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Determination of Land Fund for the Development of Static Road Traffic Demand in Hanoi (Vietnam)

PHAN Anh[1, *], VO Thi Hong Lan[2], PHAN Huy Duong[3]

[1] Hanoi Academy of Banking, Hanoi, Vietnam

[2] Hanoi Department of Finance and Planning, Ministry of Public Security, Hanoi, Vietnam

[3] Dai Nam University, Hanoi, Vietnam

Corresponding author: duongph@vnu.edu.vn

Abstract. Determining a reasonable proportion of land fund for urban static traffic will meet the current needs and future development of urban areas, contributing to improving the operational quality of urban transport systems and improve the quality of life of people in urban areas [1]. Hanoi, the capital of Viet Nam, is facing difficulties in meeting the land fund for static traffic development. In 2020, the city's land fund meets only 38.73% of the demand for traffic system development in general, static traffic in particular [2]. By using a regression model on the relationship between GDP per capita and demand for means of transport in Hanoi, the article forcats the demand for urban static traffic development in Hanoi city, demand demand for land fund for its static traffic development to 2025 and 2030. From the forecast results, the article proposes some solutions on meeting the land fund demand for static traffic development in order to achieve efficiency of the government's policis on static traffic development in Hanoi.

Keywords: Static traffic, Determination of land fund for static road traffic

1. Introduction

Static traffic means the entire facilities serving passenger and cargo vehicles during the non-moving time of modes of transport. Static traffic related to space is ground, overhead and underground [1]. Components of static traffic: garages, parking lots, terminals serving intercity transport, inner-city transport, transshipment of goods and passengers [3].

Static traffic ensures the systematic, synchronous, and compatible features of the urban transport system. Static traffic is an essential element of the transport system. The transport system can only operate effectively when the details in the synchronous system are compatible, so it is necessary to put static traffic on par with its importance. This should be considered right from the stage of planning, implementation, and operational exploitation. The main criteria considered here are (1) land fund for static traffic compared to the total urban land area (6-8%), (2) the ratio of static traffic land fund compared to land fund or urban traffic (25-30%), and (3) investment capital for static traffic in the structure of investment capital for urban traffic [4]. In the recent years, the Ministry of Transport has accelerated the investment progress of construction of urban transport infrastructure works, wharves, parking lots, inland waterway ports; urban traffic infrastructure works connecting key airports and seaports; strengthen inspection of the maintenance, maintenance and assurance of convenient bridges and roads for smooth and safe traffic. However, because of the rapid population growth in urban areas along with large travel demand, the land area for static traffic does not meet the demand for static traffic development [4] and the lack of parking spots has led to sidewalks, roadways, parks being occupied and parking lots, parking vehicles are rampant in many urban areas [5].

According to calculations by the Institute of Strategy and Transport Development, in 2025 there will be 600 thousand cars and 7.9 million motorbikes; the number will be nearly 1 million cars and 10.5 million motorbikes in 2030, therefore, it is necessary to increase investment in static traffic development of Hanoi [6]. The article forecasts the demand for static traffic development of the city, thereby determining the demand for land fund for its static traffic development. The article also proposes policy recommendations to improve the ability to meet the land fund for static traffic development, contributing to improving the effectiveness of the policy of static traffic development of the city.

2. Modeling and Research Methodology

2.1. Modeling

Urban static traffic is the entire physical and technical infrastructure serving traffic of the city but not directly involved in the traffic process. Large-scale static traffic is bus station, pier, port and the small scale is parking lot, parking place, etc. [7].

Urban static traffic development is the development of systems of wharves, grounds and space areas to serve various types of transport in non-moving time, optimally meeting the demand for static traffic [8]. According to Tran Thi Lan Huong (2011), one of the criteria to evaluate the results of the proposed static traffic development is the target of land fund for static traffic [8], the author also assumes, the demand for static transport system depends on GDP per capita, and it can be determined through GDP per capita. According to Ngoc Hai (2017), in order to develop static traffic in Hanoi in the context of the limited urban land fund, many measures are needed to expand the space for static traffic, in which, emphasizing the importance of exploiting the above and underground space [3]. Tuan Luong (2021) also said that one of the solutions to improve the effectiveness of Hanoi's static traffic development policy in Hanoi city is to determine the land fund for static traffic development and propose solutions to enhance the traffic capacity, meet the land fund for static traffic development [2].

