Journal of Science and Technology in Civil Engineering, HUCE (NUCE), 2022, 16 (4): 58–72

# ANALYZE DEVELOPMENT POTENTIAL IN AFFECTED AREAS ADJACENT TO URBAN PUBLIC TRANSIT SYSTEMS. CASE STUDY IN THE STATIONS OF KIM MA AND VAN PHUC 2 (BRT LINE NO.1)

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***Article history:***
*Received 10/5/2022, Revised 13/7/2022, Accepted 22/8/2022*

**Abstract**

The Hanoi authority has been promoting the construction and completion of the Urban Mass Rapid Transit (UMRT) system, both BRT and urban railway. The idea of land value capture for economic development in areas around public transport systems is quite popular around the world. This is considered an effective approach to urban development planning in the big cities. The 3V framework is a holistic approach used to analyze the development potentials of the affected areas by transit stations. This method mentions 3 value groups composed of Node-value, Place-value, and Market-value which are defined under dimensions. The tools utilized to calculate these dimensions are GIS, mapping and surveying. Two stations on BRT line 1, Kim Ma and Van Phuc 2 were selected to study. The results of study showed that (1) there is a relation between spatial attributes, transport characteristics, market conditions and the development potentials; (2) having the advantages and obstacles to development in the affected areas around public transit transport. These results hopefully are the basis for further studies in other stations with the support of more credibly quantitative tools such as computer software and statistical methods.

*Keywords:* TOD; 3-Value framework; Built Environment (BE); urban management; public transport.

https://doi.org/10.31814/stce.nuce2022-16(4)-05 

## 1. Introduction

Developing public transit as the dominant urban transport mode has been considered as a key strategy of mega-cities all over the world to obtain the globally GHG emissions reduction goals and to ensure the improvement of living quality aims at a sustainable development. Although Tokyo, Seoul or London, Paris, and New York are different in terms of geographic and economic context, these cities are all successful examples of urban structure models developed relying on public transport networks, mainly urban railways (UR) [1].

Transit – Oriented Development (TOD) focuses on building a large capacity transport system combined with developing the areas affected by public transit hubs, railway stations, and highly traffic

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intersections [2]. TOD will bring a real value and great benefits to the station areas through capturing the land value increase by the agglomeration of population, services, and economic activities under the support of public transit [3, 4].

It is obvious that not all stations are eligible to become large scale economic-traffic hubs. At a smaller scale, they could exist as residential service centers. This depends on the dimensions of location, traffic concentration scale, current situation, potentials of land, and employment, as well as the availability of service utilities in the neighborhood [5, 6]. Salat and Olliver in their research (2017) [7], proposed 3 categories of public transit nodes: (1) Intermodal hub/highly connective hubs – where connect many mass rapid transit lines such as metro, light rail, bus, BRT at city level, as well as regional and national level; (2) Transit interchange/node – where two or three public transit lines go through; and (3) Single-line station - exists only a public traffic line across, where to stop and pick-up passengers. Meanwhile, two categories of public transport nodes are simpler classification proposed by the Calthorpe team in the research case of San Diego city. They supposed that the extent of importance of transit stations depended much on the characteristics of the public traffic routes connecting to those stations [8]. Mai and her team, in a research of Hanoi [5, 6] classified 3 types of the transit interchanges on the basis of existing conditions and the ideas proposed in Hanoi's Public Transport Master Plan. They in turn belong to regional, urban and neighborhood level. Other classification relied on the location of stations in Hanoi space were mentioned in this study. They include the high density economic - transport core located in the inner city; the inter – regional secondary centers in satellite cities, the centers in the newly emerging city area, and in the neighborhood of the existing urban center. However, the limitation in this research is to use Node-value only as main approach to analyze areas around rail way station areas [5, 6].

Considering market potential, economic value of station areas is measured by the extent of increasing land values adjacent to those transit stations. Many studies paid attention to the relation between land value and Built Environment (BE) in affected areas around stations, through evaluation of the spatial attributes such as density, diversity of land use and accessibility to transit and urban services. Mai and Chi [9] in their research clarified the impacts of accessibility to urban services and stations on property prices in the case of Hanoi city by using hedonic pricingmethod. As far as these results, the authors gave proposals to re-adjust the spatial dimensions and to manage effectively the areas around UMRT transit stations in Hanoi.

