DEVELOPMENT OF WALKING TRIP RATES FOR DIFFERENT LAND USES

Chamali Hewawasam
Ph.D Candidate
Department of Civil Engineering
University Of Moratuwa
Sri Lanka
Email: chamalih@yahoo.com

Saman Bandara
Professor
Department of Civil Engineering
University Of Moratuwa
Sri Lanka
Email: bandaras@sltnet.lk

S.C. Wirasinghe
Professor
Department of Civil Engineering
The University of Calgary
Canada
Email: wirasing@ucalgary.ca

ABSTRACT

This paper aims to develop walking trip rates for different land uses in an urban area. Walking trip rates are developed for six identified land use categories, namely residential, commercial, institutional, recreational, transportation and religious. In conventional modeling processes, the number of trips made by a household is modeled in terms of household size, income, and other socio demographic variables; any effect of location, land use, or transportation service level is discounted. However, trip rates must vary with accessibility and some empirical studies have found that they do. In light of conflicting empirical results, and the obvious need for more truthful and policy-sensitive travel forecasts, this issue is revisited. It was found out from the literature that while methods for finding trip rates for motor vehicles are well established, there are not many established procedures for measuring and predicting trip rates for non-motorized trips, though some researchers have found trip rates for selected land uses, for households in particular. The independent effects of land use and accessibility variables on household trip rates are tested using data from house hold travel surveys and trip diaries. To collect data on travel behavior of the dwellers, household travel surveys and trip diaries were used. After developing the household travel survey form and trip diary form, a pilot study was carried out to finalize the survey forms. By analyzing these data along with road side surveys, trip rates were identified for the selected land uses. This is a unique attempt to develop walking trip rates for different types of land uses.

Key words: Pedestrian demand, Walking Trip Rates, Walkability, Travel Surveys

1. INTRODUCTION

Incorporation of pedestrian concerns into the transportation planning process is extremely important. Walking is considers as the most efficient and environmentally friendly mode of transport for shorter distance trips. Walking require no fuel energy, cost nothing and accessible to all irrespective of the age, gender and ability if facilities are provided appropriately. An appropriate pedestrian facilities system is a crucial contributor to a vibrant economy, and quality of life; it supports efforts to combat global warming and climate change. In essence, the pedestrian facilities system is important because of its positive contributions to modern life.

The aim of transport modeling is to predict patterns of movement and the functioning of movement systems, yet research in this field until now has been almost exclusively focused on motorized transport to the exclusion of other modes. Perhaps the neglect of pedestrians in the research arose because modeling started at the same time as automobile dependence became a key feature of transport, so attention was focused on understanding vehicular traffic. However, there has been growing social pressure to develop more sustainable transport polices in response to automobile dependence and this is beginning to change the agenda for transport modeling.

Past and recent research has used a combination of surveys, travel behavior models and regression analysis when developing pedestrian trip generation rates. Some researches has conducted surveys by using trip diaries and stated and revealed preferences surveys to understand how individuals' travel behavior varies under different land use and accessibility circumstances. Most of these travel

behaviour or demand models are focused on automobile. The techniques used in planning for pedestrians are underdeveloped. Since walking is now considered important, effort to develop and improve pedestrian demand models should be undertaken.
Further, in order to develop pedestrian facilities it is imperative to know the demand and for finding pedestrian demand for roads we need to know the trip generation/attraction rates for different land uses as walking trip rates has an effect on land uses. The goal of this research is to identify walking trip rates for land uses in Sri Lankan context as there are no reliable trip rates developed for urban areas in Sri Lanka. Accordingly, this paper discusses the methodology of developing walking trip rates for six chosen land use categories in Panadura urban area, namely residential, commercial, institutional, recreational, transportation and religious.

2. LITERATURE REVIEW

A literature review was undertaken as an initial step of this research to identify existing best practices relating to the generation of walking trips. Data relating to walking has been collected for many years mainly on an area-wide or corridor basis for transport modeling or monitoring purposes; not necessarily relating to individual land use activities.

One of the few existing major data source for multi-model trips associated with developments is the Trip Rate Information Computer System (TRICS), which is a UK based trip rate data base. When collecting data TRICS use a three step process; site visit/inventory, survey design/specification and data collection. TRICS have three levels of multi-modal survey collection methods. This methodology within TRICS guidelines provides a form only for multi-modal transport.

