Sri Lanka Society of Transport and Logistics

Journal of South Asian Logistics and Transport
Volume 1 Issue 2 September 2021
JSALT 1.2.4: pp. 57-72
DOI: http://doi.org/10.4038/jsalt.v1i2.34

BUS SERVICE IMPROVEMENT PLAN FOR BATTARAMULLA ALONG WITH LOCATION ANALYSIS FOR A TRANSPORT HUB

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ABSTRACT

Deteriorating quality of public transport is a major concern in Sri Lanka. This study focuses on how to improve public transport in Battaramulla, which is the administrative capital of Sri Lanka, located in its Western Province. This administrative division has 11,000 government workers, of whom 56 percent use buses. It has, over 250,000 residents, 37 percent of whose trips also are made by buses.

This study was conducted to identify the demand and supply characteristics of the area, to analyse bus routes for service improvements and to comparatively evaluate among several sites available to locate a multimodal transport terminal.

Using the results of an Origin-Destination study, it was concluded that four new bus service routes, if introduced, would improve passenger connectivity. It also inferred, through a Multi-Criteria Analysis, and considering accessibility, connectivity and costs, that the best site to locate a multimodal transport centre would be that proposed by the Urban Development Authority.

Since, this study was confined only to bus passengers and bus transport facility improvement, further research may be necessary, including other parameters and transport modes, to validate its outcomes and recommendations.

Keywords: *Public Transport, Bus service, Origin-Destination Study, Multimodal Transport Hub, Battaramulla-Sri Lanka*

1. INTRODUCTION

The term ‘multimodal transport’ refers to the use of several modes to complete a journey. A multimodal transport hub provides facilities accessible by several modes of transport. Kotte-Sri Jayewardenepura is the administrative capital of Sri Lanka, where the Parliament and over twenty ministries and institutions under their purview are located; these institutes employ over 11,000 government employees. Battaramulla is a locality within that, where a majority of these institutions have their main office premises. It is a mid-sized city, 9.2 km away from the centre of the commercial capital, Colombo. Battaramulla is located in the Colombo District of the Western Province and administered by the Kaduwela Municipal Council. It is along the A000 road corridor and is a road junction connecting three major suburban towns namely Rajagiriya, Kottawa, and Kaduwela. Currently, there are eight major bus routes passing through Battaramulla; none of those originate from or terminate at Battaramulla. People transit from Kottawa, Kaduwela and Kollupitiya to take a connecting bus to Battaramulla. Inadequate bus supply resulted in over-crowded buses with a 120% of average load factor in the peak hour.

High trip-attractors such as the Department of Immigration and Emigration and the Department for Registrations of Persons are also located in Battaramulla, attracting many vehicles and passengers daily, resulting in average speed on main roads falling well below 20 kmph [1]. Roadside loading and unloading of passengers also contribute to traffic congestion. Further, the absence of a proper city plan and parking areas cause traffic congestion. It can be observed that taxies are parked on the roadside, blocking the road and consuming more road space. Being the administrative district of the capital city, Battaramulla has passenger demand from all parts of the country. Hence providing better connectivity and better public transport is essential. Growing passenger demand and the increasing road congestion demonstrate that Battaramulla requires a public transport network capable of providing better facilities to encourage the shift of more passengers from private vehicles to public transport.

This research was conceived with the aim of studying the current demand and supply of bus transport services to and from Battaramulla with a view to proposing bus service improvements, particularly through introduction of new services or extension of existing services, and through development of Battaramulla as multimodal transport hub. With regard to the latter, the study aimed at evaluating using Multi-Criteria Analysis (MCA) the suitability of a few potential alternative sites, including that proposed by the Urban Development Authority, to establish a multimodal terminal at Battaramulla. This study was limited only to bus transport connectivity and related facility improvement but would provide some insights into realisation of

the broader objective of improving transport connectivity through different modes at the country's administrative Capital in the future.

2. LITERATURE REVIEW

The concept of 'multimodal transport' begins with freight distribution which aims at increasing the efficiency of distribution system mainly by optimising the cost and time. In common parlance, "multimodal transport" refers to carriage of goods or passengers by two or more transport modes on the basis of a single transport contract from origin to destination [2]. This differs from both intra-modal transportation (integration between the same mode) and inter-modal transportation (among different modes such as piggy-back, fishy-back or birdy-back, yet through different contracts).