Thus, the relationship between GDP per capita and demand for land fund to develop the urban static traffic is shown in Figure 1.

Fig. 1. Model of forecasting demand for land fund to develop the urban static traffic.

With the hypothesis: When GDP per capita increases, the number of vehicles will increase, the relationship between GDP per capita (GDPP) and the number of vehicles (NV) is represented by the model [9] as follows:

$$NV_i = \beta_1 + \beta_2 * Ln(GDPP_i) + U_i \quad (1)$$

Demand for land fund (LD) for static traffic development in year (t) is determined by the formula [1]:

$$LD^t = \sum_{j=1}^{m} a_j * NV_j^t * S_j \quad (2)$$

In which:

LD^t - Demand for land fund for static traffic development in year t, m^2;

NV_j^t - Number of vehicles of type j in year t, unit;

a_j - Percentage of vehicles type j using public parking, %;

S_j - Usable area of vehicles type j at the public parking lot, m^2.

2.2. Research Methodology

The article uses secondary data on GDP per capita and the number of vehicles in Hanoi to determine the sample regression function between GDP per capita and the number of vehicles according to the model (1). Secondary data are collected in the period 2008-2020, the regression model is estimated by the Ordinary Least Squares method, the fit of the sample regression function is evaluated through the coefficient of determination R^2; The level of statistical significance of the regression coefficient is tested through the T - test with Sig. < 0.05, The appropriate of the regression function is tested through Anova analysis. Based on the estimated regression model, the article forecasts the number of vehicles in the year of 2025 and 2030 corresponding to the GDP per capita in those years.

Demand for land fund for static traffic development is calculated according to formula number 2 and the data on the average rate of each type of vehicle using public parking, the forecasted quantity of each type of transport means of public parking, the average square of usable area at the public parking lot of each type of transport.

3. Results

3.1. Descriptive statistics on land fund for static traffic development in Hanoi

Parking lots and parking spots for cars and motorcycles: There are 1,178 authorized parking spots for cars and motorcycles (car parking spot: 553 spots, motorcycle parking spot: 625 spots) land area for parking lots and parking spots is 429,269 m^2 [10].

The bus station system in Hanoi consists of 11 inter-provincial bus stations and 30 intra-provincial bus stations in the districts on a small scale. The main bus stations in Hanoi area are from 10,000m^2 to more

than 30,000 m^2. The smaller bus stations vary from 100 m^2 to over 1,000 m^2 (mainly of districts and communes).

Besides, there are ten inter-provincial truck stations with a total area of 5.9 ha. Most truck stations are transformed from ancillary works associated with the wholesale market system or spontaneous ones in the areas of non-fixed traffic hubs. The stability of the truck dock system is low.

The land fund reserved for authorized public parking lots and parking spots counted and surveyed currently meets only 8-10% of the demand for parking spots. Other infrastructures can fulfill the shortage of more than 90% of parking spots. Apartment buildings and urban areas (accounting for about 24%, equivalent to 93.4 ha); offices and private houses (accounting for 63.5% or 245.3 ha); roadbed, sidewalks, dead-end lanes, and schoolyards with areas for toll parking name a few. However, parking spots in the yard of toll collection agencies are not declared by organizations and agencies. Therefore, the exact capacity of parking lots and parking spots is not determined (accounting for about 12% or 46.36 ha); parking spots in the vacant areas of projects that have not yet started construction (accounting for about 0.5%, equivalent to 1.9 ha).

Most bicycle and motorcycle parking spots are narrow in size and small in scale. All the parking spots take advantage of sidewalks and are not built specifically for bicycle and motorcycle parking. Car parking lots are mainly small ones and lack facilities to meet the demand. Most of these parking lots take advantage of sidewalks and roadbeds. Eight new spots are planned and built standardly, among which the most extensive area of 16,000 m^2 with the capacity of 400 cars per day and night is located in the city center. Other parking spots are at the entrance to Hanoi, where incoming and outgoing vehicles are not many. The most significant parking spot is in My Dinh, with two components of 22,000 m^2 and 72,000 m^2, primarily for buses or important sports events at My Dinh National Stadium. Eight current parking lots occupy a total area of 185,250 m^2 with a capacity of 2830 vehicles.

