI, G.; SADRAEI, R.; RAINERO, C. How to perceive sustainable moving and smart mobility today? **Journal of Cleaner Production**, v. 468, 2024. DOI: 10.1016/j.jclepro.2024.143121.

NAM, D. H.; DREW, D. R. Automatic measurement of trace variables for intelligent transportation systems applications. **Transportation Research Part B**, v. 33, p. 437-457, 1999.

NAM, T.; PARDO, T. Conceptualizing smart city with dimensions of technology, people and institutions. In: ANNUAL INTERNATIONAL CONFERENCE ON DIGITAL GOVERNMENT RESEARCH, 12., 2011. **Proceedings [...]**. 2011.

NEALER, R.; REICHMUTH, D.; ANAIR, D. **Cleaner cars from cradle to grave. Union of Concerned Scientists**, 2015. Available at: http://www.ucsusa.org/clean-vehicles/electric-vehicles/life-cycleev-emissions.

NGUYEN, M. P. et al. Recent progress towards smart transportation systems using triboelectric nanogenerators. **Journal of Physics: Energy**, v. 6, n. 2, 2024. DOI: 10.1088/2515-7655/ad307e.

NIKITAS, A. et al. Artificial intelligence, transport and the smart city: Definitions and dimensions of a new mobility era. **Sustainability**, v. 12, n. 7, p. 2789, 2020. DOI: 10.3390/su12072789.

OECD. **Moving freight with better trucks – summary documen**t. Paris: Transport Research Centre of the OECD, 2010.

PARIZI, S. M.; KAZEMINIYA, A. Evaluation of Human-Oriented Transport in City Hall Transportation Projects Approach to Sustainable Case Study of the Kerman City Hall. **Journal of Building Construction and Planning Research**, v. 3, n. 3, p. 149, 2015.

PASQUALE, C. et al. A multi-class model-based control scheme for reducing congestion and emissions in freeway networks. **Transportation Research Part C: Emerging Technologies**, v. 80, p. 384–408, 2017.

POPHAM, K. BENEFITS: The smart city business case for transportation electrification. In: MCCLELLAN, S. et al. (eds.). **Smart Cities**. Switzerland: Springer International Publishing AG, 2018. DOI: 10.1007/978-3-319-59381-4_7.

PROKOPENKO, O. et al. Sustainable logistics and passenger transport in smart cities. **Acta Logistica (AL)**, v. 11, n. 1, 2024. DOI: 10.22306/al.v11i1.448.

PUCHER, J.; BUEHLER, R. Cycling to work in 90 large American cities: New evidence on the role of bike paths and lanes. **Transportation**, v. 39, p. 409–432, 2012.

PUCHER, J.; DIJKSTRA, L. Making walking and cycling safer – Lessons from Europe. **Journal of Scientific Research**, v. 4, n. 3, 2010.

QUEZADA, L. E. Method for identifying strategic objectives in strategy maps. **International Journal of Production Economics**, v. 122, p. 492–500, 2009.

REZENDE, D. A.; ALMEIDA, G. G. F.; FUMAGALLI, L. A. W. Strategic digital city: Multiple projects for sustainable urban management. **Sustainability**, v. 16, n. 5450, 2024. DOI: 10.3390/su16135450.

REZENDE, D. A. et al. Sustainable city strategies for strategic digital city project in the sustainable development goals (SDGs) context. **Land**, v. 14, n. 1195, 2025. DOI: 10.3390/land14061195.

REZENDE, D. A. Strategic digital city: Concept, model, and research cases. **Journal of Infrastructure, Policy and Development**, v. 7, n. 2, p. 1–2177, 2023. DOI: 10.24294/jipd.v7i2.2177.

RODRIGUE, J. P.; COMOTIS, C.; SLAK, B. **Urban transportation. The Geography of Transport Systems**, p. 171-203, 2006.

SANTIS, R. et al. **Smart city:** fact and fiction. Munich: MPRA, Munich Personal RePEc Archive, 2014.