The same concept was adopted for passenger transportation where 'multimodal hubs' were developed to provide ground facilities for smooth transfers among different modes. The concept of a 'hub' applies not only in transportation but also in telecommunication networks. The hub concept reduced overall transportation costs. Hub location design considers capacity constraints including the number of flows at the hub and available fleet capacity [3]. The modern concept of multimodal hubs not only facilitates transfers among modes; it also facilitates other passenger needs such as meeting places, shopping, commercial needs, and parking. This concept was developed to attract more passengers to public transport [4]. Based on studies carried out for the development of the European bus system, it was identified that elements such as strategic location, integration between different modes and mobility demand, transfer time, information and signalling, and accessibility should be addressed at the early stages of planning multimodal hubs [5]. The studies for proposed multimodal hubs at Kandy [6] and Kadawatha [7] were reviewed as part of this study to identify the methods to be used at the initial stages of the planning of a multimodal hub. Accordingly, a background study for such planning, including the geographical location, urban profile, existing transport network, demand, and supply, was conducted. Supply analysis was conducted using bus frequency counts and load factors survey data. Existing bus network and transport related issues were considered for further analysis. The objective was to improve passenger experience with minimum impact to existing travel patterns.

MCA is a common method used to identify the best location for a facility out of several alternatives. In this methodology, each location is evaluated against different criteria, which are independent of each other, using a weighted average score. The location securing the highest score would be selected as the best option to locate the facility. A study carried out by Awasthi et al. [8] proposed a location planning framework for urban distribution centres which consists of criteria such as

accessibility, security, connectivity, cost, environmental impact, proximity to customer, proximity to supplier, resource availability, quality of service, and possibility of expansion. In their study, these criteria have been selected through literature review and discussions conducted with transport experts and city groups and categorised into cost criteria and benefit criteria. Proposed locations for the analysis have been identified using prior knowledge and considering city regulations along with stakeholders' interests. The researchers have used a technique called Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) to evaluate the proposed locations. As the final step of the framework, a sensitivity analysis has been performed.

As indicated in Awasthi et al., the Fuzzy Theory, introduced by Zadeh, could be used to model systems having more uncertainty and vagueness which are difficult to define precisely. The parameters would be defined in linguistic terms first, and then a conversion scale would be applied to turn those into Fuzzy numbers [8].

Colombo city public transport development is a high priority project of the Government. The Megapolis Transport Plan [8] has identified that Colombo city needs transport reform to overcome existing congestion. Continued traffic congestion on urban roads and the deteriorating quality of public transport has inflicted major negative impacts on economic performance, environment quality, and liveability of the city. To mitigate those issues, several public transport improvement projects such as introducing luxury bus services, Rapid Transit System (RTS), inland water transport system, and multimodal hubs have been proposed. Moreover, the University of Moratuwa carried out a study to review JICA COMTRANS Masterplan [10]. This study highlighted Battaramulla as the main town within the Kaduwela Municipal Council with 252,100 residents. It is located on the Colombo-Malabe main road, which has only two to three lane capacity. The review study carried out by the University of Moratuwa [10] has recommended that introducing a Monorail system along with transit-oriented development would be the most suitable solution for this corridor.

3. METHODOLOGY

The study area included Thalangama North, Subhuthipura, Udumulla, Battaramulla North, Battaramulla South, Batapotha, Aruppitiya, Asiriuyana and Rajamalwatta Grama Niladari Divisions (GND), mainly because they were considered to be the potential catchment areas for the Battaramulla multimodal transport hub.

Data collection was done with the objective of identifying existing demand and supply. Primary data pertaining to the passenger demand were collected from

employees of, and visitors to, Government institutions located within the study area. Secondary data used were sourced from Household Visit Surveys (HVS) and Bus Volume Counts (BVC) of Colombo Metropolitan Region Transport Master Plan [1]. HVS data had been collected based on Traffic Analysis Zone (TAZ) assigned to each GND to define the origin and destination of passenger trips. The plan of the proposed Multimodal Hub developed by the Urban Development Authority (UDA) was examined to assess the suitability of the proposed location.

The attraction and generation of travel patterns in the study area were observed together with their respective origins and destinations using HVS data, which were also used to calculate the traffic modal shares. Bus frequency along each route serving Battaramulla and load factors were calculated using the BVC data.

The JICA STRADA assignment model was deployed to examine bus passenger demand and supply on the existing road network. The road network, initial origin and destination by mode, and public transport networks, were given as input for STRADA along with other parameters such as speed and fare. The STRADA processed the data and allocated trips to routes by considering the shortest paths. Trip assignment was taken as an output by running the highway reporter module in STRADA which gave total trips for each road segment. Figure 1 below shows the STRADA analysis model with inputs and outputs.