Lack of parking lots is becoming a problem for a long time in Hanoi, particularly after the city expansion of the administrative boundaries. The prominent parking spot is still roadbed with a localized sign without a large-scale parking lot in the main streets. As the minimum standard for a parking spot is 25 m^2 of land, an area of 429,269 m^2 for parking lots (including the parking area on the roadbed and sidewalks) meets 30% of the parking demand in Hanoi, accounts for 0.45% of the urban land fund. Meanwhile, according to the standards of a modern city, static traffic requires 4-7% of the land fund.

Although the land area for static traffic in inner-city districts is insufficient, these districts do not have land funds to expand the number and size of parking spots. Newly built offices have basements for parking, but the capacity is negligible. In the newly constructed buildings in the central area, parking aside from the buildings is an alternative for the insufficient parking lots in the basements. The tunneling, raising the floor, or using the automated parking system of Hanoi has not been conducted due to the high construction cost of these projects. Besides, the parking fees at these spots are very high and not appropriate for living standards. The immediate measure is expanding the parking lots around the entrance to the city.

Tab. 1. Parking lots and parking spots in Hanoi.

No.	District	Number of parking stations and spots	Total area (m^2)	Capacity (vehicle)	Parking area on (m^2)		Name of station
					Roadbed, sidewalks	Parking station built according to planning	
1	Hoan Kiem	63	21,190	1,513	21,190		
2	Hai Ba Trung	27	15,038	1,034	15,038	0	
3	Ba Dinh	26	39,848	1,215	23,173	16,657	Ngoc Khanh
4	Dong Da	11	8,416	385	8,416		
5	Tay Ho	2	320	28	320		
6	Hoang Mai	2	26,717	400	4800	21,917	Kim Nguu
7	Cau Giay	11	41,148	1,236	20,248	20,900	Dich Vong
8	Long Bien	1	12,993	180		12,993	Gia Thuy
9	Tu Liem	2	93,000	1530		93,000	My Dinh 1, 2 Nam Thang Long
10	Dong Anh	1	20,000	160		20,000	Hai Boi
Total		**146**	**27,610**	**7681**	**93,185**	**185,425**	**8**

Source: Hanoi City People's Committee 2019

According to the municipal plan, roads must account for 15-20% of urban land, including 5-6% of urban land for static parking lots. In Hanoi, the land fund for transport accounts for a meager ratio, including land for static traffic. In addition, the improper use of the land fund also contributes to traffic congestion, especially in inner-city districts.

Location and arrangement of parking spots in cities

The ratio of parking lot types by scale in each district is presented in Table 2, in which the outdoor and campus parking lots are listed as "other". The ratio of parking lots on sidewalks and roadbed is 10-15%. The rest of the demand is provided by campus and public outdoor or private parking lots.

Tab. 2. Location of parking lots for vehicles in 2019.

District		Sidewalk	Roadbed	Other	Unidentified
1	Ba Dinh	5%	9%	67%	19%
2	Hoan Kiem	7%	9%	65%	20%
3	Hai Ba Trung	6%	6%	66%	21%
4	Dong Da	6%	9%	64%	21%
5	Tay Ho	5%	8%	70%	18%
6	Thanh Xuan	4%	5%	64%	27%
7	Cau Giay	5%	7%	63%	25%
8	Hoang Mai	4%	6%	66%	24%
9	Long Bien	2%	8%	53%	37%
10	Tu Liem	1%	10%	64%	25%
11	Thanh Tri	2%	11%	65%	23%
12	Soc Son	3%	7%	68%	21%
13	Dong Anh	2%	8%	63%	27%
14	Gia Lam	1%	6%	67%	26%

Source: Hanoi City People's Committee 2019

Current parking lots in Hanoi mainly take advantage of the sidewalks and roadbeds. In some places, parking on the sidewalks is a ban for bicycles and motorcycles. Still, they are kept on the roadbed, such as Hang Bong and Hang Gai Streets, Hoan Kiem District, which makes the roadbed overloaded for vehicles and is now used to keep vehicles, causing the regular occurrence of traffic congestion on the streets.

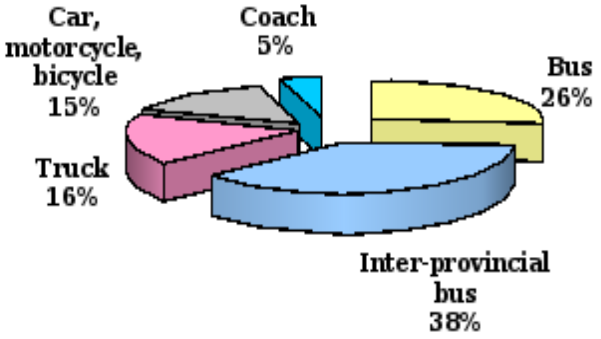

Fig. 2. Parking structure by vehicle type in Hanoi.

