ID 1342 | INFLUENCE OF URBAN MORPHOLOGY ON THE USE OF BRT TRANSPORT SYSTEM

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ABSTRACT: Urban planning has the responsibility for defining the territorial and urban models of cities, this determines the distribution of the demand for mobility in the cities. Hence, it is important to affirm the character of the two-way relationship between the spatial distribution and public transportation systems. Using the primary and secondary data with multiple regression model, the present study analyses the relationship of the built environment with the number of passengers registered in the year 2014 in the Bus Rapid Transit in the city of Quito, Ecuador. The delimitation of the service area in the built environment of stops is carried out with the support of the Geographic Information System (GIS). The results show the importance of no-resident population density and diversity of land uses and road density at the time of explaining the number of users of the system at each stop. Research allows to estimate both the future transportation system demand, as well as the impact that can have urban variables on the use of the Bus Rapid Transit in future growth of the urban area.

KEYWORDS: urban variables, Bus Rapid Transit multiple regression model, GIS

1 INTRODUCTION

Urban planning has a great responsibility in the management of urban mobility demands and conditions it (Pozueta, 2000), therefore this influences the mobility and transport system that serves, in the same way, the changes in the transport network and mobility generate territorial transformations (Miralles, 2002). In this sense, the spatial planning is a tool for generating an urban model that promotes public transportation.

In fact, this urban model has been promoted as a strategy within the sustainable planning of cities, as is the case of the European Union (EU, 2011). On the other hand, this urban model in the United States began to spread based on the Transit Oriented Development (Cervero, 1996, Boarnet and Copin N., 1999). In Latin America, the pioneer city was Curitiba, which BRT Oriented Development (BRT-OD), becoming a worldwide reference.

In the case of the city of Curitiba two elements facilitated the mobility, on the one hand the distribution of the activities of the city along the zones served by the transport, and on the other, the implementation of the Bus Rapid Transit. This system is efficient, flexible and low-cost system to meet the demand for mobility in cities (Rabinovitch and Leitman, 1996). For these qualities, this transport has expanded rapidly around the world. Currently there are 205 cities that have implemented this transportation system (GlobalBRTData, 2016).

However, not all cities that have this transport system have managed to integrate the built environment with transport. In this line of reflection some research has emerged of these urban models that were not planned as a support to the BRT, several of these analyses were carried out in cities of Latin America. The results show that the demand behaviour of the transport system depends on the supply of the service and the built environment (Estupiñan and Rodríguez, 2008, Rodríguez and Vergel, 2013, Vergel, 2014).

Notwithstanding these contributions support the relationship between the built environment and the number of users, it is difficult to determine the behaviour of some variables, especially the influence of design. These analyses determine the area of intervention within a range of 250 meters in all stops, 500 meters in the terminals and stations. This delimitation does not consider the actual distances travelled in the pedestrian networks of the built environments.

On this basis, this paper aims to analyse the built environment of the service area within distance of 300 meters at stops and 600 meters at stations and terminals. Starting from the question How does the urban form promote the use of Bus Rapid Transit in Quito? The main objective was to analyse the urban variables no-resident population density, land use diversity and road density. The hypothesis is supported by the statistical empirical analysis of the urban variables and the number of users of the Bus Rapid Transit.

For this, the research is structured in four sections. First the introduction in which review of the literature, secondly the data and the methodology used based on GIS tools, third the model is explained and finally the conclusions and contributions of the work.

2 BUS RAPID TRANSIT AND BUILD ENVIRONMENT

The Bus Rapid Transit (BRT) are high-quality surface buses that provide comfortable mobility through the use of exclusive lanes and a favourable cost-benefit ratio. These systems have performance characteristics similar rail transit, but at a lower cost. A BRT could cost from 4 to 20 times less than a tram system (LRT) and 10 to 100 times less than a metro system (Wright and Hook, 2007). For these qualities, the BRT system has gained worldwide popularity. To date, more than 200 cities around the world have implemented some form of BRT-type system, comprising about 5568 kilometres in length and more than 30 million passengers per day (GlobalBRTData, 2016). Despite the popularity of this type of transport, the fact that these systems can promote a development in the next building environment, and that this environment becomes a support for this system remains a topic of discussion. The empirical evidence shows that the built environments can be a contribution at the Bus Rapid Transit, as well as the transport system can generate significant activities in the built environment.