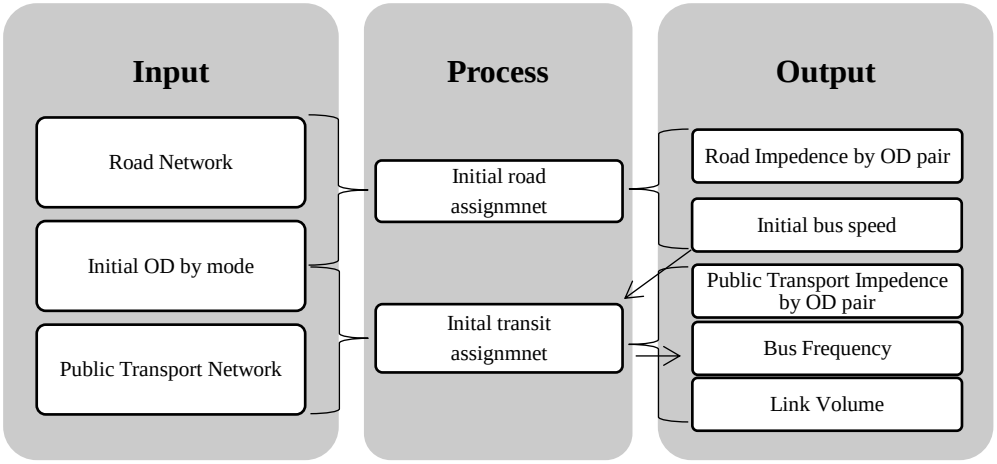


Figure 1: STRADA Analysis Model

Bus supply on each road segment and the bus-based household trip split of each road segment were identified with graphical presentation of the STRADA output. Based on the analysis of the above data the transfer points of existing bus users, the destinations with higher demand, and access roads with higher mobility were identified.

The UDA had already recommended to establish a Multimodal Transport Terminal at Battaramulla within close proximity to the building complexes, housing and most of the Government administrative institutions. The present research opted to perform a MCA to identify the most beneficial location, from among available alternative sites, to locate this Multimodal Terminal. Five candidate sites were subjected to this analysis, having been selected based on the same framework used in Awasthi et al. [8]. Two of those sites had been considered earlier by the UDA in its own evaluations (including the site which was selected by the UDA) 1 and the other three were brought in considering their space availability, proximity to trip attracting and generating points, and opinions expressed by transport experts. The decision criteria for MCA were defined through discussions with transport experts. Some decision criteria identified through the literature survey, including Awasthi et al. [8] in particular, were also considered, which included connectivity, environmental impact and proximity to user. The concept of Fuzzy model identified through the literature review was used to rank alternatives. The weightages for each criterion were decided by the author, based on the knowledge gained through the study. Considering the existing bus supply and future growth, peak hour design capacity requirement was calculated for the hub.

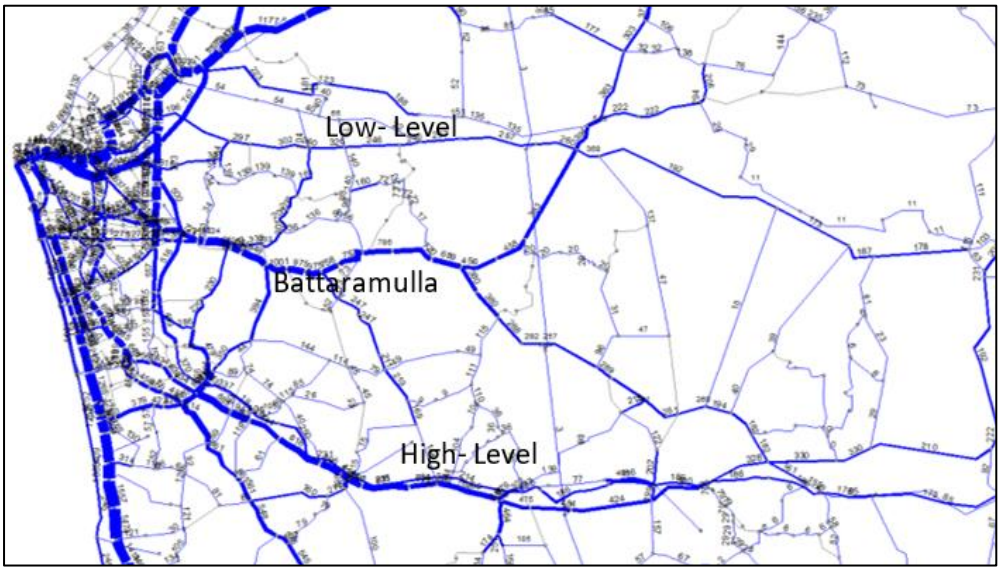


Figure 2: Trip Assignment Output from STRADA

1 Two sites had been considered by the UDA for this purpose. The first candidate site was the area located in the vicinity of the Sethsiripaya and Suhurupaya office complexes which accommodated more than twenty Government institutions, and the second was in the Denzil Kobbekaduwa Mawatha area where there was another concentration of institutions

Figure 2 depicts the trip assignment output from the JICA STRADA. The width of the line represents the number of trips using bus mode for each link and numbers above the line denote the number of trips for each link. The demand for each corridor can be identified by the thickness of each link.