Analysis of land funds and parking spots for static road traffic in Hanoi shows that the ratio of land reserved for static traffic is too low. Simultaneously, the means of transport has increased dramatically, significantly personal cars are overgrowing. Lack of parking lots and parking spots for oversized vehicles such as trucks, coaches, and current car parking lots is only suitable for cars and small trucks. The inter-provincial transport stations are usually small in scale, connected to the primary market system, and there has not been a large-scale hub truck station. The gateway areas and traffic hubs lack stops to support the traffic organizations, so the vehicles have to park on the roadbed and sidewalks, causing more congestion. The network of parking spots is not rational in terms of density, location, and distance. Many new cities have not been calculated correctly and sufficiently for parking lots but only arranged separately for high-rise buildings. Many hotels and commercial centers do not have parking space; hence, guests occupy streets

instead of parking. The construction process is always in demand, even in determining the location and size of the land fund. The technical infrastructure of parking spots and parking lots is lacking, the form of parking lots is monotonous, mainly on the ground, equipment and facilities are lacking and inconsistent, etc. Many organizations and individuals involved in the business and operation of the parking spots lead to uncontrolled and cursory management, causing confusion, insecurity, disrupting planning, and losing the city's revenue. Organization and management are still fragmented and limited. Although the City People's Committee has approved the planning for parking lots, the plan implementation is still slow due to insufficient and inconsistent policies, especially the lack of capital.

3.2. Determination of static traffic development demands in Hanoi

Planning a public parking network aims to meet about 66% of Hanoi's total parking demands. The remaining demand for parking is allocated to construction works (offices, training schools, high-rise buildings, etc.) in the direction of an increasing basement and parking area to meet the demands themselves and a part of public demands of the surrounding area.

Hanoi's different transportation types include cargo vehicles, individual cars, coaches, buses, motorcycles, special-purpose vehicles, rudimentary vehicles, and bicycles. The number of bikes has not increased in recent years and remains the same in the future. Special-purpose vehicles are in small quantity and used and preserved separately without affecting public land funds. The rudimentary cars are on a downward trend, so they also do not affect the demand for static traffic in the future. Thus, the construction of vehicle models is as follows: Trucks, coaches, cars, motorcycles, and buses.

Suppose the relationship between the number of vehicles and the GDP per capita correlates through the two-variable function.

Tab. 3. Statistics of GDP and the number of road vehicles in the inner-city areas 2008-2020.

Year	GDP per capita (VND)	Number of motorcycles	Number of cars	Number of coaches	Number of trucks
2008	57862880	785969	96679	5128	6710
2009	62832523	951083	103748	6302	6984
2010	68827318	1112976	112126	7485	8213
2011	72862880	1197166	126478	9050	8571
2012	77432523	1600000	150000	10775	9618
2013	82827318	2154646	177986	13057	10202
2014	85,430,000	2466114	187883	16137	11732
2015	89930000	2850068	209695	19525	11078
2016	93840000	3306079	244295	21380	11300
2017	98375000	3785460	285825	22983	11865
2018	112270000	4277570	332986	25282	12695
2019	120100000	4812266	369614	27304	12885
2020	125700000	5437861	401032	29134	13568

Source: Hanoi City People's Committee 2020

*** The regression results for forecasting the number of motorcycles**

Tab. 4. The results of regression analysis with motorbikes.

	Coefficients				R^2	**ANOVA[a]**	
	β	Std. Error	t	Sig.		F	Sig.
(Constant)	-112,730352.35	7,089,170.683	-15.902	.000	0.960	265.039	.000[b]
GDPP	6,316,585.65	387,996.490	16.280	.000			

The sample regression function of GDP per capita and number of motorcycles is described as follows:

NV_i = 6,316,585.65*Ln($GDPP_i$) -112,730352.35

With R^2 = 0.99 the sample regression function is considered to be relatively concordance.

With T- test, the values of Sig = 0.000 < 0.05: regression coefficients are statistically significant.

Anova analysis results: F = 265.039, Sig = 0.000< 0.05: the population regression function is considered to be concordance.

**** The regression results for forecasting the number of cars***

Tab. 5. The results of regression analysis with cas.

