# Prioritizing Urban Transport Projects with Sustainable Development Targets: Case Study for MDCs

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**Abstract**: The urban transportation system always faces big issues in densely populated cities with the limitation of land resources. The problems are especially increasing in developing countries with rapid increase in the mobility demand to serve social-economics activities. The existing imbalance between supply and demand, which continues to rapidly expand, has put great pressure on urban people's lives, posing great risks such as traffic jams, environmental pollution, and traffic accidents. The problem is that in those countries, the budget for infrastructure development is rather limited, which requires very much prioritizing measurements in different phases with the prior target, especially in such an urgent time of climate change. This article aims at (i) literature review on sustainable development requirements for transportation system; (ii) establishing the set of criteria for sustainability assessment in MDCs (motorcycle dependent cities); (iii) applying such criteria in prioritizing transportation projects as the case study.

*Keywords*: Urban Transport, Sustainable Development, Sustainable Mobility, Sustainable Transportation

## 1. INTRODUCTION

Urbanization is an inevitable trend in the development process. Cities play the role of an important driving force for the socio-economic development in the country. Living in a city can be culturally and economically beneficial since it can provide greater opportunities for access to the labor market, better education, housing, safety conditions, and reduce the time and expense of commuting and transportation. Conditions like density, proximity, diversity, and marketplace competition are environmental elements that are deemed beneficial. However, there are also harmful social phenomena that arise: alienation, stress, increased cost of living, and mass marginalization that are connected to an urban way of living. Urbanization has recently caused problems and pressure on big cities of more than one million people in Vietnam, such as infrastructure, consumption energy, environment, sanitary, living standards, etc (World Bank Group (2022)). Meanwhile, Vietnam is one of countries estimated to be the most seriously affected by climate change with nearly 60% land area and 70% population affected by natural crisis (Oh J.E., 2019).

Currently, Vietnam cities in general and Hanoi in particular depends a lot on motorcycles, which cover more than 70% traffic demand. Rapid environmental degradation, increasing dangers to pollution exposure and health, and strain on physical infrastructure are all issues that motorcycle dependent cities (MDCs) must deal with. As a result, many MDC inhabitants are seeing a decline in their quality of life. Due to a lack of public open spaces, traffic jams, poor transportation system, air pollution, and insufficient technical and social services, many cities are becoming less livable.

In previous time, Vietnam development planning system consists of such major components of (i) socio-economic development planning (SEDP); (ii) sectoral development planning; (iii) spatial planning under the Construction Law and Urban Planning Law, and (iv) natural resources planning (Law on Urban Planning, 2009). These planning systems are managed and implemented at different levels of nation, region, province and local area. However, such a system cannot work effectively as the complexity of urban immigration and growing environmental pressures cannot be adequately addressed by sector-specific techniques. The limited interdisciplinary interaction and participation of the public and stakeholders has resulted in many conflicts of interest among stakeholders along several dualities: upstream vs downstream, rural vs urban, delta-wide vs national vs local, and long-term vs short-term. In the whole country, there have been many problems and issues in the system of transportation and master plan development.

Urban policymakers are looking for answers in integrated, comprehensive urban planning as a result of the livability problem in MDC. In October 2017, the National Assembly approved a new Law on Planning (2017) which establishes a new system of national plans, regional plans, provincial plans and urban and rural plans, and sets down a number of planning principles. The new system creates the opportunity to develop an integrated spatial plan with the objective to create a comprehensive strategic framework for the entire region, which lays the foundation for the implementation of the investment programs and projects for the development of technical and social infrastructures and for production in a synchronized manner while effectively using the resources to realize the potential of the region in the context of climate change to promote sustainable socio-economic development of the region.

In an integrated approach, which has been supported by numerous local governments, international organizations, and planning experts, (i) land use, mobility, water use, and energy consumption are all managed in a coordinated way across municipal departments; and (ii) government, private sector, and civil society stakeholders collaborate to meet the city's economic objectives. From the perspective of conducting master plans of development, there are several problems and conflicts during the process of establishing different projects of master plans. Therefore, it raises the need for developing and following the integrating planning process to obtain comprehensive and efficient results.

The problem is that in such developing countries as Vietnam, the budget for infrastructure development is rather limited, which requires very much prioritizing measurements in different phases with the prior target, especially in such an urgent time of climate change.

In the last decades, green infrastructure (GI) has become a prominent concept for planners and practitioners worldwide to foster sustainable land-use (Ahern 2007; Mell, 2008; Mazza et al., 2011) and enhance human wellbeing (Tzoulas et al., 2007). Different sets of sustainable criteria have been developed to evaluate the urban development initiatives and options. However, successfully applying such measurements will depend on the different scenarios of the city.