Other researchers also had the same interests, such as Mullins (2001) with his research for Montana, USA in 2001. The study used two primary data sources, including property value data and data measuring the density in surrounding areas [10]. Chang Doek Kang (2010) also focused on studying property prices in Seoul in 2010 [11]. In order to measure land-use diversity, aggregated parameters are often used such as Balance Index (measures the balance between land-types or between labor and residences...); Dissimilarity Index (measures the difference among land-types with neighborhood areas); Entropy Index (measures the diversity of land-use based on the number of land-types and their areas in the neighborhood) [12–14]. One of the first research on the relationship between land-use diversity and property prices was done by Cao and Cory in 1981. The authors used the "hedonic pricing model" to analyze the impact of land-use diversity on housing prices in Arizona, USA [15]. Regarding the assessment of land potential and accessibility to public transport, many dimensions are taken account, including: Distance to the nearest station/transit stop; Number of stations/ transit stops accessible within a 5-minute walking distance; dimensions evaluate the level of public transport services such as: trips frequency, commercial services in the station, passenger satisfaction while traveling in public transport [16].

Considered as a holistic approach, the 3V value framework is used to evaluate development opportunities of a TOD area through 3 potential value groups like transportation (node); space (location); and economic potential (market). The 3V framework could help to differentiate many stations by its classified criteria. These are foundations for launching initiatives of policy enhancing development for each TOD station [17].

Hanoi intends to shift from motorbike-dependent city to transit-oriented city through development of a total of more than 300kms including eight lines of urban railway, and BRT system. Hanoi's TOD plan is known as "the project of integration of UMRT and urban development", was constructed for HPC under technical supports from Japan International Cooperation Agency (JICA). This plan firstly was introduced in 2011, following the "Hanoi Capital Construction Master Plan up to 2030 with vision 2050" which was approved in 2010. According to this plan, Ha Noi has begun to deploy a number of mass rapid transit routes such as BRT and light rail [18, 19]. Until March 2022, only BRT line No. 01 Kim Ma–Yen Nghia and UR No. 2A Cat Linh – Ha Dong have been put into operation since 2016 and November 2021, respectively [20, 21] UR No.1 and UR No.3 are still under construction and on-going to completion [5]. Thus, TOD is considered a hopefully effective development model for Hanoi in the future. Therefore, it is necessary to research methodology to evaluate the development potentials of TOD stations in order to provide an effective quantitative assessment tool for planners and policymakers in Hanoi. Our study initially focuses on the 3V framework for research of 2 selected station areas. Research objectives are: (1) Clarifying the 3V framework theory; (2) Experimental application of evaluation criteria for 2 selected areas; (3) Showing the relationship between the development potential and characteristics of the stations, as well as highlighting the advantages and disadvantages of their potentials. This research will also answer two assumed research question: (1) Is the 3V Framework suitable to assess the potential value of BRT stations in Hanoi, showing the impact of location, traffic characteristics, spatial dimensions to the development potentials in station's surrounded areas; (2) The 3V Framework may show the weaker development potential in smaller stations compared to central stations; however, is it always true for all potential values? These questions can be partly answered through the analysis of typical samples in Hanoi context.

According to Bertolini (2019), an urban mass rapid transit (UMRT) network can be considered as a network of nodes and links. Its operation is similar to that of an internet network, social network, DNA or neural network... There exist different values of nodes in the network and from that a hierarchy of nodes is formed according to the nodes' values [22]. The Node-Value expresses a node's potential and importance on the UMRT network.

The 3V Framework focuses on 3 specific values for each node/transit hub, including: Node-value, Location-value, and Market-Value. Node-value represents the importance of a station/transit hub in the public transport network based on passenger volume, vehicle connectivity, and centrality in the network. Location-value represents the quality and attractiveness of an area in terms of public amenities, schools, healthcare; in terms of function, accessibility by non-motorized vehicles (on foot or by bicycles) to daily services, street network and street-block characteristics which facilitating flexible commuting; and in terms of land-use diversity. Market potential value refers to the unrealized market value of station areas and is analyzed through market analysis (the study of supply and demand). It is measured through key drivers of demand including future density (both population and employment density); the number of current and future jobs accessible within 30 minutes of commuting by public transport; and other supplying resources such as develop-able land, potential changes in zoning (through FAR index), market vibrancy. These dimensions are all evaluated by complex sets of indicators. Table 1 shows the criteria for the 3 Value dimensions, calculation, and evaluation methods [7].