SARAVANAN, M.; KUMAR, P. S. Dhum: A dynamic human urban mobility model for smart public transport. In: INTERNATIONAL CONFERENCE ON MULTIDISCIPLINARY SOCIAL NETWORKS RESEARCH. **Proceedings […].** Singapore: Springer, 2019. p. 29–42.

SHI, L.; WU, L. Mobile Internet+ Campus Bicycle Sharing System Planning. In: WANG, W. et al. (eds.). **Green Intelligent Transportation Systems.** Singapore: Springer, 2018. DOI: 10.1007/978-981-10-3551-7_63.

TE PAI, J. A fuzzy-MCDM evaluation framework based on humanity-oriented transport for transforming scheme of major arterial space in Taipei metropolitan. **Journal of the Eastern Asia Society for Transportation Studies**, v. 7, p. 1731-1744, 2007.

TIBBALDS, F. (ed.). **Making people-friendly towns:** Improving the public environment in towns and cities. [S.l.]: Taylor ; Francis, 2012.

TOPPETA, D. **The smart city vision: How innovation and ICT can build smart, liveable, Sustainable Cities.** 2010. Available at: http://www.thinkinnovation.org/en/portfol/the-smart-city-vision.

TRANSPORTATION RESEARCH BOARD. **Transit Capacity and Quality of Service Manual.** Washington DC: National Research Council, 2013.

TSENKOVA, S.; MAHALEK, D. The impact of planning policies on bicycle-transit integration in Calgary. **Urban, Planning and Transport Research**, v. 2, n. 1, p. 126–146, 2014. DOI: 10.1080/21650020.2014.906910.

U.S. DEPARTMENT OF TRANSPORTATION. **National transportation statistics. 2017**. Available at: https://www.rita.dot.gov/bts/data_and_statistics/index.html.

UN-HABITAT. **United Nations Human Settlements Programme**. 2017. Available at: http://www.unhabitat.org/.

UNITED NATIONS. **World urbanization prospects: the 2014 revision, highlights.** New York: Department of Economic and Social Affairs, 2014.

US ENVIRONMENTAL PROTECTION AGENCY. **Greenhouse Gas Emissions.** 2017. Available at: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

VELLEMAN, J. D. Deciding how to decide. In: CULITY, G.; GAULT, B. **Ethics and practical reason.** Oxford: Oxford University Press, 1997. p. 29-52.

WARD'S AUTOMOTIVE GROUP. **Vehicles in operation by country**. 2010.

WARFIELD, J. W. Developing interconnected matrices in structural modelling. **IEEE Transactions on Systems Men and Cybernetics**, v. 4, n. 1, p. 51-81, 1974.

WEI, Z.; ZHAO, P.; SHULIN, A. Efficiency evaluation of Beijing intelligent traffic management system based on super-DEA. **Journal of Transportation Systems Engineering and Information Technology**, v. 12, n. 3, 2012.

WORLD ECONOMIC FORUM. **Repowering Transport. 2011**. Available at: http://www3.weforum.org/docs/WEF_RepoweringTransport_ProjectWhitePaper.

XU, Y. Research on Urban Transportation Planning and Optimization Based on the Concept of Smart City. **Advances in Economics, Management and Political Sciences**, v. 148, p. 157-163, 2025. DOI: 10.54254/2754-1169/2024.LD19186.

XYLIA, M. et al. Locating charging infrastructure for electric buses in Stockholm. **Transportation Research Part C: Emerging Technologies**, v. 78, p. 183–200, 2017.

YANG, H.; RAKHA, H. Feedback control speed harmonization algorithm: methodology and preliminary testing. **Transportation Research Part C: Emerging Technologies**, v. 81, p. 209–226, 2017.

ZHANG, Q. et al. Mobility knowledge graph: review and its application in public transport. **Transportation**, v. 52, n. 3, p. 1119–1145, 2025. DOI: 10.1007/s11116-023-10451-8.

ZHAO, C. et al. Decentralized autonomous operations and organizations in transverse: Federated intelligence for smart mobility. **IEEE Transactions on Systems, Man, and Cybernetics: Systems**, v. 53, n. 4, p. 2062–2072, 2023. DOI: 10.1109/TSMC.2022.3228914.

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