Richardson et al (1995) described in broad terms what the types of surveys available with their advantages and disadvantages and the tasks to be addressed when planning a survey. This book also suggests five reasons for a transport survey. It provides a useful description of the typical transport survey process from preliminary planning through to the presentation of results with important steps that were considered as part of this research when planning and carrying out surveys. As it was stated, it is decided to collect a limited amount of good quality data within the budget rather than a large amount of poor quality data by carrying out sample surveys. For an example, a survey with a few short questions and a very high sample rate considered to be more representative of household data. As the book gives both the advantages and disadvantages of different type of surveys, household travel surveys, trip diaries, face-to-face questionnaires, observer surveys, activity surveys and pedestrian counts and origin-destination (OD) surveys were selected to gather data and for the survey design.

Dasgupta et al (1996) reviews methodological practices and factors determining trip attraction rates, modal split, travel times and trip lengths to specific developments. It describes ‘trip generation’ as meaning something quite explicit in terms of traffic models, but suggests this is not strictly correct when considering land uses as these are usually ‘trip attractors’. ‘Trip attraction’ is therefore more applicable when describing trip rates to different land uses. Peachman et al (1997) reviewed three survey methods available for the purposes of household travel surveys, such as face-to-face interviews, drop off/mail back and mail out/mail back. Travel and activity diaries were tested for each of the three survey types. The research stated that face-to-face questionnaires using a travel survey method is the most suitable for a household travel survey as this provides the highest response rate, data quality and range of items for a similar cost to other methods.

It is clear that organizations, which have traditionally focused only on developing motor vehicle trip rates, are now beginning to recognize the need to include non motorized trips as well. The Road and Traffic Authority (RTA) in New South Wales, Australia has commenced a series of trip generation and parking demand studies, to update the background research in the widely recognized and adopted Guide to Traffic Generation Developments. The institute of Transportation Engineers’ (ITE) published trip generation rates for various types of land uses. All these rates do not include pedestrian data and they are currently in the process of including walking trip rates as well.

3. METHODOLOGY

The process adopted for the research is broadly outlined in Figure 1.

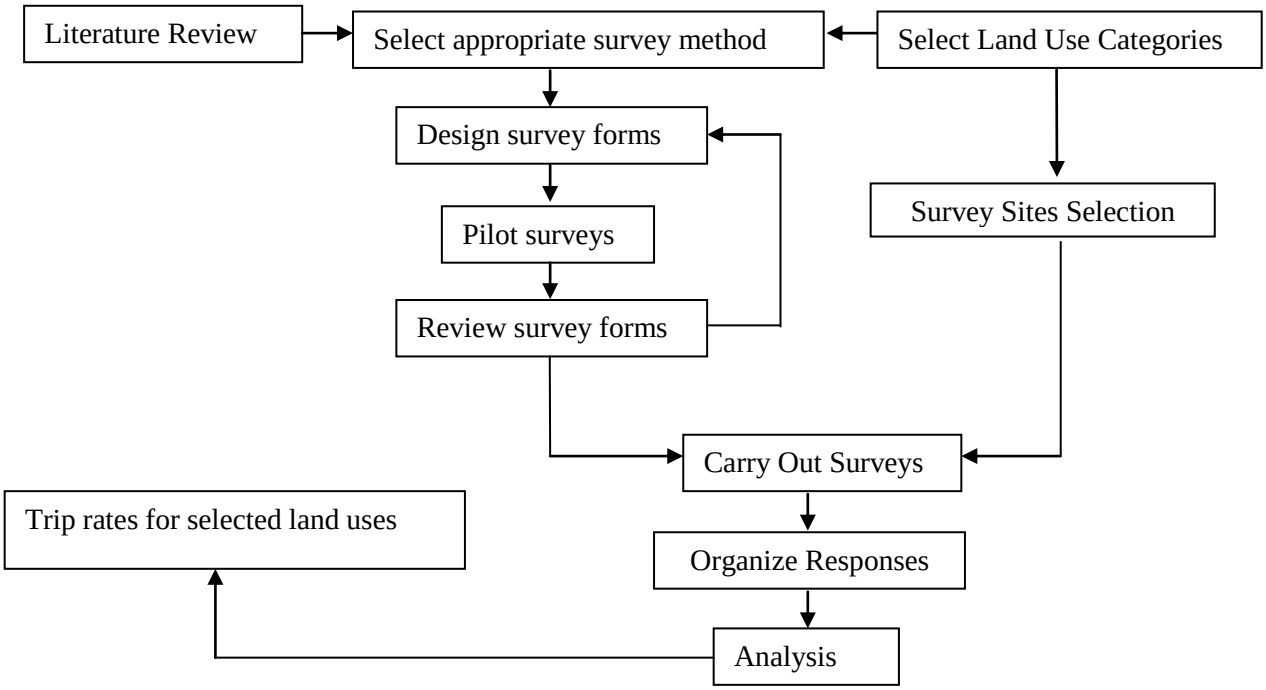

Figure 1: Research Methodology

3.1 Surveys

It was found out from the literature that while methods for finding trip rates for motor vehicles are well established, there are not many established procedures for measuring and predicting trip rates for non-motorized trips. There are household surveys and census results that are of limited use when finding trip rates. Even though developed countries do carry out household travel surveys regularly, countries like Sri Lanka does not have such surveys carrying out other than the census. Since this is an initial effort in finding trip rates for selected land use categories in Sri Lankan context, survey design became a vital component. Household travel surveys, trip diaries, face-to-face questionnaires, observer surveys, activity surveys and pedestrian counts were used to gather data for the development of pedestrian trip rates.

