

## **PARKING DEMAND AND SUPPLY BEHAVIOR OF THE USERS IN A HILLY TERRAIN AT BANDARAWELA CITY**

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**ABSTRACT** - Parking facilities can serve an important role in a city center. Parking demand and supply attribute balance is contributing to the proper traffic management in a city. Bandarawela is a one of major cities in Badulla district with higher topographic variability as the specific attributes to this city. This study has identified several issues that are inheriting to the mountainous topography. Determining the balance of parking demand and supply, most using vehicular modes, type of parking, analyzing the attributes of parking that can be used for future developments in hilly terrain. Series of analysis using statistical analysis techniques is included as the methodology for data analysis. It is expected that the outcomes and recommendations will be useful to predict parking demand and supply behavior of the users in a hilly terrain.

**Keywords:** *Parking Supply Adequacy, Adverse Geography, Hilly Terrain, Vehicle Ownership, Parking type*

### **1. INTRODUCTION**

Bandarawela is a city located at 1,200m above the mean sea level in high altitude and surrounded by large number of mountains according to the geographical perspective. Bandarawela has the most favorable climate in the country and therefore both national and international tourists' attraction is at a high level. Bandarawela is a suburb of Badulla District, about 28 km away from Badulla City along the Beragala-Hali Ela National highway (A16). The city is confined to an area of about 27Sqkm and Bandarawela has a population of about 65,000 in 2012[1]. However, Bandarawela Municipal Council area has a population of about 24,000. Parked vehicles that obstruct the road traffic, irregular parking arrangements are the major and common transportation related issues in Bandarawela City. Main reason for this situation can be understand as the present road network and the node connectivity within high dense commercial developments concentrated to the inner core area of the city. The buildings are built often in a land with high gradients where, the access roads, parking spaces, vehicle maneuvering space within the development lands are limited and stringent spacing allocations are common with the topography of the area. As a result, the common standards stipulated in the UDA regulations are often not been able to maintain by the developers of the households and the commercial entities in this hilly terrain.

Some common findings from many studies show that changing or introducing parking regulations (e.g., adjustment of parking prices and hours) serves as a straightforward approach to reduce parking problems[2]. The Urban Development authority had published the regulations [3] that includes all parking regulations and traffic circulation controls for both residential and commercial land developments.

#### **1.1 Objectives of the study**

Following are the main objectives of this research paper.

- To understand the issues on parking demand and supply attribute balance with hilly terrain inherent to Bandarawela Area and evaluate its adverse impacts to transport system.
- To find the relationship of economic strength behavior and the transportation supply attributes of the users' solutions.

## 2 METHODOLOGY

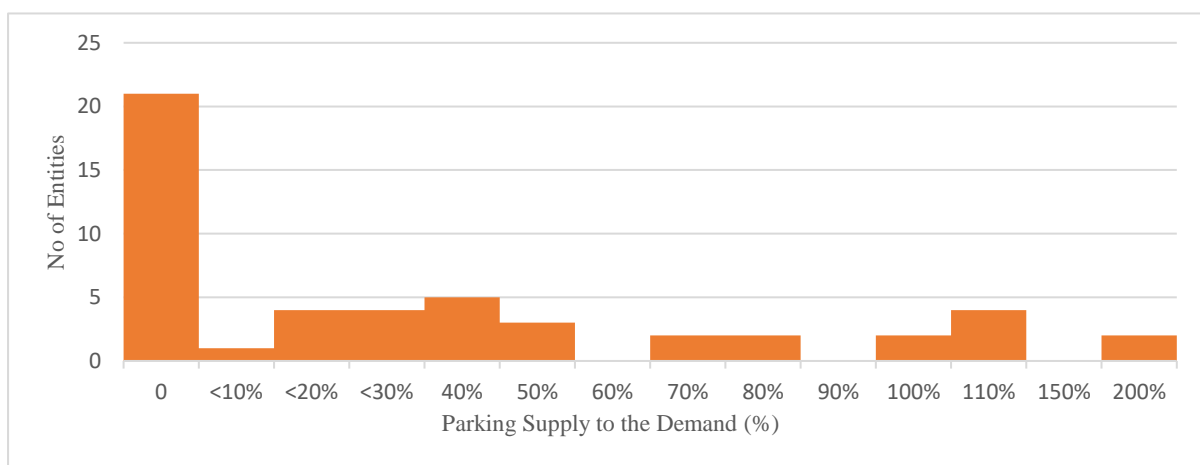
The basic approach and methodology of this analysis is to analyze the present parking supply attributes and the demand conditions with respect to the available infrastructure facilities to both residential land use and the commercial land use. This analysis is based on empirical data collected from a comprehensive survey carried out in Bandarawela City area in March 2022. Simple random sampling method is used to select the sample and 1.5% of household units were selected as the sample for the household survey. Commercial amenities were selected as they are centralized to the city center and to represent all the types of commercial activities including banks, shopping malls, retail stores, restaurants, supermarkets etc. Therefore, randomly selected 60 residential units and 50 commercial amenities within the Bandarawela Municipal Council was selected as the sample to conduct the study. Both quantitative and qualitative analysis has been done to produce the main outcomes of the research.

