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MUHAMMADAMIN KABULOVICH TOHIROVNING TAVALLUDINING 80 YILLIGIGA BAG‘ISHLANGAN "SAMARALI QURILISH MATERIALLARI, KONSTRUKSIYALARI VA TEXNOLOGIYALARI" MAVZUSIDAGI XALQARO ILMIY-AMALIY KONFERENSIYASI ILMIY ISHLARI TO‘PLAMI

Toshkent davlat transport universiteti Rossiya Arxitektura va qurilish fanlari akademiyasining akademigi, O‘zbekiston Respublikasida xizmat ko‘rsatgan yoshlar murabbiysi, texnika fanlari doktori, professor **Muhammadamin Kabulovich Tohirovning tavalludining 80 yilligiga** bag‘ishlangan **"Samarali qurilish materiallari, konstruksiyalari va texnologiyalari"** mavzusidagi xalqaro ilmiy-amaliy konferensiya ilmiy ishlari to‘plami chop etildi.

Muhammadamin Kabulovich kompozitsion qurilish materiallarining polistrukturaviy nazariyasini rivojlantirishga ulkan hissa qo‘shgan olimdir. 1995-yilda Muhammadamin Kabulovich Rossiya Arxitektura va qurilish fanlari akademiyasining (RAASN) xorijiy a’zosi etib saylangan, bu esa ularning qurilish materialshunosligi sohasiga qo‘shgan ilmiy hissasining xalqaro miqyosdagi e’tirofi bo‘ldi. Ular o‘z ilmiy faoliyati davomida 6 ta monografiya, 200 dan ortiq ilmiy maqola va 25 ta ixtiroga mualliflik guvohnomasi yaratganlar.

Ushbu konferensiyaning asosiy maqsadi – qurilish materialshunosligi, bino va inshootlarni loyihalash hamda qurilish sohasidagi zamonaviy ilmiy tadqiqotlar natijalarini muhokama qilish, shuningdek, muhandislik ta’limini takomillashtirish yo‘llarini aniqlashdir.

Konferensiyada O‘zbekiston Respublikasi hamda xorijiy mamlakatlarning oliy o‘quv yurtlari va ilmiy-tadqiqot institutlari olimlari, shuningdek, muhim ilmiy tadqiqot natijalariga ega bo‘lgan ishlab chiqarish vakillari o‘z ilmiy ishlari bilan ishtirok etdilar.

"Samarali qurilish materiallari, konstruksiyalari va texnologiyalari" mavzusidagi xalqaro ilmiy-amaliy konferensiyaning asosiy yo‘nalishlari quyidagilardan iborat:

1. **Resurs va quvvatni tejaydigan qurilish materiallari va texnologiyalari** – zamonaviy ekologik va iqtisodiy talablarni qondirishga qaratilgan innovatsion yechimlar.
2. **Bino va inshootlarning qurilish konstruksiyalari, zamonaviy hisoblash va loyihalash usullari - muhandislik** va texnologik yechimlarni takomillashtirish yo‘nalishlari.
3. **Arxitektura va shaharsozlik** – estetik va funksional jihatlarni uyg‘unlashtirgan zamonaviy loyihalar yaratish.
4. **Zamonaviy muhandislik ta’limi tizimini takomillashtirish** – kelajak mutaxassislarini yuqori malakali darajada tayyorlash uchun ta’lim jarayonini modernizatsiya qilish.

Mazkur konferensiya ilmiy hamjamiyatning turli vakillarini bir joyga jamlab, qurilish materialshunosligi sohasidagi zamonaviy muammolar va istiqbollarni muhokama qilish uchun qulay platforma vazifasini bajardi.

Transport route efficiency optimization: a new perspective integrating sustainable development and economic benefits

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Abstract: Traditional assessments of transportation route efficiency often prioritize direct economic factors, neglecting crucial environmental and social sustainability dimensions. This research integrates the core concepts of sustainable transportation - spanning environmental, social, and economic pillars - and proposes novel qualitative frameworks to evaluate economic efficiency more holistically. The aim is to provide a more comprehensive basis for optimizing transportation routes, fostering decisions that better balance operational effectiveness with long-term sustainability goals.

Keywords: Sustainable Transportation, Economic Efficiency, Qualitative Assessment

1. Introduction

Transportation systems are the veins of contemporary economies and societies, enabling the carriage of goods, enabling personal travel, and bringing people to the services they need. The stability of these corridors has a significant impact on economic productivity, supply chain efficiency, and overall welfare. Current paradigms for transportation, typically designed with first priority on velocity and the eschewal of direct operational costs, increasingly find themselves confronted with inherent limitations. These come in the shape of chronic bottlenecks to productivity like congestion, along with major negative spillovers in the shape of greenhouse gas emissions, neighbourhood air and noise pollution, and high consumption of exhaustible energy resources. The standard model ignores the broader, long-term environmental and community welfare consequences.