3.1. Results

The HVS data revealed that 85,833 person-trips were attracted to Battaramulla daily. Of these, 26,185 were intra-zonal trips, meaning that they were within the same DSD area. Another 37% of these trips were accounted for public buses. Around 2% of the trips were those transited to bus from railway at some connection point, while the balance being attributable to various other private modes.

Primary data indicated that there were around 11,285 Government employees working in Battaramulla area and it was estimated that around 10,680 visitors were being attracted by these institutions daily. Moreover, it was estimated that, on Wednesdays, being public days, an additional 6,000 people travel to Battaramulla to obtain various public services. Additionally, six schools are located within the study area attracting around 3,750 passengers including students, teachers, and school staff. Furthermore, 61% of Government servants were found using public transport as their main mode of transport while 25% used arranged transport services such "staff transport". 56% of Government servants arrived using bus routes carrying around 231 buses (in both directions) passing through Battaramulla during the morning peak period between 7 and 8 am. Table 1 below illustrates the details of bus routes going through Battaramulla along with peak hour average headway.

Table 1: Bus Routes through Battaramulla with Peak Hour Average Headway

Route Number	Origin	Destination	Peak Hour average headway (in minutes)
171	Kandawatta Junction	Colombo-Fort	4.5
170	Athurugiriya	Pettah	4.5
190	Meegoda/Godagama	Pettah	3
177	Kaduwela	Kollupitiya	2
163	Denzil Kobbekaduwa Mw	Dehiwala	4.5
17	Kandy/ Kurunegala/Nittambuwa	Panadura	20
174	Kottawa	Borella	3.5
186	Jayawadanagama	Borella	12

Figure 3 below depicts the load factors corresponding to each bus route, separately for Colombo inbound and Colombo outbound directions, during peak hours. The average load factor in buses during the peak period was around 120%, revealing an under-supply of bus services during demand peaks.[2]

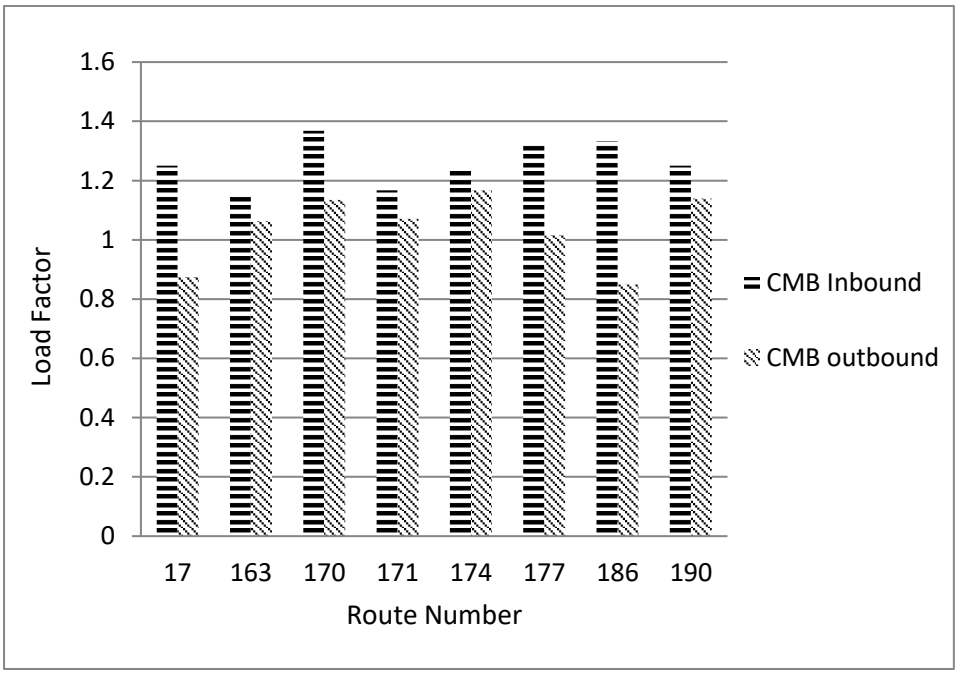
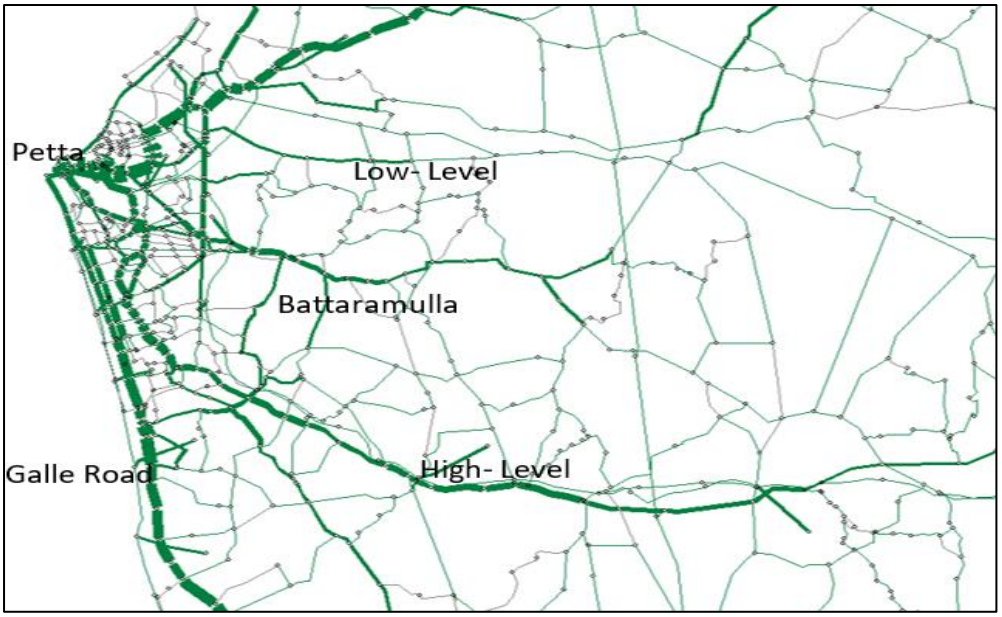