Table 1. Criteria of 3 Value Indicators

| Type of Values/Indicators | Concept/Evaluation |
|---|---|
| Node value: to assess the service capacity of the station, the traffic connectivity and the transport mode conversion | |
| Indicator 1.1: Level of node concentration. | Indicates the number of links via the node (outgoing and incoming). The higher number of links, the higher node value. |
| Indicator 1.2: Closeness centrality | The average distance measuring in number of links, from a station to every other station in the network. The shorter the average distance, the higher the value |
| Indicator 1.3: Betweeness centrality | The number of shortest paths from all stations to all others that pass through the station. The higher number of paths, the higher node value. |
| | Indicators 1.1 – 1.3 are used to estimate node value (station) in a public transport network. |
| Indicator 1.4: Intensity of node activity. | The number of passengers departure/ arrival of a node (except pass-through passengers). The higher number of passengers, the higher node value |
| Indicator 1.5: Intermodal diversity in the radius of 800 meters. | The number and variety of transportation modes a station connects within the the radius of 800 meters. The higher the number of modes, the higher node value. |
| Place value - to assess the attractiveness of economic activities through the number and quality of urban services in the area within 800 meters around the station. | |
| Indicator 2.1: Density of street intersections within 800 meters around a station. | Number of street intersections within an 800-meter radius of each station. The higher the number of street intersections, the higher value place. |
| Indicator 2.2: Pedestrian accessibility to a station. | Ratio of area covered within a 10-minute walk of the station and the area within a radius of 800 meters from the station/bus station. The higher the proportion, the higher place value. |
| Indicator 2.3: Diversity of land-use (Measuring Entropy index). | The level of land-use diversity within a 800-meter radius of each station. Entropy index varies from 0 to 1. The closer it is to 1, the higher the degree of land-use mix and diversity. |
| Indicator 2.4: Density of social service facilities within 800 meters of a station. | Number of cultural, educational, and health services, and others within a 800-meter radius of each station. The higher the number, the higher place value. |
| Market potential value – to assess the increase of land and house prices caused by job attractiveness, job sources within a 800-meter radius of a station. | |
| Indicator 3.1: Population and employment density (unit: people/hectares). | Number of people and jobs/labours per unit area within a 800-meter radius of each station. The assessment depends on each specific case. |

| Type of Values/Indicators | Concept/Evaluation |
|---|---|
| Indicator 3.2: Activity mix (unit: %). | The percentage of number of jobs/total residents within a 800-meter radius of each station. The assessment depends on each specific case. |
| Indicator 3.3: Forecasted rate of growth in population and employment density (unit: %). | The forecasted rate of growth in population and employment for 10 to 20 years in an area within a 800-meter radius of each station. The assessment depends on each specific case. |
| Indicator 3.4: Social characteristics of the area around the station. | 3.4.1 Average household income; 3.4.2 Percentage of people holding senior positions in the labour force.<br>3.4.1 & 3.4.2: a high percentage of high social class reflects a higher land value. |
| Indicator 3.5: Number of jobs accessible through transit and walking. | Number of jobs accessible through transit and walking within 30 minutes. The attractiveness of the job market accompanies with the convenient access to public transport. |
| Indicator 3.6: Real estate opportunities in areas within a 800-meter radius of each station (unit: %). | Land can be redeveloped (vacant land or inefficiently exploited land) for the high-end market within 800 meters around a station and from 800 meters to 1 kilometer for the common market. The higher the percentage of the develop-able land, the higher the market value. |
| Indicator 3.7: Real estate vibrancy. | The appearance of new constructions in the area around a station in the past 10 years. The rapid appearance of buildings over time is directly proportional to the growth of the driving force behind the real estate market. |

The 3V framework aims to achieve two goals. First, it is to help classify stations based on an assessment of the indicators and to compare the positive of the indicators in each value group. Second, the 3V framework also allows identifying gaps and the balance between three values in a station such as connectivity, accessibility, location quality and market potential value. City planners and leaders can rely on the results of 3V analysis to decide development directions for each area through policy solutions to enhance or control the indicators as desired.

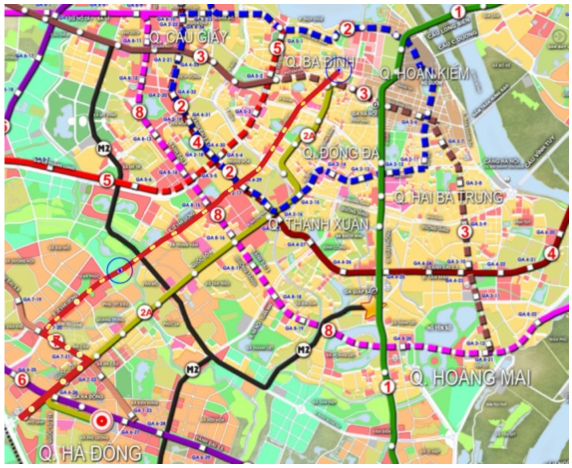
## 2. Research method

### *2.1. Introduction of the study area BRT line No.1 [23]*

BRT line No.1 operates from Kim Ma bus station in the center of Hanoi, going southwest along Giang Vo, Lang Ha, Le Van Luong, Le Van Luong, Le Trong Tan, and Quang Trung streets to Yen Nghia bus station. It runs at a frequency of 5-15 minutes/trip, has a transport capacity of 90 passengers/time, has 4 doors, and travels at a speed of 22 km/h.