This is a challenging task for planners, logisticians, and policy makers alike: It is important maximize transportation route efficiency beyond conventional metrics, as gains accrue to environmental protection, social equity, and sustainable economic resilience.

The growth of the world's population, increasing life expectancy, increasing consumption and production volumes, investment in the development of infrastructure that ensures the movement of goods from producers to consumers leads to the expansion of the transport and logistics services market. The size of the freight and logistics transportation market in 2024 was estimated at US$ 6.03 trillion and is expected to reach US$ 7.54 trillion by 2029, with a CAGR of 4.57% during the forecast period 2024-2029.Optimizing for time or fuel price alone is no longer sufficient in the presence of high-stakes global sustainability imperatives and mounting societal pressures.

There must be a paradigm change, toward a more integrated and holistic frame of reference for what constitutes an "efficient" transportation corridor within a sustainable development paradigm.

Therefore, the primary aim of this research is to bridge this gap by exploring the complex concept of sustainable transport. It will first explore the essential components and distinctive dimensions – environmental, social, and economic – that make up sustainable mobility. Based on this theory, the research will subsequently outline and discuss new conceptual frameworks and qualitative indicators specially created to measure the economic efficiency of transportation routes from an overall, sustainability-based perspective. By outlining this theoretical model, the research aims to provide helpful analytical tools and support for enhancing transportation routes so that in fact makes amends between short-term operational effectiveness and longer-term environmental accountability and social benefit.

2. Research methodology

Sustainable transport is, by definition, marked by its capacity to meet the mobility needs of the present generation without compromising future generations' ability to meet their own needs. The concept goes beyond traditional efficiency measures to a fundamental balance and integrated development on three interdependent axes: the environment, social, and economics [1, 2]. Achieving truly sustainable transport modes calls for systems thinking that accommodates the essential complexity and interdependencies involved.

This operationalization typically involves building and analyzing indicators which capture performance by these pillars of sustainability so comparative judgments and policy recommendations can be formulated [4].

The above research agenda addresses refining these ideas and charting realistic paths toward sustainable mobility transition [5].

Environmental sustainability

The primary goal of environmental sustainability of transport is decreasing the negative influence of mobility activity on the nature environment [6, 7]. This means addressing some of the most sensitive factors:

Greenhouse Gas (GHG) Emissions: Reducing the carbon footprint of transport is critical. Solutions include promoting the use of clean energy vehicles (electric, hydrogen), route optimization to minimize travel distances, improving logistics to optimize load factors, and freight transfer to lower-emission modes [3,7].

Air Pollutant Emissions: Transport is one of the key sources of on-road air pollutants like nitrogen oxides (NOx) and particulate matter (PM2.5), which deteriorate human health and ecosystems. Their mitigation includes equipping vehicles with state-of-the-art emission control technologies

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and routing or using traffic management systems that divert from heavily congested areas [7, 8].

Noise Pollution: Traffic noise negatively impacts quality of life, particularly in cities. To sustainably direct traffic is to stay away from noise-sensitive areas (residential areas, schools, hospitals) wherever possible or else to apply noise reduction technologies, such as the use of quieter vehicle technology and surfacing [8].

Energy Consumption: Reducing the reliance on fossil fuels and increasing overall energy efficiency are critical. This can be achieved by technology improvements in vehicle efficiency, promoting energy-saving driving practices, and inducing modal changes to less energy-intensive modes like public transport and rail freight, including the development of efficient multimodal systems [7].

Land Use Efficiency: Much of the land space is occupied by transportation infrastructure. Green strategies involve minimizing the plan and design of roads, railways, and terminals to minimize habitat fragmentation and overall footprint on precious ecosystems and agricultural lands [8].

Social Sustainability

Social sustainability seeks to make transport systems equitable, safe, accessible, and promote healthy results for all the members of society [8]. The key components involve:

Equity: Transport systems must provide equal access to mobility options for everyone regardless of income, place, age, or physical capacity. Route planning and service design must prioritize extensive coverage of services and affordability to prevent social exclusion [9, 10].

Safety: Minimizing the potential for accidents and maximizing traveler safety is a critical consideration. Planning routes must consider factors such as road design quality, history of accidents on the road, traffic flow, and adequate lighting, particularly for vulnerable road users [8].