Figure 3: Peak Hour Load Factor

3.2. Analysis of the Adequacy of Bus Services

Given that buses have provided the backbone of public transport for over 100 years [11] in these suburbs, this analysis attempted to examine the adequacy of coverage of bus transport services in this developing area. The STRADA output pertaining to the current demand for bus services by passengers in relation to supply capacity, in terms of the existing bus routes and service frequencies, illustrates that many bus passengers to and from Battaramulla need to get a bus-to-bus transfer either at Borella or Pettah to connect to the major bus corridors serving Colombo city and its environs. Some other access roads to Battaramulla do not have a direct bus supply, thus, dominated by private vehicles. Figure 4 below depicts the existing bus supply within the study area.

[2] The causes behind this observation have to be identified through in depth studies. Some routes may even have excess availability of buses, but overloading could still prevail for other reasons such as not having proper schedules or non-adherence to schedules.



Note: Highlighted lines denote bus supply along the road sectors whereas tiny lines denoted only access roads. The thickness of the line is proportionate to frequency of buses

Figure 4: Bus Supply along the Road Sectors

Figure 5 below shows the attractions and generations to and from each zone along with the current spread of bus routes serving Battaramulla.

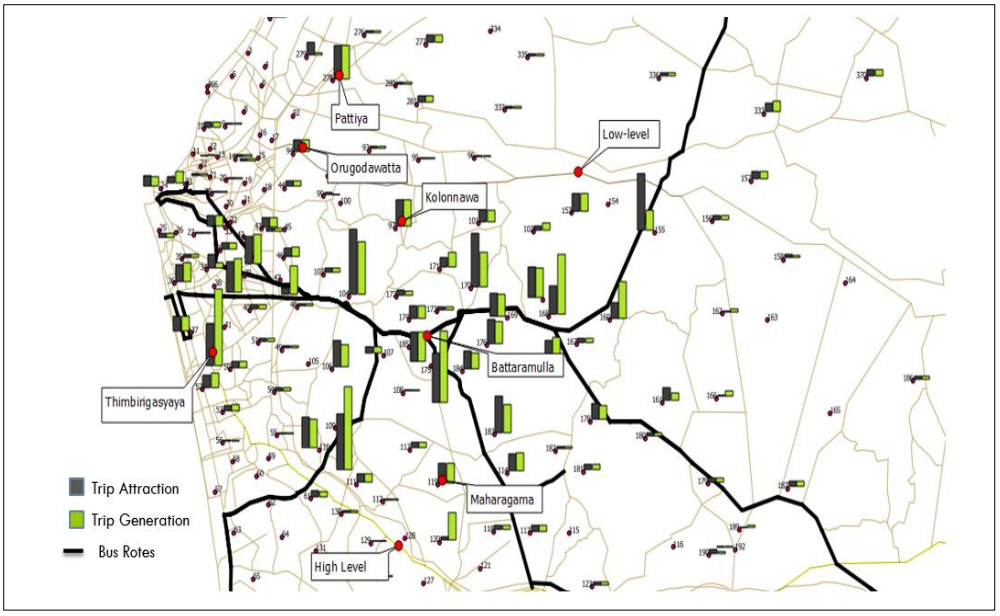


Figure 5: Demand for and Supply of Bus Transport by Zone and Route

Accordingly, it could be observed that places such as Thimbirigasyaya, Maharagama, Kolonnawa, Gampaha, Orugodawatta are found to be locations which, having a large passenger trip attractions and generations to and from Battaramulla, do not have direct bus routes.