## 2. RESEARCH METHODOLOGY

### 2.1 Basic Structure

In 1980, Saaty proposed the AHP method as a decision support tool. This is considered one of the most popular tools used for decision-making in various fields. Many studies have applied AHP in different fields such as manufacturing, industry, education, engineering, banking, social

sciences, politics, etc. Bich *et al.* (2011). This method is often used to compare and select the optimal option based on the analysis of comparison criteria.
From literature reviews, some researchers have applied Analytic Hierarchy Process (AHP) into evaluating the efficiency of investment project.
Machatis *et al.* (2010) proposed the Multi-Actor Multi-Criteria Analysis (MAMCA) method to evaluate transportation projects. This evaluation method particularly focuses on incorporating both qualitative and quantitative criteria (with their relative importance determined by multiple stakeholders) into a comprehensive evaluation process to facilitate decision-making by various stakeholders. Browne and Ryan (2010) conducted a study to test and compare the use of several policy evaluation tools that can be used to measure the impact of transportation policies and programs.
Phan and Linh (2016) applied GIS and AHP to determine the location of bus rapid transit stops: Vo Van Kiet - Mai Chi Tho route, Ho Chi Minh City. This study applied 13 criteria among three groups and 13 thematic layers. The author then collect data and build up data layers, including six base layers (administrative boundaries, transportation, water systems, bridges, metro routes, and study area boundaries). The data layers were built and stored in GIS shapefile format based on land use planning maps (from Department of Planning and Architecture), urban railway system maps (from Urban Railway Management Board), current Lidar image data (from GIS Application Center), Google Maps, and field surveys.
Chau Bao Ngoc (2018) studied factors influencing the selection of construction materials in sustainable development using the AHP method. This study presented the results of a survey on factors influencing material selection in sustainable construction. The survey was conducted through questionnaires and statistical data analysis. The survey results ranked the factors influencing the selection of construction materials (CEM) for sustainable development. Additionally, using the Exploratory Factor Analysis (EFA) method, the author identified five groups of factors influencing material selection in sustainable construction, related to the environment, cost, technical design, culture, and social factors.
Such research shows that the methodology of AHP is rather useful, especially in case of lacking quantified data for project assessment.
The steps to implement the AHP evaluation process can be described as follows.
Assume we have a decision-making problem (called the goal), based on *k* main factors, with n sub-criteria (sub-factors). There may be *m* options to choose from. The issues of the problem are modeled in Figure 1.

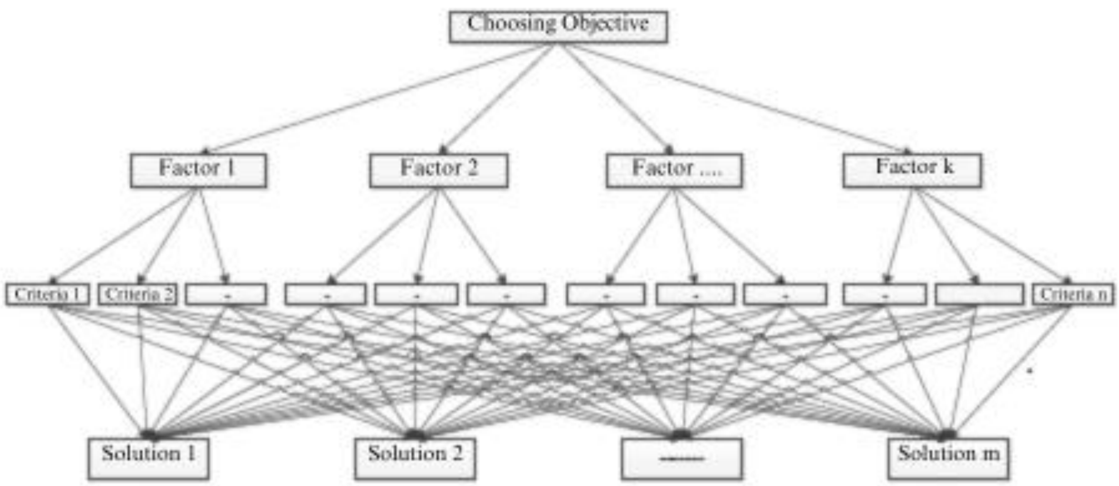

Figure 1. Diagram describing the Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is implemented through the following steps:
Step 1: Identify the problem and the goal to be solved.
Step 2: Build a hierarchical structure model, including
(i) Proposing a system of criteria.
(ii) Identifying important related criteria through expert surveys using questionnaires.
(iii) Building a criteria tree for issues related to the decision-making process for prioritizing investment projects after obtaining survey results on important criteria from experts.
Step 3: Determine the priority level of groups and criteria within groups through expert surveys.
Step 4: Perform pairwise comparisons for groups and criteria within the same group to determine the weight of each criterion, as follows:
A pairwise comparison matrix between groups is built as follows:

Table 1. Pairwise comparison matrix between groups

| | Factor 1 | Factor 2 | Factor … | Factor k |
|---|---|---|---|---|
| Factor 1 | 1 | a12 | … | a1k |
| Factor 2 | a21 | 1 | … | a2k |
| Factor … | … | … | 1 | …. |
| Factor k | ak1 | ak2 | … | 1 |

Table 2. Pairwise evaluation of criteria based on priority level

| **Priority Level** | **Numerical Value** |
|---|---|
| Equal priority | 1 |
| Equal to moderate priority | 2 |
| Moderate priority | 3 |
| Moderate to slightly higher priority | 4 |
| Slightly higher priority | 5 |
| Slightly higher to very high priority | 6 |
| Very high priority | 7 |
| Very high to extremely high priority | 8 |
| Extremely high priority | 9 |

This step includes:
(i) Calculating the weight of each group: by summing the values of the matrix by column, then dividing each value of the matrix by the sum of the corresponding column, and replacing the calculated value with the new value. The weight of each group corresponds to the average of the values across each row. The result is a single-column matrix.
(ii) Determining the consistency of the expert's evaluation throughout the process. The Consistency Ratio (CR) is determined as follows:

$$CR = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (1)$$

Where

- CI: Consistency Index $CI = \frac{\lambda max - n}{n - 1}$

- Λmax: The eigenvalue of the comparison matrix, calculated as follows:

$$\lambda max = \sum_{i=0}^{n} wi * \sum_{j=0}^{n} aij$$

- n: The number of elements are compared in pairs in the calculation, which is the size of the calculation matrix.
- RI: Random Index. RI is determined from a given table (see Table 2 - this table only presents RI values for up to 15 criteria).

Table 3. Random Index corresponding to the number of criteria considered

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

| n | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|
| RI | 1.51 | 1.54 | 1.56 | 1.57 | 1.59 |

In all cases, CR should not exceed 10%. If CR exceeds this level, it indicates inconsistency in the expert's evaluation, and the evaluation and calculation must be redone.
(iii) Similarly, building a pairwise comparison matrix for criteria within the same group.
(iv) Creating a summary table and calculate the weight of each criterion based on the pairwise comparison tables mentioned above, resulting in an n-row and 1-column matrix:

Table 4. Criteria Weight

| Criteria | Criterion 1 | Criterion 2 | … | Criterion n-1 | Criterion n |
|---|---|---|---|---|---|
| Weight Coefficient | C1 | C2 | … | Cn-1 | Cn |

Step 5: Apply AHP to specific proposed options, which means:
- Determining the impact level of the proposed options on each criterion. Perform steps similar to Step 4, resulting in a summary matrix as follows:

Table 5. Table 5. Prioritizing proposed options

| | Criterion 1 | Criterion 2 | … | Criterion n-1 | Criterion n |
|---|---|---|---|---|---|
| Option 1 | x(1.1) | x(1.2) | … | x(1.n-1) | x(1.n) |
| Option 2 | x(2.1) | x(2.2) | … | x(2.n-1) | x(2.n) |
| Option … | … | … | … | … | … |
| Option m | x(m.1) | x(m.2) | … | x(m.n-1) | x(m.n) |

- Multiplying the summary matrix from this step (with m rows and n columns) by the summary matrix from Step 4 (n rows and 1 column), resulting in a final matrix (m rows and 1 column).

Based on this result, prioritize the optimal option based on the values from high to low.

## 2.2 AHP application in infrastructure projects

After reviewing Hanoi city's transportation development plan until 2030, with a vision to 2050, the research team selected 05 typical projects to conduct the pilot assessment of socio-economic efficiency. These are 5 of 11 key investment projects being considered by Hanoi authority in the period until 2030.

(1) **Tran Hung Dao Bridge**. According to the transportation planning, by 2030 with a vision to 2050, Tran Hung Dao Bridge (Hanoi City) is located on inter-regional road LK30, at the urban main road level. With a design speed of 80km/h, the main bridge covers 06 vehicle lanes, 02 bicycle lanes, 2 walking lanes, with a total estimated investment of 9,982 billion VND. The main target is to reduce the load on existing bridges and increase connectivity between the two banks of the Red River.

(2) **Ngoc Hoi Bridge**: locates in Ring Road 3.5. The project belongs to the group of important national projects. Total investment (expected): 11,700 billion VND. The main function is to enhance connections to highways, reduce traffic congestion for Ring Road 3 and connect with Hung Yen province

(3) **The investment project to renovate and upgrade National Highway 21,** section Son Tay - Hoa Lac - Xuan Mai, has a starting point connecting with the Tung Thien Street investment project at the beginning of Quan bridge; The end point is at Km25+745, connecting to the current National Highway 21, Xuan Mai town - Chuong My district. Total investment (expected) 18,722 billion VND. The main function is to Reduce traffic congestion, reduce travel time

(4) **Elevated Ring Road 2**: renovates and expands Ring Road 2 from Nga Tu So to Cau Giay with a total length of about 3.8km, width of 53.5m, belonging to a group of important national projects. The total expected investment is 17,241 billion VND. The main function is to reduce traffic congestion on Ring Road 2.