In the first phase, two UR lines, No. 3 and No. 2A will intersect the BRT line No.1. Besides, there are 17 bus routes running along BRT No.1 on some sections such as lines 09A, 09 ACT, 18, 22A, 23, 25, 32, 34, 38, 50, 99, 107, CNG03, 19, 22C, 57, 89. Kim Ma BRT bus station and Van Phuc 2 station are randomly selected based on criteria of location relative to the center, population density, number of routes, and passenger size. We hypothesized that there would be a marked difference in node values between these two transfer points according to the evaluation based on the 3V framework. . .


(a) Map of BRT line No.1




(b) Linking BRT line No.1 and UR lines in Hanoi's public transport planning map

Figure 1. BRT line No.1 and UR lines in Hanoi [18]

- Kim Ma station: Kim Ma BRT & bus station is located at Nguyen Thai Hoc - Giang Vo junction, is both the terminus of the BRT route, the inner city bus station, and concentrates on many bus routes such as 40, 22, 32, 71, 33, 20C, 31. It is an important public transport hub with a large passenger volume. This station is located in the central urban district of Hanoi capital - Ba Dinh district, near the old quarter. Within a radius of 800 meters around Kim Ma BRT bus station, there are many architectures with many famous cultural and historical values and many educational and healthcare services...
- Van Phuc 2 station: It is located on To Huu street, opposite the Van Phuc craft village market. Currently, the Van Phuc 2 station is only serving the BRT bus route No.1. Future urban railways are not located near the Van Phuc 2, except for a planned Metro 2 line in the future and be 500 meters away from this station. As of this moment, no bus lines are found directly connecting to this station.

### 2.2. *Methodology and tools*

To conduct the initial assessment of these two BRT stations, the research team considered and selected representative criteria, using a simple, accessible and suitable method for the current status of Hanoi public transport development. Specifically, we consider preparations for the operation of UR No. 2A and No. 3 in the near future. The selection of indicators and calculation methods are sufficient to assess the potential value of the area with an acceptable accuracy. These indicators involve 1.1, 1.4, 1.5; 2.1, 2.2, 2.3, 2.4; 3.1, 3.2, 3.3, 3.6, 3.7 (Table 2). The main methods used are: (1) quick interview and survey (using the questionnaires carried out on the whole line with an area of 800 m around the BRT stops (stations) in 2019); (2) actual survey on the BRT route (counting passengers on the BRT bus); (3) Processing on planning maps and current AutoCad maps, aerial maps...; (4) GIS methods; (5) Inheriting documents from previous studies. The selection indicators calculated according to the 3V framework are mentioned in Table 2.

Table 2. Indicators to assess development potential in the areas within 800-meter radius from Kim Ma and Van Phuc 2 stations

| Value/Indicators | Methodology | Tools |
|---|---|---|
| 1. Node value | | |
| Indicator 1.1: Level of node concentration;<br>(unit: No. of link) | Count the number of routes that link through the node (both incoming and outgoing). | Urban railway network planning map, bus route map, BRT. |
| Indicator 1.4: Intensity of node activity<br>(unit: people/day) | Total number of passengers arriving and departing during the day (excluding transit passengers) | Document inheritance, data analysis. |
| Indicator 1.5: Intermodal diversity in the radius of 800 meters.<br>(unit: No of mode) | Calculate the number of modes of public transport within a radius of 800m around the station. | Bus and BRT route map, google map, site survey. |
| 2. Place value | | |
| Indicator 2.1: Density of street intersections within 800 meters around a station<br>(unit: No of intersections/ ha or km$^2$) | Count the number of intersection nodes of neighborhood streets that cars can pass. | Aerial map, site survey. |
| Indicator 2.2: Pedestrian accessibility to a station<br>(unit: %) | Ratio of area covered within a 10-minute walk of the station and the area within a radius of 800 meters from the station/bus station. | Aerial map, site survey. |
| Indicator 2.3: Diversity of land-use (Measuring Entropy index). | Calculation by entropy index (Shannon):<br>$\text{Entropy} = -\dfrac{\sum_{i=1}^{n}\left(\frac{Pi}{Pn}\times\log\frac{Pi}{Pn}\right)}{\log(\text{n})}$<br>where $i$ is the types of land-use (commercial, public, residential, industrial); $n$ is the number of land-use types; $Pi$ is the area used for purpose $i$; $Pn$ is the area of all land uses. The value of the entropy index increases as the number of functions increases and the distribution becomes more balanced. | Land-use map in Zoning Plan at the scale of 1/2000 (Auto-Cad map). |