Total number of trip attractions and generations at Battaramulla relating to the above identified locations, and the status of having direct bus service (or not) are summarised in the Table 2.

Table 2: Highest Trip Attraction and Generating points at Battaramulla

Location	Total number of trips to and from Battaramulla	Availability of direct bus supply to Battaramulla
Kolonnawa	5,779	No
Maharagama	6,350	No
Gampaha	12,685	No
Thibirigasyaya	52,371	No

Note: Orugodawatta and Peliyagoda zones were grouped in to Kolonnawa.

Source: Analysis of HVS data, and BVC data on current bus supply, 2013 [1].

Based on the above analysis, it is evident that at least four most significant Origins and Destinations of bus passenger trips connecting to Battaramulla have no direct bus services to Battaramulla, and those passengers have to transit at some point during their trip. The following new bus routes could therefore be introduced newly, and subject to their economic viability assessment, could potentially provide and sustain direct and regular bus services to and from Battaramulla:

- Battaramulla to Bambalapitiya (via Borella and Thummulla)
- Battaramulla to Maharagama (via Japanese Friendship Rd and Pathiragoda Road)
- Battaramulla to Peliyagoda (via Angoda and Low-Level Rd)
- Battaramulla to Gampaha (via Expressway E02 and Kadawatha)

Provision of direct bus services connecting those nodes to Battaramulla is likely to greatly convenience the passengers and could possibly encourage modal shift to bus transport.

As the next step, intra-zonal bus passenger trips within Battaramulla were examined. Data sourced from HVS and BVC surveys [1], which categorised the study area, Battaramulla, into seven Traffic Analysis Zones (TAZ), namely, TAZ170, TAZ173, TAZ174, TAZ175, TAZ176, TAZ184 and TAZ185, were used for this purpose.

Table 3: Bus mode user trips distribution within Battaramulla

Zone Code	TAZ 170	TAZ 173	TAZ 174	TAZ 175	TAZ 176	TAZ 184	TAZ 185	Total no of trips
TAZ170	0	65.8	53.2	750.8	29.9	130.4	0	1,030.1
TAZ173	65.6	77.2	0	59.7	40.5	0	0	243.0
TAZ174	52.7	0	0	0	0	0	26.6	79.4
TAZ175	319.8	59.5	0	172.6	257.3	153.0	0	962.2
TAZ176	29.9	40.5	0	291.9	72.2	0	31.0	465.6
TAZ184	216.9	0	0	100.9	0	0	38.1	356.0
TAZ185	0	0	26.6	0	31.0	38.4	481.6	577.7
Total								3,714.0

Sources: Data from HVS and BVC, 2013 [1]

Intra-zonal bus trips within this area, depicted in Table 3, clearly indicates that the highest number of trips made has been within the zone TAZ170 and TAZ175 (Between Thalangama North and Battaramulla North which is from Denzil Kobbekaduwa Mawatha to Battaramulla junction).

This observation suggests that the existing bus services within this section may have to be further strengthened. In this respect, the authorities may consider extending the presently existing bus route number 152 to serve Battaramulla, which is currently starting at Koswatta (Talangama North). This extended service could operate via Denzil Kobbekaduwa Mawatha from Koswatta to Battaramulla to provide a more direct service for passengers, as well as would provide better bus connectivity high trip generating Government agencies such as Department of Immigration and Emigration, which was relocated recently.

3.3. Seamless Bus Connectivity at Battaramulla - A Transport Hub

Public transport service improvement would not be successful unless those improved services are properly coordinated and inter-connected. Seamless transfer, fisrtly among bus services, and thereafter among all modes of transport, would be necessary, for improved bus passenger transport system is to sustain its service delivery efficacy, and also to ensure greater modal shift to bus transport. In this respect, the “Hub Concept” becomes important. This study atempted, (i) to estimate the bus loading and unloading facility requirement at Battaramulla, considering it as a “Bus Transport Hub”, and (ii) to examine a suitable site to locate it, developing it as a Multimodal Transport Terminal.