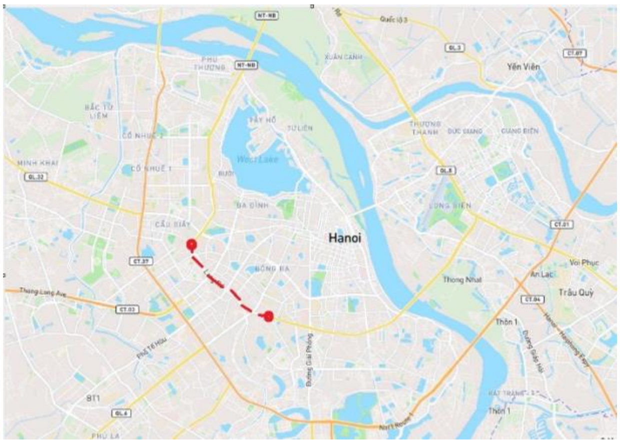

Figure 2. Sketch of Ring Road 2 project

(5) **Building an underpass on Hoang Quoc Viet** Street extending to Pham Van Dong street and connecting to Tran Vi street has a tunnel scale with an estimated total length of 357m (including 135m closed tunnel and 222m open tunnel). The project has a total investment (expected) of 2,293 billion VND. The main function is to reduce urban traffic congestion, improve traffic safety on Ring Road 3.

The selection of projects has been preliminarily evaluated on the basis of (1) being important to economic development and solving the problem of large-scale congestion; (2) large investment capital.

In order to establish the decision-making model to prioritize Hanoi investment projects in AHP approach, the research has applied such steps of (i) identifying the sustainable issues and solution goal; (ii) establishing a hierarchical structure model; (iii) constructing a set of pairwise comparison matrices; (iv) converting the comparisons to weights and check the decision maker's comparisons for consistency; (v) using weights to score options (among selected projects); and (vi) making the final decision. The process of evaluating the priority of projects is carried out as shown below.

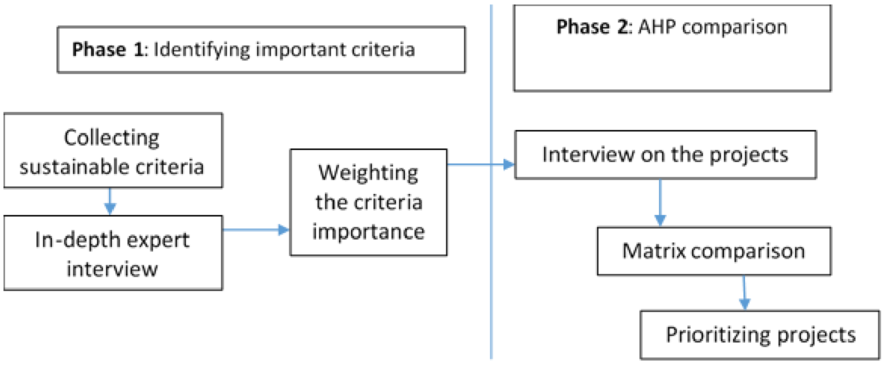


Figure 3. Project evaluation process using AHP

## 3. RESULT AND DISCUSSION

### 3.1 Prioritizing criteria

Vietnam is one of the countries which are the most seriously effected by socio-natural disasters in the coming years. Flooding, erosion, and sea level rise pose immediate threats, whereas epidemiological hazards including hemorrhagic fevers pose indirect risks as in Bich *et al.* (2011). As commonly seen in Vietnam (Adger (1999)), those risks have posed high dangers to urban citizens. Particularly impacted are the impoverished who reside in rural and undeveloped areas. It is important to take into account these variables and determinants of vulnerabilities to hazards that are caused by climate change, both directly and indirectly.

In an attempt to increase climate change resilience, Vietnam has recently envisioned expanding urban greenery to support sustainable urban growth. Greening techniques should ideally maximize ecosystem services (ESS) while simultaneously minimizing the effects of climate change by lowering heat stress and storm vulnerability (Jodi *et al.*, 2016; An *et al.*, 2021). Nevertheless, trade-offs could result if strategies are incompatible. Vulnerability analysis of urban forests at the district level should be included in trade-off assessments. However, in Vietnam, no research has been done on these topics.

The outcomes of the sustainable development concept may help to select species and manage regional greeneries so that a win-win situation (ie high adaptation and mitigation capabilities of regional forests, landscapes, etc.) can be guaranteed. From the vision of orienting towards a sustainable development city, the development frame for Hanoi urban transportation (as well as other major cities in Vietnam) can be described in the following figure.