	Coefficients				R^2	**ANOVA[a]**	
	β	Std. Error	t	Sig.		F	Sig.
(Constant)	-7,446,466.894	529,075.619	-14.074	.000	0.950	209.743	.000[b]
GDPP	419,366.647	28,956.770	14.483	.000			

The sample regression function of GDP per capita and number of cars is described as follows:

NV_i = 419,366.65*Ln($GDPP_i$) – 7,446,466.89

With R^2 = 0.95, the sample regression function is considered to be relatively concordance.

With T- test, the values of Sig = 0.000 < 0.05: regression coefficients are statistically significant.

Anova analysis results: F = 209.743, Sig = 0.000< 0.05 the population regression function is considered to be concordance.

**** The regression results for forecasting the number of coaches***

Tab. 6. The results of regression analysis with coaches.

	Coefficients				R^2	**ANOVA[a]**	
	β	Std. Error	t	Sig.		F	Sig.
(Constant)	-606,796.760	35,677.169	-17.008	.000	0.965	305.194	.000[b]
GDPP	34,112.291	1,952.643	17.470	.000			

The sample regression function of GDP per capita and number of coaches is described as follows:

NV_i = 34,112.29*Ln($GDPP_i$) – 606,796.76

With R^2 = 0.965 the sample regression function is considered to be relatively concordance.

With T- test, the values of Sig = 0.000 < 0.05: regression coefficients are statistically significant.

Anova Analysis results: F = 305.194 the population regression function is considered to be concordance; ensures tightness to make the forecast:

**** The regression results for forecasting the number of trucks***

Tab. 7. The results of regression analysis with trucks.

	Coefficients				R^2	**ANOVA[a]**	
	β	Std. Error	t	Sig.		F	Sig.
(Constant)	-155,585.346	11,377.457	212.916	.000[b]	0.951	212.916	.000[b]
GDPP	9,086.185	622.698	212.916	.000[b]			

Coaches Analysis and calculation of model for forecasting number of trucks as follows:

NV_i = 9,086.185*Ln($GDPP_i$) – 155,585.35

With R^2 = 0.951 the sample regression function is considered to be relatively concordance.

With T- test, the values of Sig = 0.000 < 0.05: regression coefficients are statistically significant.

Anova analysis results: F = 212.916, Sig = .000 <0.05 the population regression function is considered to be concordance; ensures tightness to make the forecast

**** Using the model for forecasting the number of vehicles according to GDP per capita in Hanoi.***

Calculation results show that the demand for land fund for static traffic development is 22,780,610.05 m^2 by 2025 and 28,921,103.73 m^2 by 2030**.** The calculation of total parking demand in the table above is based on the area norm for each vehicle type and assumes the total number of vehicles mentioned above but has not considered the static traffic land fund for rail transport, air transport, and waterway transport.

Tab. 8. Forecast results in the inner-city of Hanoi.

Year	Norms	Type of transport			
		Motorcycles	Cars	Coaches	Trucks
2025	GDPP	197,000,000			
	MT	7,908,312	562,896	44,704	17,949
	a	92.67	6.60	0.52	0.21
	S	3	21	52	65
	LDj	21,985,898.19	780,173.86	12,087.96	2,450.04
	LD	**22,780,610.05**			
2030	GDPP	276,000,000			
	MT	10,038,246	704,306	56,206	21,012
	a	92.78	6.51	0.52	0.19
	S	3	21	52	65
	LD_j	27,940,453.92	962,856.73	15,198.10	2594.98
	LD	**28,921,103.73**			

4. Solutions to develop the static traffic system in Hanoi

According to the city's static traffic planning project to 2030, with a vision to 2050, Hanoi will have: 7 inter-provincial bus stations, 8 truck stations; 18,300,000 m^2 of land for public parking; ensure the ratio of land for static traffic reaches 3-4% of urban construction land [2]. However, this plan only meets 60-70% of the land fund for urban static traffic development, so in the coming time, in order to ensure the land fund for the development of static traffic in Hanoi, some solutions can be suggested, include:

Firstly, the investment for smart parking lots is Increase to take advantage of underground and overhead space for static traffic.

High-rise smart parking lots can meet the demand for land fund 3-4 times higher than the traditional parking lots. However, the amount of investment is very large, so in order to strengthen the construction of smart parking lots, the Government should have policies to socialize investment activities for building smart parking lots.