| Value/Indicators | Methodology | Tools |
|---|---|---|
| Indicator 2.4: Density of social service facilities within 800 meters of a station (unit: No of building) | Count the number of public service works within a 800-meter radius around the station. | Google maps, site survey. |
| 3. Market value | | |
| Indicator 3.1: Population and employment density (unit: people/hectares) | Average population density based on data for the district(s) to which the station belongs. Number of employees calculated by employment/m$^2$ of floor (refer to Zoning Plan criteria). | Statistical yearbook, Zoning Plan. Investigation, documentation. |
| Indicator 3.2: Activity mix (unit: %). | Calculate according to the formula Balance Index BAL = $1 - (\lvert x - y \rvert / \lvert x + y \rvert)$ ($x$ is population, $y$ is labours). | Statistical yearbook, Zoning Plan. |
| Indicator 3.3: Forecasted rate of growth in population and employment density (unit: %). | Forecast in the next 10 years, interpolate according to the rate of population and labor growth in consecutive years within the last 5 years. | Statistical yearbook. |
| Indicator 3.6: Real estate opportunities in areas within a 800-meter radius of each station (unit: %). | 3.6.1 Inventory of unused land (%); 3.6.2 Inventory of area (%) capable of being converted, within a radius of 800 m around each station. | Zoning Plan Maps, Google maps. |
| Indicator 3.7: Real estates vibrancy. | Observe on the aerial map of new buildings appearing over time. Support with data from the local planning authority or real estate monitoring agency. | Google earth map 2010, 2020. Inheritance of research materials. |

## 3. Results

Based on the data in Tables 3, 4, 5, it can be seen that 8/12 indicators are evaluated more positively at Kim Ma station than at Van Phuc 2 station (4/12).

Kim Ma station has advantages in Node value group (3/3 indicators) and Location value group (3/4 indicators), except for indicator 2.3 on land-use diversity. The indicators for evaluating the Node value at Kim Ma station are totally higher than those of Van Phuc 2, such as the indicator of route concentration in Kim Ma is more than doubled (4/2); the number of arrival/departure trips in Kim Ma is more than 7 times (5418/774); the diversity of transit modes in Kim Ma area is as high as 230% than at Van Phuc 2 area. The results also reflect that the indicator of intersection density and walking accessibility at the BRT station Van Phuc 2 is lower than Kim Ma, which are 28 and 44 intersections, respectively, and the area which can be accessed within 10-minute of walking is 18% in Van Phuc 2 station and 23% in Kim Ma station. The Location value and Market value groups also show the advantages of the Kim Ma BRT station area compared to the Van Phuc BRT station. such as population and employment density is 76787/20928, employment growth/population growth ratio (1.14/0.73). Public works do not have much difference between the two areas, shown in the indicator of social infrastructure density around Kim Ma station is 16 and that of Van Phuc 2 station is 13.

Table 3. Calculation results of indicators to evaluate node value at Kim Ma and Van Phuc 2 stations (source: research team)

| Kim Ma | Van Phuc 2 |
|---|---|
| 1. Indicator 1.1 Level of node concentration | |
| 4 links | 2 links |
| BRT No1: 1 link towards Van Phuc; LRT 2A: 1 link to Ha Đong; LRT 3: 2 links to Nhon and Hoang Mai. | BRT No1: 2 links to Kim Ma and Yen Nghia. |
| 2. Indicator 1.4: Intensity of node activity (unit: people/day) | |
| 5418 people/day. | 774 people/day |
| 3. Indicator 1.5: Intermodal diversity in the radius of 800 meters. (unit: No of mode) | |
| 14 routes | 6 routes |
| 1 BRT route và 13 bus routes (09A, 09ACT, 18, 22A, 23, 25, 32, 34, 38, 50, 99, 107, CNG03) | 1 BRT route và 5 bus routes (19, 22C, 33, 57, 89) |

Table 4. Calculation results of indicators to evaluate place value at Kim Ma and Van Phuc 2 stations

| Kim Ma | Van Phuc |
|---|---|
| 1. Indicator 2.1: Density of street intersections within 800 meters around a station | |
| 44 intersections | 28 intersections |
| 2. Indicator 2.2: Pedestrian accessibility to a station (unit: %) (Calculate by the ratio of area covered within a 10-minute walk of the station and the area within a radius of 800 meters from the station/bus station) | |
| 23%. | 18%. |
| 23 road sections which can be walkable within 10 minutes to the station within a radius of 800 m; Coverage area of the 10-minute walk: 0.46 $km^2$; Area within radius of 800 m: 2 $km^2$. | 18 road sections which can be walkable within 10 minutes to the station within a radius of 800 m; Coverage area of the 10-minute walk: 0.36 $km^2$; Area within radius of 800m: 2 $km^2$. |