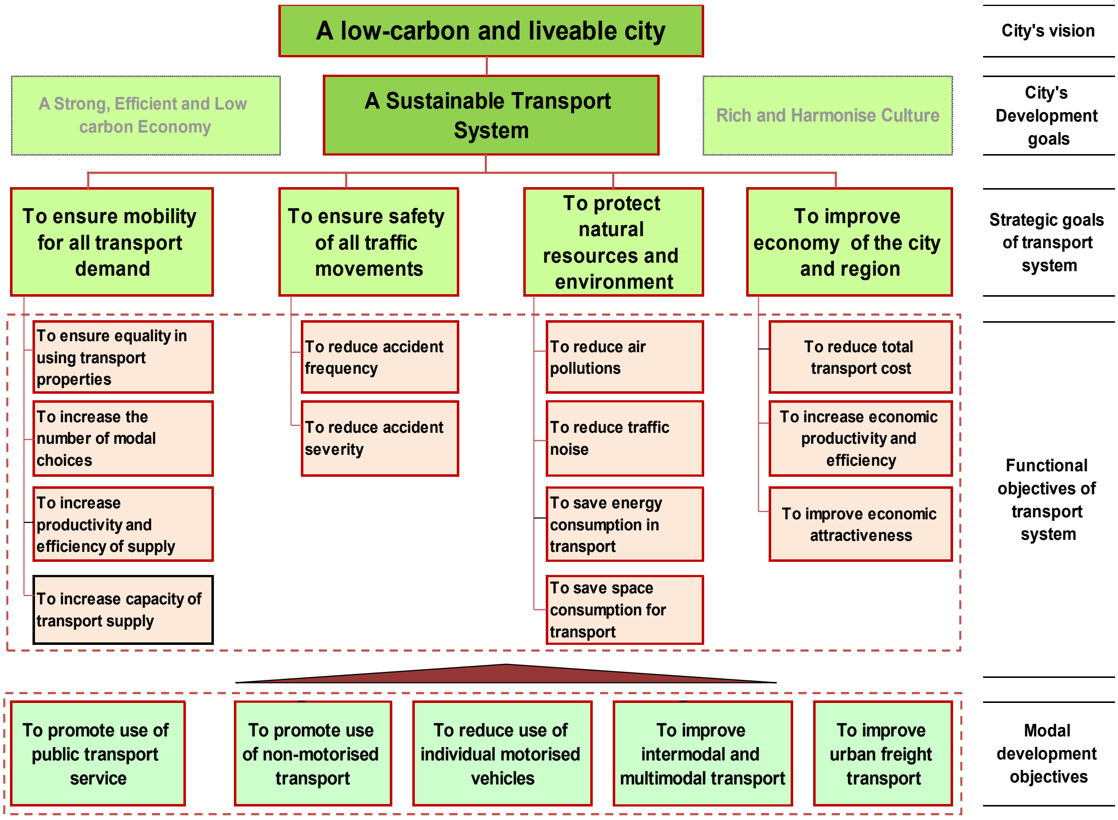


Figure 4. Sustainable urban development framework
Source: adapted from Nowak and Van den (2019)

The study team has developed a framework of objectives for the sustainable development of the urban transportation system, which includes four levels, based on the findings of multiple studies. Brundtland's concept of a sustainable urban development is at the top, followed by Newman and Kenworthy's (1999) definition of the goals of sustainable urban development. According to Alber Speer et al. (2009) the third level is the idea of a sustainable urban transportation system, which is a system that accomplishes the following objectives: (1) traffic flow, (2) traffic safety, (3) environmentally friendly transportation, and (4) transportation fosters economic growth.

In order to have a sustainable transportation system, 13 criteria must be met at the fourth level. These include four criteria for smooth traffic, two criteria for safe traffic, four criteria for environmentally friendly transportation, and three criteria for transportation that fosters economic growth. Generally speaking, the author has created a target framework that outlines the requirements that must be fulfilled for the urban transportation system to meet the Sustainable Development goal, even though this is not the most comprehensive set of criteria.

Those criteria has been evaluated by interviewing experts' opinion. The research team developed a questionnaire with detailed content on the evaluation criteria for sustainable development-oriented transportation projects for Hanoi, which was surveyed by experts. Information about the experts surveyed is presented on the table below.

Table 6. Information on Expert Interview

| **Information** | **Details** | **Quantity** | **Percentage (%)** |
|---|---|---|---|
| ***Total Experts Interviewed*** | | ***55*** | **-** |

| | | | |
|---|---|---|---|
| Age Group | < 30 years old | 4 | 7% |
| | 30 - 40 years old | 21 | 38% |
| | 40 - 55 years old | 23 | 42% |
| | > 55 years old | 7 | 13% |
| Year of experience in Transportation field | < 5 years | 5 | 9% |
| | 5 - 10 years | 28 | 51% |
| | 10 - 20 years | 14 | 25% |
| | > 20 years | 8 | 15% |
| Job Position | Specialist | 36 | 65% |
| | Department Manager at District Level | 15 | 27% |
| | Hanoi Urban Traffic Management Center | 4 | 7% |

The survey was conducted as direct interviews, primarily at the workplace of the experts. The results show that 80% of the experts are between 30-55 years old, a group with significant work experience. Among them, 76% have between 5 to 20 years of experience in the transportation sector. Additionally, 65% of the experts currently work as specialists at the Department of Transport, Urban Management Offices at district and town levels.

