

Cyclist Route Analysis using the Geographical Information Systems: A Brazilian City Case Study

1 - Introduction

Public Transportation fares in many third world countries are more expensive than the lower economic class people can afford. It is verified that there is a scarcity in terms of alternatives to deslocate this class of people. The population is facing several problems related with traffic such as congestion, accidents, parking space and environment degradation.

The possibilities to get solutions in order to eradicate those problems seems to be far. However is possible to stablish some alternatives that could contribute to the urban chaos minimisation. The use of bicycles could be considered a individual mode of trip. It is adequate for short distance daily trips in the areas where concentrated activities are observed.

In order for the bicycle be considered a transportation mode the population must pass through sociocultural changes. Theoretical tools for implementing a systematic cyclist policy must also be developed. In the present situation, the bicycle is considered a kind of dangerous vehicle, disputing space with pedestrians on the sidewalk and competing with automobiles on the streets. On the other hand it has been noted that the Public Sector has suffered a lot of difficulties in this study on the planning and implementing of cycleways, forming barriers in the execution of concrete decisions in just time.

This difficulties come from the absence of specific transportation models for travel forecast of bicycle mode. The methodologies applied to planning the cycleways does not consider the cyclist dislocation in a systemic approach. The transportation models were developed for motorised vehicles modes, which have different characteristics and can not be applied in the bicycle case. It is verified that in the traditional cycleways methodology where each sector of the dislocation is analysed separately starting with the trip generation, route choice until attraction. area.

This paper describes a methodology to analyse the cyclist routes using a Geographical Information System software (GIS). It is intend to establish the relationship between the travel forecasting Transportation Models and the Cycleways Methodologies that will consider some specific Cyclist travels characteristics and provide new information which could be used in a treatment of this kind of travel. In this context the GIS has the fundamental role, once it is able to identify and modelling Cyclist Transportation Network. In this way, GIS works such as integration element within the methodology to cycleway study.

This study is developed in five sections such as transport modelling and cycleway methodology analysis; GIS; description of new methodology; case study of Sobradinho city - Brasília and finally conclusion are presented.

2 - Theoretical Background

In this section will be analysed the travel forecasting transportation model and methodologies used in cycleway planning. The theoretical framework is described showing how cyclist trip could be made.

2.1 - Travel Forecasting Transportation Model Analysis

The travel forecasting model is used in the transport planning process. The main objective is to define the current and future dislocation profile in order to support decisions and investments to be done in the urban development process. The principal elements of the transport planning process are inventories, land use forecast, travel forecast, plan definition, plan testing and evaluation (Bruton,1979).

According to Hutchinson (1979) in the travel forecast step is developed the equations that allows estimate the number of trips generated in a traffic zones. This trip estimation is based on the land use properties, collected in these traffic zone. This travel forecasting is achieved in four steps such as Trip Generation; Trip Distribution; Modal Split; and Assignment. In this process are considered variables related with land use, transport system, socioeconomics characteristics and quantitative parameters (distance, time and cost of trips) (Bruton, 1979).

Since this transport process models was developed until the present days most part of the applications has being done to analyse motorised vehicle trips. Even so, the basic formulation has also considered variables related with bicycle. According to Greenberg (1995)an incompatibility is verified between the traditional transport network to bicycle mode. While motorised vehicles is running on the streets, avenues and highways, the bicycle mode is more flexible due to the main requirement be the energy . Consequently, a large number of alternatives has to be analysed and leading the assignment step more complex.

2.2 - Analysis of existing methodology

The public sector in terms of form of administrators, planners and executors of studies for the implantation of cycle ways have obtained few satisfactory results in their activities. Among the principal reasons for such situation, we could list the inexistence of a conception of the use of bicycle as a form of transportation, as well as the incapability of existing methodologies to attend to the movements of cyclists considering their specific characteristics.

The present methodologies in general are concerned with actual matters in the planning , attribution and implantation of cycle ways. These basically deal with matters such as dimension, signalization, security and location, in other words with the physical characteristics of cycle ways, without considering them in their systematic form, in other words each aspect is examined separately. In WISCONSIN (1993) we can see cycle way planning being divided in 7 stages, showing a certain sequence between each stage and at the same time analyzing and solving the problems in each stage omitting a global analysis of items involved. The GEIPOT (1980) study, describes the necessity to deal with the problem in a systematic view, considering the different factors such as traffic survey, O/D survey, home base survey, fleet quantification, accidents quantification, etc., in a descriptive form though, lacking a presentation of how these factors are linked.

In the WISCONSIN (1993) methodology, firstly the goals and objectives are drawn, which is considered as one of the principal stages and which presents a strong connection with the next stage, concerned with the establishment of criteria for planning, where the necessity to evaluate and consider the routes and preferences which should be given to bicycles in an urban network are verified. In the third stage, a complete inventory is carried out on the usage of bicycles, accidents, cycle ways, in general, all elements linked in some way with bicycles. The fourth stage identifies bicycle trip corridors, which present a lot of resemblance with that of automobiles, since their origin and destination are mixed up. Hence forth the next stage, the proposal is molded, with the evaluation a selection of specific routes and types of facilities to be given. The sixth stage presents the components of security, while in the last stage, an evaluation of the final plan is done facing the initial goals and objectives of planning.