Residential land use always acts as a trip generator. To collect data on travel behavior of residential land use, household travel surveys and trip diaries were used. After developing the household travel survey form and trip diary form, a pilot study was carried out to finalize the survey forms. It was clear from the initial surveys that there was a clear lack of such experience except for the national census carry out in every 10 years. Respondents find it difficult to understand; especially the trip diaries and the survey sheets were further simplified. Due to this lack of understanding, the survey questions were further simplified and in trip diaries the instruction given were simplified with more clarifications. For the data collection from households, stratified sampling was used. This was done by using the smallest administrative division that is Grama Niladari Division (GN) level. All the surveys were done in one selected day and trip diaries were filled to get travel data only for that particular day only.

All the other observer surveys, face-to-face questionnaire surveys and pedestrian counts at the selected sites were also done selecting a week day. Although observational surveys require less staffing and are comparatively less expensive, face-to-face questionnaire surveys were the preferred method for the research due to improved levels of accuracy and hence cost effectiveness. Subsequent surveys concentrated on the face-to-face questionnaire methodology. It was also clear from the initial surveys that interviewing was reliable only for the inbound direction only as people are in a hurry to leave the premises once their need was done. The surveyors mentioned that people leaving were less inclined to answer the questions because they are in a hurry to leave once their work or purchase is done. For that reason surveys one direction only was chosen.

3.2 Land uses and site selection

A number of researchers have proved that proximity to nonresidential land uses, specifically retail uses, has been linked to higher walking rates for utilitarian purposes in the general population. (Patricia et al (2008), Leslie et al (2003), Pendall and Chen (2003)) Beyond the presence of specific land uses, others have argued that the proportion of land devoted to different uses within a given distance from a home location may also affect levels of walkability. (Chris Bradshaw (1993), Saelens et al (2003), Metaxatos and Morocoima (2008))

Both the theory and practice tell that although land cover (LC) and land use (LU) are closely related, thus many proposed land use classifications are actually mixing land cover and land use. Natural and semi-natural vegetation are described in terms of land cover whereas agricultural and urban areas in terms of land use. The definition of forests is a combination on land cover and land use as natural vegetation and eco tourism spots or monasteries are included within such forests. Still it is necessary to develop LU classification separately from LC classification due to the differences between these two. In this research six land uses were selected to develop walking trip rates. Since the rates are selecting for medium size urban areas, the land use were categorized as, Residential (single- and multi-family housing) Commercial (supermarket, fair, retail shop) Institutional (educational, financial, medical and other public offices) Recreational (play ground, cinema, children park, beach Park) Transportation facilities (bus/rail stations, parking) and Religious (temple, church, kovil, mosque).

The process for site selection of these land use categories except for residential land use was done considering the physical characteristics of the particular land use activity. Data collection varies according to the specifics of the subject land use. Pedestrian counts and face-to-face questionnaires were used and they were compiled to determine daily pedestrian trip rates for those land uses. Depending on the specific land use, the independent variables being floor area, number of employees, number of beds, number of trains/buses per day, etc.

3.3 Analysis

The trip rates were developed for the selected land use categories by using statistical software. First the variables were recoded and grouped after doing a Chi-square analysis. This was done in order to find out the relationships and their significance for groping and those grouped variables were then used to find out the trip rates. Additionally, multivariate regression analysis was used to find out trip rates for these selected land use categories.

For the residential land use, the total sample size was 3233 households. The response rate was 87% for households while the response rate for all land use activity sites are as given below in table 1. The time periods of the surveys were 12 hours, from 6am to 6pm. In the institutional land use, surveys at the schools were done at 6-9am and 12-3pm time slots.