Accessibility: Transportation should facilitate simple access to such essential locations as employment centers, schools, health centers, and social facilities. Quality routes effectively connect origins and destinations, reducing travel effort and time [9].

Health Impacts: In addition to safety, transport choices affect public health by exposing individuals to air and noise pollution. Sustainable transport planning aims to reduce these exposures and actively encourages active modes of travel like walking and cycling, often integrated with public transport journeys, which have physical health co-benefits [9, 10].

Community Impacts: Transport infrastructure and routes can physically isolate communities or cause local disturbance. Socially sustainable planning seeks to minimize such negative impacts, so routes integrate well with existing community structure and enhance, rather than degrade, local quality of life [9].

Economic Sustainability

Economic sustainability ensures that transport systems are economically sustainable, efficient, and beneficial to long-term economic growth [7, 8]. This dimension includes:

Operational Efficiency: This involves optimizing the utilization of transport assets. Key initiatives involve reducing journey times, reducing deadheading (empty running), improving turnaround time for vehicles, and asset utilization optimization [7].

Cost-Effectiveness: Achieving an optimal balance between the cost (inputs) and the output benefits of transport services is crucial. This involves managing direct operating costs like fuel, labor, and maintenance, along with considering indirect costs like congestion, delay, and environmental externalities [8].

Infrastructure Investment Return: Investments in transportation infrastructure (roads, bridges, ports, railroads) have to yield dividends in the form of long-term economic and social returns to counterbalance the cost of initial investment and maintenance [8].

Facilitating Economic Activity: Efficient transportation systems are essential to economic prosperity, enabling goods to move from production hubs to markets and employees to travel to jobs [7].

System Resilience: Economic sustainability also concerns whether the transport system is capable of surviving and recovering from disturbances, e.g., extreme weather conditions, accidents, infrastructure failures, or unexpected changes in demand, so that service continuity is assured [10].

Interrelation of the three pillars

Notably, these three pillars – environmental, social, and economic – are not separate fields but are thoroughly interrelated and interdependent [7, 8]. Actions to increase performance in one of the metrics have a synergistic or counteractive effect in the other metrics. A case in point is investing in fuel-efficient vehicles or optimizing routes in order to save miles, which increases economic cost-effectiveness immediately by reducing environmental emissions. Similarly, improving access to public transport (a social goal) can lead to reduced reliance on private vehicles, delivering environmental benefits (reduced pollution, less congestion) and potentially economic ones (reduced infrastructure burden, lower household travel expenditure). However, achieving true sustainability often involves breaking through intrinsic dilemmas and trade-offs, where cost reduction in one aspect may compromise another, necessitating sensitive balancing and combined policy action [11].

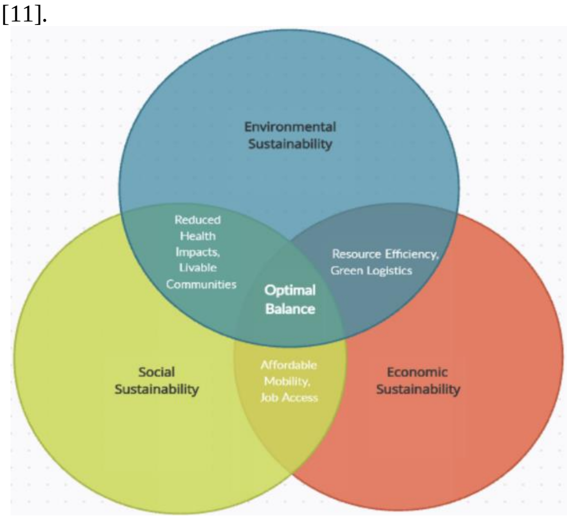

Figure 1. The three interlocking pillars of sustainable transportation

Therefore, determining transportation route efficiency from a genuinely sustainable perspective necessitates a complete analysis that consciously addresses and compares performance in all three dimensions.

3. Results and discussion

Whilst traditional economic efficiency assessments, generally founded on measures such as cost per tonnekilometer or transit time, provide valuable operational data, they all too frequently omit the complete view required of a sustainable transport system [7]. These conventional methodologies tend to center on readily quantifiable direct costs but struggle with internalizing high environmental externalities, e.g., GHG emissions, noise and air pollution, or biodiversity impacts, which are central determinants of environmental sustainability [6, 8]. Similarly, social considerations of equity, access, safety, and public welfare, although instrumental for social acceptability and ultimate success [9, 10], are often omitted or insufficiently treated in purely monetary calculations. This limited focus can lead to economically optimal short-term route decisions that result in high levels of hidden costs or in the neglect of longer-term viability factors such as system resilience [7].