| Kim Ma | Van Phuc |
|---|---|
| 3. Indicator 2.3: Diversity of land-use (Measuring Entropy index). | |
| 0.48 | 0.75 |
| 9 types of land used out of a total of 13 types. Existing residential land: 0.500 $km^2$; Mix-used land : 0.110 $km^2$; Urban public land: 0.017 $km^2$; Educational land: 0.010 $km^2$; Parking land: 0.0140 $km^2$; Neighborhood public land 0.005 $km^2$; Neighborhood green land: 0.003 $km^2$; Land for religions: 0.002 $km^2$; Military land: 0.050 $km^2$; Water bodies: 0.000 $km^2$; Urban green land: 0.000 $km^2$; Land for new housing: 0.000 $km^2$; Office land: 0.000 $km^2$ | 10 types of land used out of a total of 13 types. Existing residential land: 0.086 $km^2$; Mix-used land: 0.570 $km^2$; Urban public land: 0.200 $km^2$; Educational land: 0.210 $km^2$; Parking land: 0.075 $km^2$; Neighborhood public land: 0.067 $km^2$; Neighborhood green land: 0.000 $km^2$; Land for religions: 0.000 $km^2$; Military land: 0.000 $km^2$ ; Water bodies: 0.077 $km^2$; Urban green land: 0.071 $km^2$; Land for new housing: 0.350 $km^2$; Office land: 0.370 $km^2$ |
| 4. Indicator 2.4: Density of social service facilities within 800 meters of a station (unit: No of building) | |
| 16 public buildings. | 13 public buildings. |
| Cultural facilities: 10 facilities: Ho Chi Minh Mausoleum, Hang Day Stadium, Van Mieu-Quoc Tu Giam, Phung Hung Temple, Kim Son Pagoda, Cat Linh Pagoda, Vietnam Cheo Theater, Chien Thang Museum, Phung Khanh Pagoda, Ho Chi Minh Museum.<br>Educational institutions: 5 campuses: Cat Linh Primary School, Cat Linh Secondary School, Cat Linh Kindergarten, IGG English Center, Dai Yen Primary School.<br>Medical facilities: 1 facility: Saint Paul General Hospital. | Cultural facilities: 7 facilities: Hanh Phuc Cultural House, Bach Dang Residential Group Cultural House, Van Phuc Pagoda, Van Phuc Silk Village, Van Phuc Communal House, Van Phuc Ancient Temple, Ngoc Truc Pagoda.<br>Educational institutions: 4 campuses: Van Phuc Primary School, Van Phuc Secondary School, Van Phuc 2 Kindergarten, Van Phuc B Kindergarten.<br>Medical facilities: 2 facilities: Ha Noi Nursing Home, Van Phuc Ward clinic. |

Table 5. Calculation results of indicators to evaluate market value at Kim Ma and Van Phuc 2 stations (source: research team)

| Kim Ma | Van Phuc 2 |
|---|---|
| 1. Indicator 3.1: Population and employment density within a 800-meter radius around each station (unit: people/hectares). | |
| 76787 people | 20928 people |
| Population: 53,659 people; Labour: 23,128 labours | Population: 12,884 people; Labour: 8,044 labours |
| 2. Indicator 3.2: Ratio of jobs/residential | |
| 0.602 | 0.769 |

| | |
|---|---|
| 3. Indicator 3.3: Forecasted rate of growth in population and employment density (unit: %). | |
| Average population growth rate is 10.5% per year; Average employment growth rate is 15.1% per year; Employment/population growth rate: 1.14. | Average population growth rate is 11.03% per year; Average employment growth rate is approximately 8% per year; Employment/population growth rate: 0.73. |
| 4. Indicator 3.6: Real estate opportunities in areas within a 800-meter radius of each station (%). | |
| Percentage of unused land 0 $km^2$ (0%) (project land); Percentage of inefficient land which is convertible: 0.08 $km^2$ (4%). | Percentage of unused land 0.456 $km^2$ (22.8%) (project land); Percentage of inefficient land which is convertible: 0.318 $km^2$ (15.9%). |
| 5. Indicator 3.7: Real estates vibrancy | |
| The area has developed stably, the land change is not much. Some locations such as the Hao Nam pond area on the map in 2020 have appeared at the Cat Linh Urban Railway station. | The area has changed markedly in the last 10 years: new urban areas, high-rise buildings sprung up (such as Roman Plaza urban area (3.6 ha), Xuan Mai Riverside apartment building (3.1 ha) with 33 floors...), the green area is narrowed. |