In addition, investment in the construction of underground parking lots also contributes to a increase in the land fund for static traffic development. Hanoi is planning to invest in parking lots in the underground space at 295 Le Duan, Dong Da district with the scale of 1.03 ha, the total estimated investment of 600 billion VND; parking lot in front of the gate and in Thong Nhat Park, adjacent to Tran Nhan Tong street, Hai Ba Trung district with a scale of 0.3 ha, total estimated investment of 450 billion VND; Youth Park parking lot (Thanh Nhan, Hai Ba Trung district) with a scale of 1.12ha, total estimated investment of 800 billion VND; 19/8 Square car park (including the area under the flower garden) in Hoan Kiem district with a scale of 0.32ha, total estimated investment of 350 billion VND; Underground parking lot at Quan Ngua stadium, Ba Dinh district with a scale of 1.12 ha, total estimated investment of 800 billion VND [2]. For achieving the efficiency of planning, it is necessary to issue specific regulations and standards for point and parking projects for investors to implement. Strengthen the management of investment activities, support administrative procedures, prioritize loans, remove obstacles on price mechanism, site clearance, etc. create the most favorable conditions for investors

Secondly, organizations, businesses, hotels, buildings should be encouraged to invest in building parking lots to meet their parking needs. The investment on building parking lots of that organizations will contribute to increasing the land fund for the city's static traffic development. For newly built areas, it is mandatory to fulfill the parking space requirement for the sites and partly support the surrounding. The arrangement of parking spots needs to consider the function of the city's automotive engineering services in this area. It is also obligatory to have independent parking lots and parking spots with an additional 20% of the land fund for greenery to ensure the critical coverage of parking lots reaches over 60% of the total land area. For high-rise apartment buildings, apartment buildings must have adequate parking spaces. High-rise garages should utilize the land fund, such as apartment buildings of over ten floors must have independent high-rise garages, less than ten floors must have underground garages. It is possible to arrange high-rise garages for some alternative low-rise apartment complexes. For sports and entertainment areas, if possible, parking lots should be arranged right on campus. Taking public transportation as the primary form of transportation to reduce the land fund for parking, put into operation in public parking service for the parking places with low use time and the parking places that are often not fully used up their capacity. It is also essential to tree planting to ensure landscape and thermal stability to protect vehicles.

Thirdly, space along some roads, the space of agencies and schools can be enhancing the use of as night parking places.

Some streets and administrative offices with large campuses in the area can be sites for parking, especially at night. Another proposal is arranging parking spots in the vicinity, especially in new cities, specialized in service of restricted development areas. A convenient parking location, combined with low fares and synchronized vehicle engineering services, can be an appropriate solution. Due to the restrictions of the traffic network, when investing in the construction of new routes, parking spots and parking lot systems must be additionally designed and connected to the road.

Fourthly, public transport with the se bus system should be encouraged to develop

Hanoi is the capital of Vietnam, in which most of the Party and State agencies are located, where important diplomatic activities of the country take place. Therefore, the use of public passenger transport services is an urgent need that cannot be separated from the lives of citizens of the capital, creating an urban landscape. Moreover, the increased provision of bus transportation services will contribute to reducing the demand for private means of transport, thereby enhancing the development of static traffic in Hanoi.

Fifthly, the planning on land fund for static traffic development must be complied

The land fund should not be converted to other functional purposes for sites with limited development and expansion but prioritize parking lots and retain the existing parking lots with good positions. It is possible to build an underground garage under park gardens and even lakes. The land of factories and enterprises in the city that must be relocated to the suburbs can transform into parking lots by building high-rise garages or take underground floors as parking spots, depending on the scale.

5. Conclusion

The development of urban static traffic with the demand for land fund is required indispensably to meet the travel demands of the people and achieve the social - economic growth of Hanoi city. To meet the demand for land fund for static traffic development, Hanoi needs to promote the completion and implementation of the land fund development plan for static traffic, increase investment attraction for smart parking lots, underground parking lots, and make use of the space of agencies and organizations. Organizations, hotels, buildings for parking as well as encouraging people in the city to travel by public transport such as buses… To implement the solutions, it is necessary to mobilize resources to socialize and invest in urban static traffic infrastructure development to build a sustainable urban space, to have the mechanisms and policies to encourage and attract the investors' participation, to isue appropriate regulations and standards for parking lots and parking spots projects to guide the investors to contribute to the future's static traffic development.

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