These studies have analysed the urban variables proposed in the TOD, which is the urban form considered inherent, efficient and sustainable (Calthorpe, 1993; Curtis et al., 2009). In other words, they analysed residential and employment population density, the diversity of land uses and urban design (Cervero and Koclelman, 1997, Cervero, 2007, Badoe and Miller 2000, Cervero and Duncan 2003). Thus, the city of California identified correlations between population density and number of passengers, however, this also depended on the proximity factor (Cervero, 2007). Similar was the behaviour of the employment density variable located in the environment close to BRT transport (Frank and Pivo, 1994).

In relation to the diversity of land use, this variable and accessibility are considered relevant for the behaviour to ridership, even more than the characteristics of the residential density (Badoe and Miller, 2000). The Portland study found that the diversity of land use in residences decreased the likelihood of private vehicle travel, while in residential exclusive use areas the number of private vehicle journeys increased. Similar to the result was obtained in the bus stop of Florida (Chu, 2004). However, it depends on the willingness of the residents to walk. Thus, they found that local commerce located within a radius of a mile (1.6 km) may have a greater chance of displacements pedestrian (Cervero and Duncan, 2003)

On the other hand, urban design is one of the variables with broad meaning depending on the context, in general, understood as the form that acquires the connection space that allows the integration of different land uses in cities. Under this concept, the variable acquires its importance when considering that, the displacement does not end at the entrance or exit door of the transport system but includes the urban environment to capture the clients (Wright, 2007). Thus, the study of the city of San Francisco concludes that, the landscape and the urban form directly affects nonmotorized modes, especially by design factors such as the distance between blocks, the perception of safety or other factors as Topography (Cervero and Duncan, 2003; Kitamura et al., 1997).

In this sense, the demand of the Bus Rapid Transit has a similar behaviour to other types of transport analysed in other contexts, in which the demand of the transport system depends both on the supply of the system (speed, Service and frequency) and of the characteristics of the near urban environment (Cervero and Koclelman, 1997; Cervero, 2007).

3 BUS RAPID TRANSIT IN QUITO-ECUADOR

Quito is the capital both Republic of Ecuador and province of Pichincha. Due to its characteristic of centrality it welcomes the majority of the population of the Metropolitan District. The city is located on a plateau at 2850 m a.s.l., in an area of 18,860 hectares (DMQ, 2009). The urban area is articulated by public transportation that facilitates the movement of the population through the integrated Bus Rapid Transit known MetrobúsQ, conventional buses, vans and informal buses (EMQ, 2011). The system integrated BRT(Metrobús-Q) was built and implemented gradually in some phases since 1995. At present, the trunk corridors Trolebús, Ecovía, Suroriental, Central Norte, Suroccidental have a total of 135.70 kilometres of length between exclusive lanes and mixed traffic. In the exclusive corridors articulated buses circulate while in the mixed traffic corridors the conventional buses circulate (EPMTP, 2016; Barrera A. and EMBARQ, 2013).

The Trolebús system is the central corridor. It is also known as the "green line", which covers an approximate distance of 18 km from the south of the city with the El Recreo terminal to the north of the city in the terminal La Y (Guía, 2012). These articulated buses run through exclusive corridors, has 31 stops, two stations and four transfer terminals (EPMTP, 2016). The Ecovía corridor is known as "red line", the fleet is composed of articulated buses. It travels a distance of 9,5 km in exclusive lane, that goes from the transfer station the Marín (sector center) to the terminal Rio Coca located in the north zone of the city (Guide, 2012). This articulated bus system has 16 stops, one station and two terminals (EPMTP, 2016). Regarding demand, the results of the mobility survey (2011) highlighted that 67.3% of the population depends on the supply of the public transport system. Of this percentage of trips, 22.7% correspond to the integrated transport of Metrobús-Q, of which 45.6% are Trolebuses, 19.7% to Ecovía and Eastern Southeast with 8,0% (EMQ, 2011).

In relation to the urban form, the city of Quito presents diverse characteristics. The city maintains a structure that concentrates equipment and services in the centre, whereas a tendency of distribution of the population is registered in the periphery of the city. This heterogeneous distribution has an impact on the mobility of the city.