The survey suggests 14 criteria for Hanoi's urban transport infrastructure development until 2030 based on the target framework and criteria mentioned above, as well as revisions from expert interviews, specifically the criteria according to the following target groups:

a. The target of **smooth traffic flow** covers criteria of GT1- Average speed; GT2- Travel time in congested conditions; GT3- Percentage of main roads that are not congested during peak hours; GT4- Service level of the road network;

b. The target of **traffic safety**, covers criteria of AT1- Number of places with many accidents (or dangerous locations); AT2- Physical damage in accidents/km-vehicle trips; AT3- Road sections that do not meet safety standards.

c. The target of **environmental protection and effective use of resources** covers criteria of MT1- Rate of conversion from other types of land use to transportation usage (%); MT2- Energy consumption per vehicle trip (km-vehicle); MT3- Level of emissions on the road; MT4- Trip length by public transport over total trip length; MT5- Percentage of using non-motorized vehicles for regular trips or total trips.

d. The target of **promoting urban economic development** covers criteria of KT1-Economic loss due to traffic congestion or accidents; KT2- Number of direct jobs created by the transportation sector.

Table 7. List of Evaluation Criteria for Hanoi's Transport Projects

| Sustainable Development Goal | Evaluation Criteria | Code | Description |
|---|---|---|---|
| **Smooth Traffic Flow** | Average speed | GT1 | Increase average speed; |
| | Travel time in congested conditions | GT2 | Reduce travel time in congested conditions; |
| | Uncongested main | GT3 | Percentage of main roads that remain |

| | | | |
|---|---|---|---|
| | roads | | uncongested during peak hours; |
| | Road network service level | GT4 | Service level of the road network; |
| | Intersection service level | remove | Service level of intersections; |
| | Transport mode distribution | remove | Distribution of transport modes by infrastructure or route. |
| **Traffic Safety** | Number of accidents | AT1 | Number of high-accident locations (or hazardous spots); |
| | Infrastructure maintenance frequency | remove | Number of maintenance operations related to safety; |
| | Accident-related losses | AT2 | Material damage from accidents per km-vehicle trip; |
| | Substandard roads | | Road sections that do not meet safety standards; |
| | Quality of main roads | AT3 | Percentage of main roads with good pavement condition; |
| | Accidents due to road structure | remove | Accidents related to bridge and road features. |
| **Environmental Protection & Efficient Resource Use** | Land-use conversion | MT1 | Percentage of land converted to transportation use (%); |
| | Energy consumption | MT2 | Energy consumption per vehicle trip (km-vehicle); |
| | Emission levels | MT3 | Emission levels on roads; |
| | Public transport trip ratio | MT4 | Share of trips made using public transport; |
| | Non-motorized transport use | MT5 | Percentage of trips made by non-motorized transport. |
| **Urban Economic Development** | Economic losses | KT1 | Economic losses due to congestion and accidents; |
| | New job creation | KT2 | Number of direct jobs created by the transport sector; |
| | Job growth from transport mode shifts | remove | Increase in employment due to intermodal transport infrastructure; |

### 3.2 Applying the evaluation criteria for project assessment

In step 2, the number of interviewed experts was reduced to 7 people for a more focused evaluation.

Determining the priority level of groups and composition criteria is conducted through the focus expert interview. The results of data synthesis for groups are shown in the following table.

Table 8. Prioritizing sustainable development criteria

| Sustainable target | Survey form | | | | | | | Results |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Traffic (GT) – Safety (AT) | 1/2 | 2 | 1/2 | 1/3 | 4 | 1/2 | 1/3 | 1.17 |
| Traffic – Environment (MT) | 3 | 1/2 | 1/2 | 1/2 | 1/5 | 1 | 1/4 | 0.85 |
| Traffic – Economy (KT) | 1 | 1/2 | 2 | 5 | 1/2 | 1/2 | 1/2 | 1.43 |
| Safety – Environment | 1/3 | 2 | 1/2 | 3 | 1/2 | 2 | 4 | 1.76 |
| Safety – Economic | 1/2 | 1 | 4 | 1/3 | 2 | 5 | 5 | 2.55 |
| Economic environment | 1 | 1/2 | 1/2 | 2 | 1 | 1 | 1/2 | 0.93 |

Pairwise comparisons between groups give results of the priorities and weights of the groups as shown in the following tables.