Table 1: Overall site response rates

Site	Total Pedestrians	Interviewed	Percentage (%)
Commercial			
Supermarket (02)	70	48	68.57%
Fair	102	42	41.17%
Retail (02)	46	28	60.86%
Hardware	17	10	58.82%
Restaurant/ snack bar (02)	22	20	90.90%
Institutional			
School (03)	1833	245	13.36%
Hospital (02)	378	102	26.98%
Medical center	32	27	84.37%
Bank	47	31	65.95%
Leasing company	28	23	82.14%
Library	21	20	95.23%
Town Hall	36	29	80.55%
DS Office	86	72	83.72%
Post office	34	29	85.29%
Recreational			
Play ground	62	41	66.12%
Park	27	18	66.66%
Cinema	83	48	57.83%
Transportation facilities			
Bus stand	196	58	29.59%
Railway station	118	63	53.38%
Parking	14	14	100%
Religious			
Temple	23	16	69.56%
Church	41	27	65.85%
Kovil	62	40	64.51%
Mosque	48	22	45.83%

4. RESULTS AND DISCUSSION

The results of the analysis were compiled to determine the trip rates as per the independent variables for the subject use. Depending on the specific land use, the independent variables considered are floor area, household size, number of beds or seats, etc. Table 2 represents the residential walking trip rates. Residential trip generation rates defined herein as the total number of walking trips per household during a 24-hour period. The residential trip rates were calculated using the following multivariate equation.

$$Y_i = b_0 + b_1X_{i1} + \ldots\ldots + b_kX_{kj}$$

The column vector Yi represents the trip rate as the dependent variable of the i^{th} observation and matrix X_{ij} represents the variables of household size, household vehicles and floor area of the households. The column vector b represents the parameters.

Table2: Residential Walking Trip Rates

HH Size	HH vehicles	Floor Area	Trip Rate (per household)
1-2	0	1-6 m^2	2.36
	1-2	6-20 m^2	1.41
3-4	0	1-6 m^2	2.83
	1-2	6-50 m^2	2.02
5>	0	1-6 m^2	2.94
	1-2	6-50 m^2	1.86

The data for commercial, institutional, recreational, transportation and religious were collected from the sites selected to carry out the surveys and the results are specific to the Panadura Urban area and these rates may be used as a reference for a similar land use elsewhere. Table 3 illustrates the trip rates for other land uses. When calculating these trip rates natural logarithmic equation was used. This was because majority of the trip generation rates for classified land uses depends on its size and its relationship is continuous. The formula reflects that the number of trips do not increase proportionally to increases in the size of the land use activity, especially in super markets.

Table 3: Walking Trip Rates for other land uses

Land use	Trip Rates
Commercial	
Super market	1.96 trips per 100m^2
Retail	16.9 trips per 100m^2
Hardware stores	8.7 trips per 100m^2
Fair	16.4 trips per 100m^2
Restaurant	13.3 trips per 100m^2
Institutional	
Banks	2.68 trips per 100m^2
Insurance and leasing companies	2.56 trips per 100m^2
Primary Schools	1.37 trips per student
Secondary Schools	8.7 trips per student
Hospitals	0.74 trips per bed/ 1.36 trips per 100m^2
Medical centers	4.15 trips per 100m^2
Town hall	0.71 trips per 100m^2
Library	0.62 trips per 100m^2
Government offices	1.13 trips per 100m^2
Post office	2.28 trips per 100m^2
Recreational	
Play ground	0.54 trips per 100m^2
Children park	0.47 trips per 100m^2
Cinema	0.71 trips per seat / 2.15 trips per 100m^2
Transportation	
Bus Depot	4.21 trips per bus
Bus Station	18.87 trips per bus
Railway station	37.59 trips per train

Parking	2.66 trips per vehicle
Religious	
Temple	3.7 trips per 100m^2
Church	1.4 trips per 100m^2
Kovil	3.5 trips per 100m^2
Mosque	4.2 trips per 100m^2

5. CONCLUSIONS & RECOMMENDATIONS

Face-to-face questionnaire surveys are the best way to collect data based on the literature review. Given the simplicity of the face-to-face questionnaire, there was little likelihood the answers given were not accurate due to misunderstanding the question. In addition, given the simplistic nature of the potential answers, it was unlikely the surveyor would not understand the answers given. However, face-to-face questionnaire surveys were always better undertaken by people familiar with such survey methods, this meant there would be opportunities for clarification should that are necessary. In this regard the survey team needs to be educated on the surveys prior to the carrying out of actual surveys

Once the data collection method and survey sites were selected, the surveys were carried out and data were compiled for the analysis. The analysis represent that the walking trip rates of households mainly differs with the vehicle ownership. Household walking trip rates are always higher in the households without a vehicle irrespective to the size of the household. With respect to the floor area of the households it can be seen that more walking trips are generated from the households of relatively small floor area. When considering the commercial land use super markets produce the lowest walking trip rate while retail shops having highest walking trip rates. This is mainly because retail shops are within the neighbourhood. The walking trip rate is higher in secondary school category as the schools are located within the walking distance from the bus stand and railway station. The trip rates presented in this paper are the results of pedestrian trip rates developed for Panadura Urban council area. These rates may be used as a reference for a similar land use elsewhere.

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