Particularly in Brazil, the situation is intensified due to the non-existence of a conception focused on cyclists. One of the factors which has contributed to this is the automobilistic civilization and its consequences in the transportation system structure and its planning. This automobilistic civilization becomes more evident when the methodologies for implantation of cycle ways are compared with vehicular ways, where it is perceived that the first is an imitation of the second.

Due to the varying characteristics of bicycles which involve both human beings and machines, its understanding and treatment must be differentiated from other modes of transportation. Henceforth this conception, it becomes essential to consider the analysis, the energetic requirements and psycho-socials involved in bicycle dislocations.

This implies that factors such as road slopes, climate, soil usage, sidewalks conditions, cyclists exact necessities and physical and geometric characteristics for implementation of cycle ways must be focused on systematically, permitting dislocation from this mode in the most effective form possible,

The inadequacy of planning of cyclists is in part due to the existence of a strong difference between the theoretical models proposed and the description of methodology to be followed. This motivates the existence of studies for the implementation of cycle ways with restricted analysis. This fact can be explained by the level of difficulty in analyzing the circumstance in a systematic way, considering the different influencing factors in the choice/selection/preference of this mode of transportation by the population. These factors are formed by the most possible varieties, varying from quantitative items to the qualitative items.

3 - Geographic Information System - GIS

In the latest year the Geographic Information System - SIG has been an important tool to resolution of transport problems. It can be verified through the crescent number of publications using this system in planning, manegement, operation and transport system analysis.

According to Dantas *et alli* (1996) the publication in this area is identified by three evolutionary phases in the GIS concept. Firstly, is verified that the GIS application in only to visualise and manipulate the database. In the second moment, the analytic operations with non graphic dates is considered. Finally, in now days , GIS is appreciated such as instrument capable to develop functions more complex considering spatial analysis and conditions to systemic manegement. The spatial analysis can be explained such as capability to obtain information through interpretations of topological maps (maps that collect geometric information from mathematics functions and geographic coordinates) and images generated from remote sensing like satellite, radar image or aerial photographic.

The few studies in transport has used the true capacity of SIG. However, some studies can be outstanding by the positive experience such as Bartoli et alli (1996), Taco (1997) that allow to detect great capacity to treat transport problems. Those studies try to joint traditional information (O/D matrix, home based survey) with other kind of dates considered to analyse the problem. The information about topographic characteristic, security, physical condition, pavement quality can provide subsidies to define impedance to cyclist dislocation.

4 - Elaboration of Methodology

The theoretical analysis for item 2 focuses on the necessity of the adoption of an instrument which relates the formulation of transportation models to methodologies for cycle ways. It was verified that the adoption of traditional models is not adequate, since these don't take into consideration the

particularities of the bicycle mode. On the other hand, these methodologies fail in not integrating the analyzed elements. Seeking solutions, these limitations seek to take advantage of the capacity of GIS software, which has proved capable of manipulating a great quantity of different types of data and generating essential information for this type of application.

This way, this methodology was elaborated with the objective to analyze the displacements of cyclists in the urban area and contribute to the transportation planning for bicycle mode. Particularly, we intend to define the routes from the generation pole to the attraction pole and quantify the number of trips, considering the conditions of pavements and slope which are not commonly focused on traditional studies, through the use of aerial photographs and the GIS software. In this way, the methodology was subdivided in four phases, described as follows.

4.1 - Trip generation and attraction

In this methodological phase, the generation and attraction poles of trips are identified and characterized. For this purpose, the photo-interpretation technique which consists of the identification of objects and conditions of aerial photographs and the determination of its meanings (Avery; Berlím; 1990) For the identification of objects, the classification system elaborated in the United State Geological Survey (USGS) is used, which seeks to identify standards, types and forms of coverage and usage of soil. This system consists of the hierarquization of the properties observed in the aerial photographs in levels, which once achieved, permit the obtain of photo interpreted classes. Consequently, these classes help determine which are the generation and attraction trip poles for transportation cases.

The activity which follows up in this phase is the estimation of the number of generated and attracted trips for each type of soil usage, applying the model elaborated by Taco (1996), which states that the number of trips in an urban area can be obtained through the following formula.

$$V_{G/A}^{ZT} = w + f_1^V A_{f_1} + f_2^V A_{f_2} + \dots + f_n^V A_{f_n} + U$$

onde:

$V_{G/A}^{ZT}$ = estimativa das viagens geradas ou atraídas para valores dados das áreas foto-interpretadas A_{f_1} , A_{f_2} , ..., A_{f_n} ; na Zona de Tráfego;

w = constante de regressão;

f_k^V = fator das viagens da classe foto-interpretada k , $\forall k \in \{1, 2, 3, 4, \dots, n\}$;

A_{f_k} = área da classe foto-interpretada k , $\forall k \in \{1, 2, 3, 4, \dots, n\}$;

U = componente aleatória (erro), que expressa as variações das medidas, e as influências das variáveis que foram omitidas no modelo.

In this model, trips are not directly related to the type of use or occupation of soil and the area it occupies. In this form, one can obtain the number of pole trips, through statistic procedures of multiple linear regression. It is important to emphasize that in this stage, GIS carries out the function of assisting the classification and identification of photo-interpreted classes and obtainance of their areas.

4.2 - Building the transportation network

The identification and characterization of routes which link the attractive and generator poles is accomplished in this methodological phase. Once again using photo-interpretation, all the roads,

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