Table 9. Priority levels of sustainable target

| Sustainable target | GT | AT | MT | KT |
|---|---|---|---|---|
| **GT** | 1.00 | 1.17 | 0.85 | 1.43 |
| **AT** | 0.86 | 1.00 | 1.76 | 2.55 |
| **MT** | 1.18 | 0.57 | 1.00 | 0.93 |
| **KT** | 0.70 | 0.39 | 1.08 | 1.00 |
| **Total** | **3.73** | **3.13** | **4.69** | **5.90** |

Table 10. Weighting sustainable targets

| Sustainable target | GT | AT | MT | KT | Weight |
|---|---|---|---|---|---|
| **GT** | 0.27 | 0.37 | 0.18 | 0.24 | 0.27 |
| **AT** | 0.23 | 0.32 | 0.38 | 0.43 | 0.34 |
| **MT** | 0.32 | 0.18 | 0.21 | 0.16 | 0.22 |
| **KT** | 0.19 | 0.13 | 0.23 | 0.17 | 0.18 |
| **Total** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** |

Checking for consistency results as follows:

| | |
|---|---|
| λmax | 4.12 |
| CI | 0.04 |
| CR | 4.5% |

The same procedure is repeated for the component criteria in each criterion group. Therefore, the results of evaluating the priority and weight of the criteria are obtained as shown in the table below.

Table 11. Importance level of sustainable criteria

| Target | Target weight | Criteria | Criterion weight | Importance score |
|---|---|---|---|---|
| Smooth traffic flow | 0.27 | GT1 | 0.24 | 0.06 |
| | | GT2 | 0.22 | 0.06 |
| | | GT3 | 0.31 | 0.08 |
| | | GT4 | 0.23 | 0.06 |
| Traffic Safety | 0.34 | AT1 | 0.35 | 0.12 |
| | | AT2 | 0.29 | 0.10 |
| | | AT3 | 0.37 | 0.13 |
| Environmentally friendly | 0.22 | MT1 | 0.26 | 0.06 |
| | | MT2 | 0.22 | 0.05 |
| | | MT3 | 0.15 | 0.03 |
| | | MT4 | 0.21 | 0.05 |
| | | MT5 | 0.16 | 0.04 |
| Economic development | 0.18 | KT1 | 0.45 | 0.08 |
| | | KT2 | 0.55 | 0.10 |

Similar to the process of evaluating priorities and calculating the weight of the criteria described above, the research team sought expert opinions to evaluate the socio-economic efficiency of 05 typical transportation projects in Hanoi city until 2030. Then the priority order of projects can be determined according to sustainable urban development goals.

Experts were consulted to evaluate the impact level of each project based on various sustainable development criteria (including transportation, environmental, traffic safety and socio-economics criteria). The table below provides an example of the environmental criteria assessment.

Table 12. Prioritizing environmental criteria

| MT1 Criteria | Survey Responses | | | | | | | Aggregated Score |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| DA1 – DA2 | 1 | 1/2 | 3 | 2 | 2 | 1/2 | 2 | 1.57 |
| DA1 – DA3 | 1 | 2 | 1/2 | 2 | 1/3 | 1/2 | 1/2 | 0.98 |
| DA1 – DA4 | 1/2 | 1/2 | 2 | 1/4 | 1/5 | 1/2 | 1/3 | 0.61 |
| DA1 – DA5 | 2 | 2 | 3 | 1 | 1/5 | 1/3 | 1 | 1.36 |
| DA2 – DA3 | 3 | 1/2 | 1/2 | 1/3 | 2 | 1/2 | 1/2 | 1.05 |
| DA2 – DA4 | 1/3 | 1/2 | 1/4 | 1/3 | 1/5 | 2 | 3 | 0.95 |
| DA2 – DA5 | 1/2 | 1/2 | 2 | 1/2 | 2 | 1/2 | 3 | 1.29 |
| DA3 – DA4 | 1/3 | 1/2 | 1/2 | 1 | 1/2 | 1/2 | 1/3 | 0.52 |
| DA3 – DA5 | 1 | 2 | 1 | 1/3 | 1 | 1/2 | 1 | 0.98 |
| DA4 – DA5 | 1 | 1 | 1/3 | 1/3 | 2 | 1 | 1/3 | 0.98 |

From such assessments, the priority weights of the projects can be summarized according to the evaluation criteria as follows:

Table 13. Priority Weights for Each Project by Evaluation Criteria

| Project | GT1 | GT2 | GT3 | GT4 | AT1 | AT2 | AT3 | MT1 | MT2 | MT3 | MT4 | MT5 | KT1 | KT2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DA1 | 0.21 | 0.22 | 0.21 | 0.19 | 0.18 | 0.18 | 0.20 | 0.15 | 0.12 | 0.13 | 0.12 | 0.16 | 0.30 | 0.33 |
| DA2 | 0.19 | 0.25 | 0.21 | 0.23 | 0.20 | 0.18 | 0.19 | 0.15 | 0.16 | 0.16 | 0.18 | 0.19 | 0.29 | 0.26 |
| DA3 | 0.17 | 0.19 | 0.17 | 0.21 | 0.20 | 0.18 | 0.17 | 0.18 | 0.20 | 0.19 | 0.15 | 0.22 | 0.19 | 0.19 |
| DA4 | 0.25 | 0.20 | 0.21 | 0.20 | 0.23 | 0.27 | 0.20 | 0.24 | 0.22 | 0.25 | 0.34 | 0.22 | 0.13 | 0.12 |
| DA5 | 0.18 | 0.15 | 0.20 | 0.17 | 0.18 | 0.18 | 0.24 | 0.28 | 0.29 | 0.27 | 0.22 | 0.22 | 0.10 | 0.10 |

Table 14. Evaluating the investment project priority using the AHP method

| Project Code | Project Name | Evaluation Score | Priority Ranking |
|---|---|---|---|
| DA1 | Tran Hung Dao Bridge | 0.204 | 3 |
| DA2 | Ngoc Hoi Bridge | 0.209 | 2 |
| DA3 | National Highway 21 Upgrade | 0.185 | 5 |
| DA4 | Elevated Ring Road 2 Project | 0.212 | 1 |
| DA5 | Hoang Quoc Viet Underpass | 0.189 | 4 |

The research results show that the city's most important project during this period is the completion of Ring Road 2, which involves finishing the elevated section and expanding the ground section. This recommendation is strongly supported by Hanoi Department of Transport.
The Ngoc Hoi Bridge project, part of Ring Road 3 in the northern area, is ranked the second. This project requires a total investment of approximately 12 trillion VND, or nearly 500 million USD. It is crucial for connecting Hanoi with neighboring provinces and promoting socio-economic development. Although it has been proposed for investment in the upcoming period, the significant investment required may pose challenges in capital allocation.
The third-ranked project is Tran Hung Dao Bridge, an important project aiming at fulfilling travel demands across the Red River and reducing pressure on the two adjacent bridges, thereby easing traffic congestion in the city center.
Ranking the fourth is the underpass on Hoang Quoc Viet Street, also a component of Ring Road 3. However, due to the focus on completing the ring roads of the Hanoi Department of Transport, this project might be more suitable for third position in the priority list.
The analysis took into account economic, technical, environmental, and financial criteria consistent with the city's general infrastructure development orientation. These results can further support regulatory authorities in detailed planning, budget allocation, and implementation of high-priority projects. Additional considerations for effective construction investment include Environmental Impact Assessment (EIA), community consultation, and monitoring and impact evaluation to ensure the project is implemented as planned.

## CONCLUSION

Vietnam's urbanization process, along with the process of industrialization, modernization and globalization, has had a great influence on the socio-economic characteristics as well as the shape of urban areas and people's lifestyle. Most likely, Vietnam in general and Hanoi in particular will develop following the model of countries that have become industrialized countries such as Japan, Korea, Malaysia and China.

In the coming time, Hanoi, as well as Vietnam big cities, still strongly depends on motorcycles in fulfilling mobility demands. The motorcycle dependent traffic flow with the serious (and increasing) unbalance between transport demand and supply is causing serious problems of urban transport environment.

In fact, the method of evaluating socio-economic efficiency using cost benefits may be effective in cases where there is enough evaluation data. However, forecasting all (potential) socio-economic benefits of a project is not easy, especially in the preliminary assessment stage to select prior investment projects. Qualitative assessment methods combined with expert opinions will be much more effective in this stage.

The use AHP tool to assist in the prioritization criteria for proposals' portfolio management was successful. The AHP is a decision support methodology, which establishes the construction of a hierarchical structure and value judgment for decision making. This methodology does not eliminate the figure of the selecting committee, but it facilitates its performance, using the knowledge for the individual pairwise comparison of the criteria involved in the analysis.

The application of AHP in evaluating 5 projects enables the prioritization of a project over another, based on technical criteria, considering both the objective and subjective views of these criteria, allowing a greater likelihood of success in project selection. To review and project prioritization, the tool proved to be adequate due to its ability to adapt to different situations that may occur in the evaluation proposals. The application of the tool in a larger set of projects with more evaluators should be considered as the next step of this work.

This study has several limitations, notably the relatively small number of experts (7) in the focus interview, which may introduce biases into the survey results. Additionally, due to the complexity and time-consuming nature of pairwise comparison calculations and weight determination, we have yet to be able to conduct a sensitivity analysis of the survey results. If there is sufficient time and budget, our research team may perform a sensitivity analysis by varying the criteria weights to observe whether the priority rankings change significantly. Conducting a sensitivity analysis would help evaluate the stability of the results and provide a better understanding of the extent to which each criterion influences the outcome.

**ACKNOWLEDGEMENT**

This research is funded by the EASTS under the project code IRG-49-2023

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