To overcome these limitations involves a shift towards more integrated methods of evaluation that embrace the tenets of sustainable development [1, 2]. It is then necessary to bring in qualitative or semi-quantitative evaluation frameworks to bring in the considerations that are difficult to price but are crucial to all-around decision-making [4, 5]. Such frameworks allow systematic consideration of environmental and social performance alongside traditional economic metrics, towards a more balanced and strategically sound basis for comparing and evaluating transport route options, especially in the process of negotiating the inherent complexities and trade-offs between rival sustainability objectives [11].

This section proposes four conceptual frameworks that are designed to enable such a qualitative assessment of economic efficiency within a sustainability context. These are not for precise numerical computation but as systematic instruments for comparative analysis and strategic appraisal.

Conceptual frameworks for qualitative assessment

Integrated Value Efficiency Index(IVEI):

To quantify a route's total "value efficiency" by considering its positive contributions in relation to its total costs and risks, looking beyond direct operating costs.

Conceptual Formula:

IVEI=(Economic Output Promotion+Social Benefit Contribution)/(Direct Operational Cost+Environmental Impact Factor+Social Risk Factor)

Component Explanation:

Economic Output Promotion: Qualitatively measures the effectiveness of the route in stimulating trade, connecting production and consumption centers, and facilitating economic activity [7].

Social Benefit Contribution: Measures the contribution of the route towards enhancing accessibility, offering service equity between populations, and connecting communities [9, 10].

Direct Operational Cost: The traditional measurable costs (fuel, labor, maintenance) [7, 8].

Environmental Impact Factor: Qualitative or scored indicator based on the estimated GHG emissions of the route, intensities of pollution at location, energy demand profile, and ecological sensitivity effect [6, 7, 8]. (e.g., High/Medium/Low impact score).

Social Risk Factor: Records potential negative social impact, including risk to safety (accident frequency, security risk) and other negative community effect (noise, fragmentation) due to the route [8, 9]. (e.g., High/Medium/Low risk score).

Meaning: A higher IVEI suggests that a route is offering higher overall value compared to its inclusive costs and risks in the sustainable transport system.

Route Resilience and Adaptability Coefficient (RRAC)

To measure specifically the economic effect of how well a route can still operate and recover from disruption, a significant problem with long-term economic sustainability [7, 10].

Conceptual Formula

RRAC=(Alternative Availability×Disruption Recovery Speed)/(Vulnerability Exposure)

Component explanation:

Alternative Availability: Qualitatively assesses the availability and practicability of alternative routes or modes in case of disruption of the primary route [10]. (e.g., Multiple/Few/No good alternatives).

Disruption Recovery Speed: Estimate (based on historical data or from the evaluation of an expert) of how quickly normal operation can be regained after typical interruptions (e.g., accidents, congestion, weather) [10]. (e.g., Fast/Moderate/Slow recovery).

Vulnerability Exposure: Refers to the frequency with which the route is exposed to noted threats like usual congestion points, accident hot spots, adverse weather patterns, or infra-structure bottlenecks [8]. (e.g., High/Medium/Low exposure).

Interpretation: The greater the RRAC, the lower the chance of extended operational breakdown, thereby its input into extended economic activity in a more secure manner.

Route Synergy Utilisation Rate (RSUR)

To quantify the level of coordination and performance while utilizing various resources (vehicles, infrastructure, energy, information) along the route beyond just load factors.

Conceptual Formula:

RSUR=(Vehicle Cycle Efficiency×Energy Matching Degree×Information Sharing Level)/(Empty Haulage and Waiting Time Factor)

Component explanation:

Vehicle Cycle Efficiency: Numerically estimates the speed and smoothness at which the vehicles complete their transport task and are available for the next one [7]. (e.g., High/Medium/Low efficiency).

Energy Matching Degree: Estimates how well the used source of energy (e.g., diesel, electric, LNG) fits the route conditions, distance, and cargo type for greatest efficiency and least impact upon the environment [6, 7]. (e.g., Excellent/Good/Fair/Poor match).

Information Sharing Level: Measures the quality and extent of sharing of information between the various stakeholders (carriers, shippers, infrastructure managers) on route planning, real-time conditions, and cargo tracking [1]. (e.g., High/Medium/Low level).

Empty Haulage and Waiting Time Factor: A qualitative measure of the proportion of unproductive distance and time, including empty backhauls and node waiting times (warehouses, ports) [7]. (e.g., High/Medium/Low occurrence, best being Low).

Interpretation: The higher the RSUR, the more intelligent resource utilization, the less wastage, and the stronger underlying economic performance.

Sustainable Service Value-Added Ratio (SSVAR)

To evaluate the non-market environmental and social value added by a transport service route over and above its total cost.