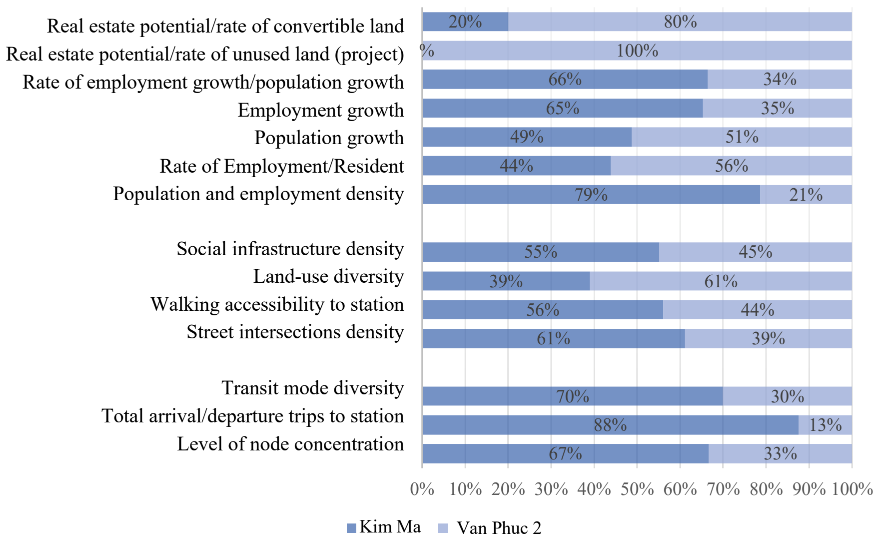



Figure 2. Potential value comparison chart based on the 3V Framework between Kim Ma and Van Phuc station

For the Market value, Van Phuc 2 station has an advantage in 3/5 indicators. Indicators on the percentage of unused land (in project) and the percentage of idle land, inefficiently used land that can be converted at Kim Ma station are 0% and 4%, respectively. Meanwhile, these indicators are 22.8% and 15.9% respectively at Van Phuc 2 station. Besides, the population growth rate in Van Phuc 2 is slightly higher than in Kim Ma, 11.03% and 10.5%, respectively. On the other hand, there is an opposite trend in employment growth: the employment growth in Kim Ma is nearly double than in Van Phuc 2, 15.1% compared to 8% in Van Phuc 2. Besides, indicator 2.3 on land use diversity (entropy index) at Van Phuc 2 station is higher than that of Kim Ma, 0.75 and 0.48, respectively.

On the other hand, compared to Kim Ma, the ratio of people who live within 800 meters from the station and also use public transport is higher in Van Phuc 2 station, according to the results of a questionnaire survey conducted in 2019 [24].

## 4. Discussions

### *4.1. Development potential of a BRT station/terminal area reflects the characteristics of transport infrastructure and its location to the urban center*

Kim Ma BRT station is located in Ba Dinh district in the central area with a long history of development. The street network here has been formed and developed since the beginning of the 20th century. Although only the North-Eastern half of the study area near Hoan Kiem district has a typical grid-shaped street network, the street density here is quite thick, and has many main roads running through such as Tran Phu, Giang Vo, Doi Can, Giang Van Minh... Van Phuc 2 BRT station belongs to Ha Dong district, a new district (established in 2009) in the southwest of Hanoi. This area was developed from suburban villages and agricultural land, interspersed with recently formed urban areas. The street network is mainly village roads with "fish-bone" type and small roads run across the detached house areas. There is only one city main road, which is To Huu street and the district main roads such as Van Phuc - Dai Mo, Ngo Thi Nham street are in new urban areas. The density of car-accessible intersections is poor. It means that the connectivity and accessibility to the Van Phuc 2 station is lower than that of the Kim Ma station. Moreover, the strong urbanization process here together with many new constructions and infrastructure being completed, is partly limiting the travel and access to this station, in addition to the difficulties caused by construction site barriers.

Besides this, the bus route density passing through Kim Ma BRT station area is higher than that of Van Phuc station, in order to easily connect to diverse services in the city center. This shows that Kim Ma has more advantages in terms of passenger scale using public transport and the flexibility of vehicle conversion.

Kim Ma station is located in the inner city area of a historical capital limited from the 1st Ring road, while the Van Phuc 2 station is located in the newly developed area outside the 3rd ring. The advantages of city centers in terms of economic growth drivers through potentially colorful activities like trade services, tourism, job density, land value or public service faciliies were proved both in practice and theory. The calculation results of the location value and market value indicators in the research also indicated the advantages of Kim Ma station area compared to Van Phuc 2 station.

### *4.2. Not every node is weak in terms of development potential*

The above discussion indicates that the advantage of development potential belongs to the Kim Ma area where having twice the number of positive indicators in comparision with Van Phuc 2 station. However, if considering market potential value, 02 related indicators, real estate potential and dynamics during the past 10-20 years showed a reverse trend. Kim Ma area no longer had empty land to transform land use since it had stably developed for a long time. It is different from the case of Van Phuc 2 station - Ha dong district. The real estate market in Van Phuc 2 has been vibrant since the past decades, along with the fast growth of population and the high speed of land-use transformation. The indicator 2.3 about land use diversity indicates the bright spots of market potential in Van Phuc 2 with higher value than in Kim Ma station (0.75/0.48). More over, unrestricted permission of number of floors in Van Phuc 2 would create more attraction to invest high building projects there.

Thus, excluding other indicators, Van Phuc 2 proved its advantage in terms of market potential value. The authority should seek for asuitable management policy to exploit efficiently public transport service, to create attraction and benefits from the agglomeration of jobs and services.