## 3. RESULTS AND DISCUSSION

The data collected were first analyzed to identify adequacy of parking supply at the households and the commercial amenities in Bandarawela City Center. Then the standards of parking slots have been analyzed by focusing the aspects such as aisle width, width of access road, gradient of access road, stall length and width etc.

### 2.1 Parking Supply and Demand Balance

According to the analysis, majority of commercial activities have not provided required parking spaces for their facility users as per the regulation requirements. Moreover, there are some shops (apparel) with large floor area which are having higher parking requirement, not considered to provide any parking facilities as of now clearly depicts that the gap between the parking demand and the provided supply where majority of the developments have provided no parking for customers even though their estimated demand is more than 30 number of parking spaces. Only 16% of the commercial entities have provided their own car parks satisfied the total demand and above while 75% of the commercial entities have failed to provide at least 20% of the parking demand out of the selected sample for the study. In general, the commercial entities of the City area have failed to provide the minimum requirements as per the UDA regulations as per this analysis[4].



**Figure 4.** Parking Demand vs. parking supply

## 2.2 Vehicle Ownership per Household

As shown in **Error! Reference source not found.**, the results depict that majority (74%) of households have at least a vehicle. 61% of households which are having motorcycles, have another vehicle. The weather conditions on the upcountry geography with intermediate rains trough out the year might have resulted in having another vehicle in in addition to motorcycle where people can use them in all weather conditions. Most of the time parking facilities are arranged by them for all their vehicles within their own premises.

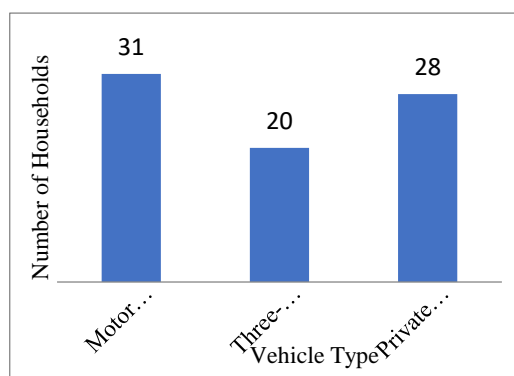


Figure 5. Vehicle Type Vs. No of Households

**Table 3.** Vehicle Ownership per Household

Vehicle Ownership	Number of households
One vehicle per household	37
Two vehicle per household	16
Three vehicle per household	7

As shown in **Error! Reference source not found.**, 62% of households are owning a vehicle and 27% of households are owning two vehicles. Higher operating and maintaining cost for vehicles due to terrain characteristics might have resulted in using motorcycles often.

However, one of the major issues in households is access roads though ramps and gradients of ramps are higher than standards. With the limitation of space in land plots and the topography of the area most of the users have failed to supply standard ramps to access the development. According to outcomes, 23 households are having ramps as access road and gradient distribution of these ramps are shown in **Table 4** below. The majority of the selected households are having the ramps steeper than 20%.

**Table 4.** Distribution of Ramp Gradients

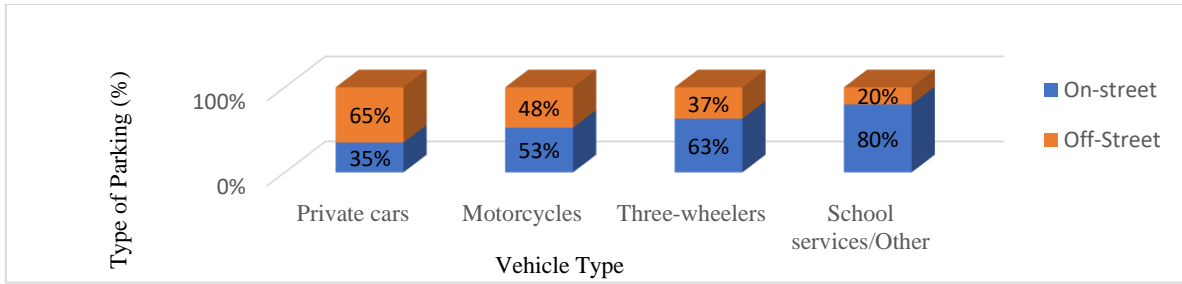
Ramp Gradient	Number of HH	%	Motorcycles	Three wheelers	Cars
0-5%	2	9%	1		2
5%-10%	4	17%	2		3
10%-20%	5	22%	1	4	2
Above 20%	12	52%	8	5	4

## 2.3 Vehicle ownership and Travel pattern analysis

The details of trips performed during a single day were enquired from the respondents of the survey to capture the trip modes and the parking related attributes. As in **Table 5**, the majority of the respondents have chosen motorbikes for their travel needs while approximate equal number of respondents have used private cars and public transport which stands the second highest.