Conceptual Formula:

SSVAR=(Customer Satisfaction Enhancement+Environmental Benefit Score+Social Equity Contribution Score)/(Total Cost of Ownership)

Component explanation:

Customer Satisfaction Improvement: Qualitatively evaluates the value added by superior service quality attributes like reliability, punctuality, safety, and delivery of information, above pure transport function [5]. (e.g., On the basis of surveys or expert view).

Environmental Benefit Measure: A measure of the environmentally positive performance of the route compared with others or benchmarks for emission reduction, energy saving, or biodiversity protection achieved [6, 8]. (e.g., Based on standardized criteria).

Social Equity Contribution Score: Assesses the route's contribution to social goals, e.g., reaching disadvantaged areas, providing accessible alternatives for disadvantaged groups, or improving safety outcomes [9, 10]. (e.g., Rated against pre-defined criteria).

Total Cost of Ownership (TCO): Considers not only direct operating expenses but also longer-term costs such as maintenance, potential environmental cleanup, decommissioning, and risk mitigation costs [8]. (Can be quantitative or qualitative category).

Interpretation: A higher SSVAR indicates that the corridor offers greater environmental and social benefit (sustainability-related value) per unit of total cost, indicating a more economically valuable whole-choice.

Application Considerations

The practical application of these conceptual frameworks (IVEI, RRAC, RSUR, SSVAR) has to be approached with care. In the first instance, since they are highly reliant on qualitative factors, there need to be clear, consistent, and transparent scoring or rating criteria (e.g., what precisely does 'High', 'Medium', or 'Low' mean for every factor) to provide the ability to compare and reduce subjectivity [4]. This will typically consist of context-dependent definitions particular to the particular transport operation or area of investigation.

Secondly, the qualitative nature of many components emphasizes the necessity to apply expert judgment and engage with concerned stakeholders (e.g., logistics managers, environmentalists, community members, customers) when evaluating [1, 11]. Their array of perspectives can provide crucial input to assess aspects like social impact, resilience capacity, or service value and lead to more robust and credible judgments.

Thirdly, these frameworks are best used as comparative tools, rather than as absolute measures of efficiency. Their utility lies in facilitating systematic comparison of different alternatives, analysis of potential improvements to existing alternatives, or tracking shifts in performance over time in relation to sustainability objectives [5]. They help to elicit the relative strengths and weaknesses of alternatives in different dimensions, thereby facilitating more informed and balanced decision-making [11].

While introduced conceptually, application of these frameworks can be significantly enhanced by leveraging available data sources and analytical techniques where possible. Geographic Information Systems (GIS), traffic simulation models, environmental impact assessment data, and operational performance records can provide valuable inputs to inform the qualitative judgments in each framework element. Integrating these frameworks into more broad multi-criteria decision analysis (MCDA) approaches might further structure the evaluation process, especially when confronted with complex trade-offs among competing sustainability objectives.

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4. Conclusion

The necessity to enhance the efficiency of transport corridors while simultaneously addressing pressing environmental and societal challenges demands a shift in paradigm away from conventional economic analysis. This paper has emphasized the limited perspective of conventional approaches that fail to take into account the vital environmental externalities and social equity considerations inherent in transport operations. In returning to first principles of sustainable transport, it reaffirmed the need to embrace environmental stewardship, social well-being, and economic sustainability as interrelated pillars to underpin transport system development and evaluation. The exploration of environmental aspects like emissions and resource use, social aspects like equity and accessibility, and reframed economic aspects like resilience and holistic cost-effectiveness forms the basis for more unified understandings.

Based on this, the article introduced novel qualitative models – Integrated Value Efficiency Index (IVEI), Route Resilience and Adaptability Coefficient (RRAC), Resource Synergy Utilization Rate (RSUR), and Sustainable Service Value-Added Ratio (SSVAR). These conceptual tools are proposed not as substitutes for quantitative data, but as necessary complements to the inclusion of hard-to-monetize sustainability factors in economic efficiency assessment. They provide a structured approach to evaluate routes based on their broader value contribution, risk profile, resource visibility, and alignment to sustainable service goals.

Transport route planning in the 21st century needs this holistic vision. The application of qualitative and integrated appraisal techniques, such as those described, gives decision-makers a more robust and ethically grounded basis for option comparison and investment guidance. Embracing this wider vision of efficiency is necessary to encourage transport systems that are not only operationally efficient but also environmentally sustainable, socially equitable, and economically viable in the long run, and hence contribute positively to overall societal growth and resilience.

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3 section. Architecture and Urban Planning

4 section. Improvement of modern engineering education system

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