(i) Required Bus Bays for a Bus Transport Hub at Battaramulla

The study used STRADA calculations of bus passengers who would either board or transfer at Battaramulla to estimate the required number of bus bays for effective and seamless interchange. For this purpose, Colombo inbound and outbound buses during peak hours were clustered separately according to destination. The number of buses that could be allocated per bus bay per hour was calculated using assumed dwell times of 2 minutes, 10 minutes, and 15 minutes, for through buses, local buses starting at Battaramulla, and Expressway buses, respectively. The required number of bus bays to accommodate the number of busses per hour that would be needed to meet the estimated passenger demand on existing and newly proposed routes, could thus be worked out. Summarised results are presented in the Table 4.

Table 4: Number of Bus Bays Required for New Hub

Bay Cluster Number	Colombo Inbound Buses		Colombo Outbound Buses	
	Description	Number of Bus Bays	Description	Number of Bus Bays
1	Buses to Pettah (171,170,190)	2	Buses to Malabe Side (170,190,177,17)	3
2	Buses to Galle Road (17,163,177)	2	Buses to Denzil K.R (171,163)	2
3	Buses to Borella (174,186)	1	Buses to Pelawatta (174,186)	1
4	New Route Originate from Battaramulla (local & express)	8	New buses end from Battaramulla	1
Total		13		7

Assumptions:

(a) Buses going through the hub would have a dwell time of two minutes.
(b) Incoming passengers of buses terminating at Battaramulla would disembark at a common bay
(c) Local routes starting from Battaramulla would take 10 minutes of boarding time
(d) Expressway buses would take 15 minutes of boarding time.
(e) Existing bus frequency will be increased by 20% with improvements

Note: The calculation was based on the supply of and demand for buses only. The requirement for mode sharing within the terminal, when the Bus Transport Hub is upgraded to a Multimodal Transport Terminal, has to be estimated separately.

Accordingly, it is estimated that a totality of 20 bus loading and unloading bays would be required for a Bus Transport Hub at Battaramulla to accommodate and facilitate peak hour bus supply and passenger demand.

(ii) Location for a Multimodal Terminal

Battaramulla has limited land availability to accommodate a multimodal transport terminal. As described earlier in the methodology section, five locations were identified after examining the area carefully; these were considered as potential sites for the purpose. Figure 6 illustrates the geographical dispersion of candidate sites listed below which were selected for MCA:

- Location 1 - Rajamalwatta, near Timber Corporation Road
- Location 2 - Subhuthipura, near to Suhurupaya
- Location 3 - Udumulla, near to Kanatta Road
- Location 4 - Aruppitiya, Denzil Kobbekaduwa Road
- Location 5 - Between Suhurupaya and T-junction

(Locations 4 and 5 were considered by the UDA as well, in its analyses)