**Table 5.** Transport Modes

Transport Mode	Private Car	Motorcycle	Three-Wheeler	School services/ Other	Public Transport	On Foot
Number of Trips	20	40	5	8	19	11
%	19%	39%	5%	8%	18%	11%



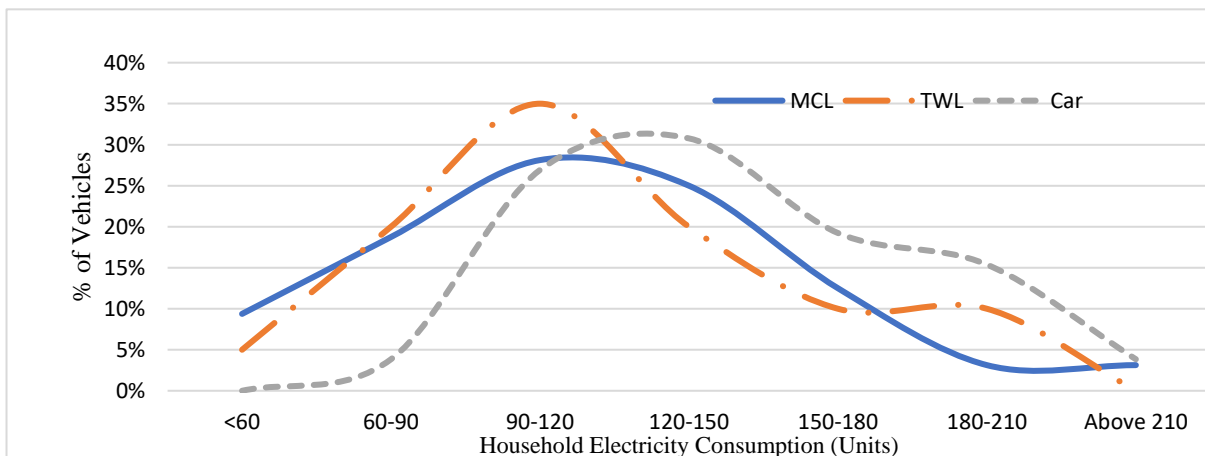
**Figure 6.** Vehicle mode use by vehicle users and parking facility

At the destination of the trip, type of the properties of parking facility used by the respondents is illustrated in

**Figure 6.** Majority of parking facility except cars is taken by on-street parking. It is to be specially noted that more than 80% of the school vans are using on street parking which is promoting large number of under aged school children walking considerable distance along the road to board their respective school vans.

## 2.4 Relationship between Vehicle Ownership and Electricity Consumption

The relationship between household electricity consumption and income levels are correlated and has been researched in the past. Therefore, electricity consumption can be treated as a surrogate variable for the income in which case is very difficult to collect accurately through household interview surveys. Relationship between vehicle ownership and electricity consumption is illustrated in **Figure 7**. **Reference source not found..** The outcomes depict that majority of households which are having motorcycles are consumed 90-150 units of electricity and households which are having three-wheelers are consumed 90-120 units of electricity. When it comes to car owners, most of them have high consumption compared to other users with majority in 120-150 units category. It implies that the comfortable level of vehicle of the household is correspondingly proportional to the electricity consumption which is an indication of the household income level.



**Figure 7.** Vehicle Ownership and Electricity Consumption

## 4. CONCLUSION

Bandarawela is a city with significant variability in topography. Therefore, the study reveals that most of the parking spaces at households are sloppy in geography and access roads are also ramps which are having higher gradients. Moreover, due to less width of access road (less than 3m), sloppy topography of parking spaces, maneuvering process of vehicles in households become difficult. Research outcomes

show that there is not balance between parking demand and supply of commercial amenities where 76% of commercial amenities not providing required parking facilities when it considered the difficult hilly terrain of land use inherent to Bandarawela area. This had led to significant level of on-street parking within the city. As results, traffic congestion is caused, and pedestrian movements are restricted. On the other hand, due to un-provided parking space, people have to park their vehicles somewhere faraway and reach the commercial amenities. It has led to increase in pedestrian movements, pedestrian crossings and decrease in safety. Moreover, Multi-axle vehicle are arrived the commercial amenities and if those vehicles are parked in the on-street parking places, turning is difficult & width of lane is decreased. One reason for this scenario is turning radius is not enough for multi-axle vehicles. Public parking area for affordable pricing, adequate parking supply for new developments are recommendations for avoid these issues. Many other commercial and economic activities such as tourism, street foods can be improved by solving this issue in Bandarawela.

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