### *4.3. A full approach is the most effective to improve the development potentials in the station area and its vicinity*

The research results relied on evaluating a large enough number of 3V framework indicators. We used a simple and easily accessible way to calculate indicators. Specifically, the node value indicators attained 60% (3 out of 5 indicators); while in location value is 100% (4 out of 4 indicators); and the market value is 70% (5 out of 7 indicators).

The reasons that some indicators were not evaluated are due to data-shortages and lack of information in the context of incomplete public transport systems so far. Another reason stems from insufficient calculation tools and application software. For example, the excluded indicators are 1.2 and 1.3 concerning the proximity and centrality of nodes in the network. These indicators will be more meaningful when Hanoi's public transport network is complete, including urban railways, BRTs, and metros. In the short-term forecast, Hanoi will still develop as a private car/motor - dependent city. Hence, the important indicators related to the density of intersections (car-accessible intersections), and walking distance to the station/terminal won't be much meaningful until the public transit system would be accomplished. At that time, the evaluation of the traffic connectivity and modality conversion is required. The same reason is also explained with the indicator 3.5 on the number of jobs accessible to public transport. Indicators 3.4.1 and 3.4.2 are used to assess the characteristics of social groups who prefer to use public transport. In this study, these were considered as additional indicators. In practice, regarding developed cities, people using public transport regularly belong to the middle and lower income groups who have stable jobs, or simple and self-employed work. Our past study also showed similar consideration. It showed that a higher proportion of people using public transport in Van Phuc 2 area, which has a high concentration of many offices and houses, including in the old surrounding villages.

So even though a few indicators have not been included in this study, we recognized that most of them had similarity and did not affect much of the evaluation results at the time of study.

### *4.4. Addition of management policy to enhance the potential value of indicators to reach more balanced development in the areas affected by BRT stations/terminals*

These initial assessment results showed both advantages and limitations of development potential in the two surveyed BRT stations. On that basis, a number of suggestions to enhance the development potentials for the two station areas were established. For Kim Ma station, most of the indicators revealed higher than in Van Phuc 2 staion, except for the entropy index evaluating land-use diversity. However, solutions to increase floor area, and to build large-scale projects aiming at market value promotion in Kim Ma are not appropriate. Due to the regulation about limiting development in the historical center in Hanoi, the proper choice is still to promote the efficiency of land use rather than increase the quantity. In addition, improving transport infrastructure to ensure connectivity, smoothness and accessibility to the station and architectural works, services, historical and cultural relics, workplaces, and entertainment centers... should be prioritized. In parallel, the conservation and preservation of architectural heritage, landscape, and open space are considered as necessary solutions to attract more tourists coming here by public transport or low emissions vehicles.

In the case of Van Phuc 2 station, the priority is to complete the street network, enhance the connectivity, and encourage pedestrian and cyclist roads within an appropriate distance to the BRT station and other buildings in the area. Parking and spaces for transforming the transport modes need to be planned in the appropriate locations. The permission for raising the large scale and high-rise buildings is suitable because of their advantages in raising the market value there. A fully developed model based on public transit in combination with efficient land exploitation is applicable in Van Phuc 2. It is considered as the advantage of the area around suburban stations.

## 5. Conclusions

The study selected two typical station areas having quite opposite characteristics in terms of the important role of stations in public transit networks, differences in space features, and infrastructure conditions; and the extent of accessibility to the center. The study purpose was to examine and evaluate the indicators of the 3V Framework under different influence conditions. The results also showed a contrast in potential value in the areas around the station or public transit interchange. It is clear that the advantage of development potential always belongs to the area around the station which has a more important role in the public transport network, and owns better conditions to access to the station, such as high-density street network, convenience for pedestrians... Potential values of these stations increase if their location is in the city center where economic activities and commercial services are available, along with a system of historical and cultural values established for a long time. These elements will expectedly attract numerous passengers using public transport. Besides this, the deficiency of areas around smaller transit nodes such as Van Phuc 2 station will be compensated by the potential of the land, and real estate market, as well as loosening development regulations here. Hence, even though the station is located in the city periphery and their important role perhaps lower in network, they still express many opportunities to become a new city center, with many vibrant economic activities, attract many residents and workforces.

In this study, although a few indicators are excluded and the calculation methods used by hand, rather simple, the results still show clearly the weaknesses and advantages in terms of development potentials in each station area. In order to build a comprehensive city development policy, it is necessary to promote research more methodically and apply it above all stations in the public transport system, both BRT and UR. There exists a close relationship between the development potential of the station area which is understood through the market value, and the spatial characteristics of the area, such as infrastructure conditions, accessibility to services. The city development policies need to exploit this relationship effectively in order to propose the suitable measures of planning and management to achieve the potential values of the areas as desired.

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