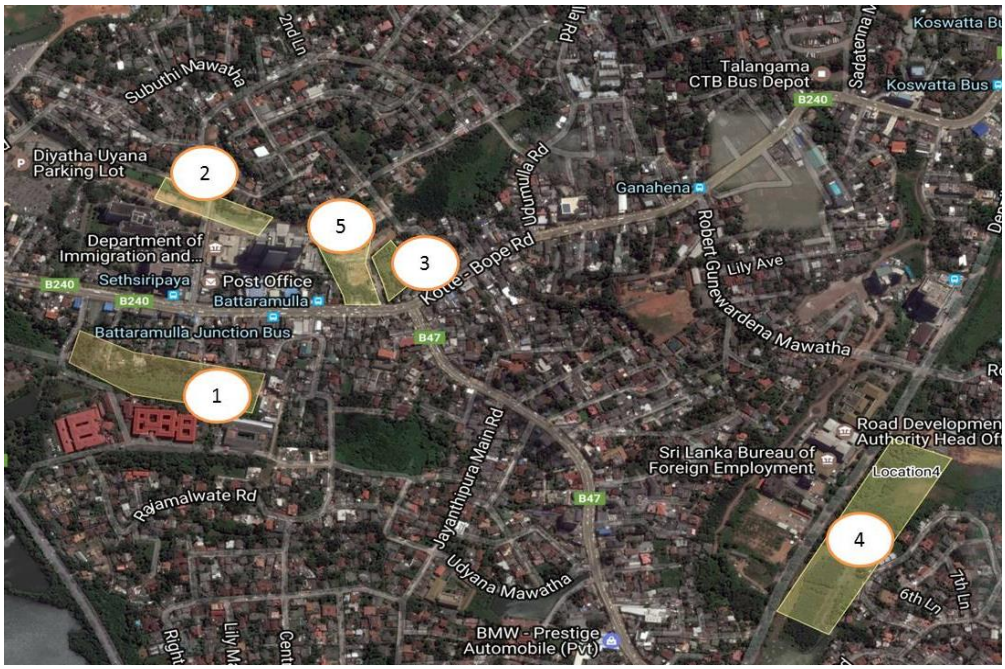


Figure 6: Alternative Locations for Multimodal Hub Development

All locations were subject to MCA. Decision criteria for the analysis were identified through literature survey and discussions during the field survey. Weight for each criterion was also determined by the author with experience gained through the study and those were further validated through discussions with transport experts. Accordingly, higher weights were assigned for more important criteria. Inputs were obtained from transport experts when ranking among criteria using the range from 1 to 5; the highest rank of 5 being assigned to the best choice and 1 for the worst.

Table 5: Multi-Criteria Analysis for Location Identification

Decision Criteria	Weight	Rating					Score				
		L1	L2	L3	L4	L5	L1	L2	L3	L4	L5
Connectivity to existing bus network	15	2	3	4	1	5	30	45	60	15	75
Minimum distance to the bus route	5	1	2	4	3	5	5	10	20	15	25
Space availability (land size)	15	5	2	1	3	4	75	30	15	45	60
Proximity to users (employees and visitors)	15	3	4	1	2	5	45	60	15	30	75
Demand (trip attraction, trip generation HVS)	10	3	4	1	2	5	30	40	10	20	50
Minimum environmental impact	10	2	5	3	1	4	20	50	30	10	40
Minimum impact on traffic during construction	5	5	3	2	4	1	25	15	10	20	5
Possibility of land acquisition	10	5	2	1	4	3	50	20	10	40	30
Expansion for future demand	10	4	2	1	5	3	40	20	10	50	30
Cost of site development	5	2	4	3	1	5	10	20	15	5	25
Total	100	32	31	21	26	40	330	310	195	250	415

Table 5 presents the results of the MCA. Outcomes revealed that Location between Suhurupaya and T-Junction (L5), the site selected by the Urban Development Authority (UDA) as well, would be the best option among all sites considered. Location L1 could be identified as the second-best option.

4. CONCLUSIONS AND RECOMMENDATIONS

The outcomes of the research were very clear, pertaining to the importance of Battaramulla as an important transport node, and to the need of improving public bus transportation to and from Battaramulla. This was amply reflected by very high load factors found in buses during peak hours. Analyses of data sourced from JAICA STRADA and Household Visit Surveys and Bus Volume Counts of Colombo Metropolitan Region Transport Master Plan, further substantiated this finding, particularly through trip assignment output and bus supply output of the research.

Investigations into ways and means of improving the bus services, and particularly those suggested in the previous studies, yielded several possibilities. First, bus services could be improved with four new services and two service route changes, the

study revealed. Bambalapitiya, Maharagama, Peliyagoda, and Gampaha emerged as the most suitable destinations to introduce those new routes, while route number 152 could be suggested to be extended to Battaramulla via Denzil Kobbekaduwa Mawatha to provide better connectivity and accessibility at Battaramulla, while minimising the need to transit. Second, it was found that the improvement of the bus service could be further strengthened, firstly by coordinating the bus services at Battaramulla by organising it as a Bus Transport Hub, and thereafter by integrating it with the proposed Multimodal Transport Hub at Battaramulla.

The outcomes of the MCA conducted considering five criteria including connectivity, proximity, and cost of development, in view of comparatively examining the possible alternative sites for the proposed multimodal transport hub, enabled recommending the land behind the Suhurupaya building, proposed also by the UDA, as the most suited site to locate it. The Multimodal Terminal would perform as a hub and facilitate better connectivity among different modes, near-seamless interchange, parking and provide other facilities at one place. The newly proposed bus routes would help reduce bus load factors. These solutions, together with future development around the multimodal hub, could be expected to incentivise usage of bus travel, and to potentially reduce the use of taxi services and private vehicles, thus, would pave the way for a sustainable modal shift from private vehicles to public transport, resulting in reduced traffic congestion as well.

It may be noted, however, that this research was limited to bus network coverage improvement based on a demand and supply analysis. Besides, only a limited number of candidate sites, those were made known to the study, in the close proximity to Battaramulla town centre, were taken into comparative analysis in view of locating the proposed multimodal transport terminal. Furthermore, many situational changes have occurred since this study was conducted in 2017/2018, including the cancellation of the LRT project discussed in the study, the expansion of expressway and other roadways, the construction of a new road bypassing the Battaramulla junction, which have substantially changed the transport landscape. Therefore, future research may be required to update and re-validate the findings of this study, while, at the same time, considering other possible areas of service improvement and other potential locations for the proposed multimodal terminal, that may have become material since then.

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