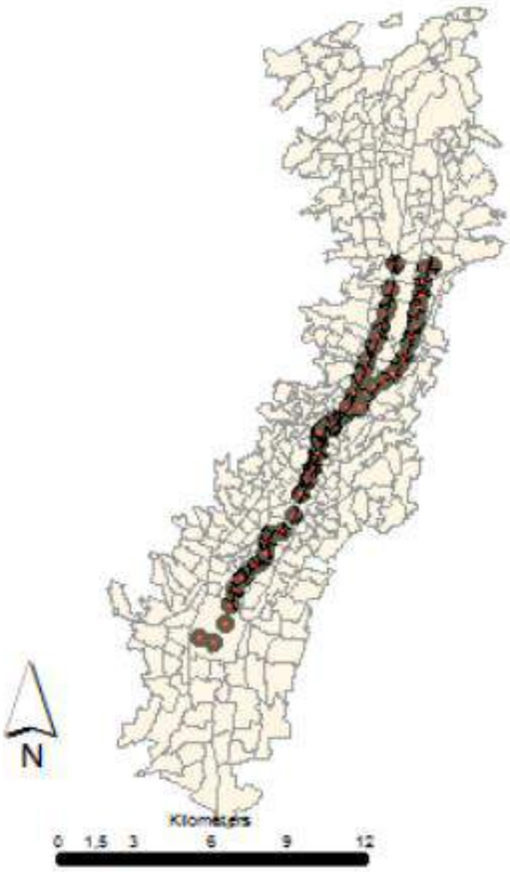

Fig.1 Quito's Trole and Ecovia BRT stations audited

4 DATA AND ANALYSIS TOOLS

The study analyses the variables of the stopping environment in terms of no-resident population density, land use and network density in the surroundings near the shutdowns, stations and terminals of the transport system. Primary and secondary data are used for the 2008-2016. This period time is justified in the first instance by the sources provided. To obtain no-resident density, it uses the number of employees in public entities, the number of students and the number of employees in shopping centres. For the index land use, it uses the database (2008) available at the Secretariat of Territory of Habitat and Housing. This information is superimposed with available on the internet using the Google maps tool and also with the data obtained in situ. The road and corridors of the BRT system, stops, stations and terminals (2008) available in the Metropolitan Public Enterprise of Mobility and Public Works. The number of passengers per stop (2014) Metropolitan Public Transport Company of Passengers. In the case of the dependent variable (number of passengers), we use the data corresponds to he averages recorded in one day in the stops, stations and terminals of the Bus Rapid Transit obtained from the database of the year 2014, the base is used of data this year because in recent years the stops are in a process of remodelling, for such reason its operation has been unusual.

Table 1 shows the description of the data, the level of data collection, the source of information. In addition to the statistical descriptive analysis of the 53 stops, stations and terminals studied. In the case of the density variable, it analysed the number of people who are not residents of only those who work in public entities, shopping malls and educational institutions, the latter includes students. In relation at index land use are considered according to the current legislation (education, health, recreation, religious, administration, hotels, specialized commerce, malls, small scale commerce, and industry). Finally, the density of the network which is the result of the total length of the pedestrian network in kilometres divided for the service area.

Variable	Definition	Mean	Std. Desv.	Min	Max	Spatial Level	Source
Dependent Bordings 2014	Number of daily boarding per station for 2014	4897,04	3501,06	617,3	19940,83	Station	EPMTP
Centrality	Distance of Centrality activities form stop	5,73	4,5	0,58	15,41	Station	GIS
Density	Density (Persons do not live per hectare)	123,98	124,74	0	585,56	Station	MEC, MTRH
Land use	Land use index (0-100)	656,6	194,75	18	100	Station	EPMMOP
Road Density	Road density (linear kilometres in service area)	0,24	0,055	0,15	0,41	Station	EPMMOP

Table 1 Description of the variables used in the model and descriptive statistical analysis (N = 53)

For the calculation of the independent variables, it analysed the data within the service area of each stop, station or terminal. In the case of no-resident population density it superimposes the information of the number of public employees, students, teachers and number of employees of shopping centres with the service areas of each stop, thereby calculating the population number within the float population inside of the service area which is calculated in hectares. Using the land use layer (2008), the layer with the data obtained in the field is superimposed on google maps. These data are filtered into the tables and the number of uses in each service area is quantified. These activities were classified according to the current regulations, establishing a range of 0-100 for this indicator. In order to integrate the design variable into the model, it is considered the road density. For this, it calculated road density by means of overlap the layer road (length kilometres) and the service area. Once the independent variables are obtained, a multiple linear regression model is obtained from the statistical analysis system, this tool is available in the Geographic Information System (GIS).

5 METHODOLOGY

Using primary and secondary data, the present work combines the quantitative and qualitative analysis to explain the relationship between the built environment and the Bus Rapid Transit. For this, it selects the corridors Trolebús and Ecovía which the bus systems were the first to be implemented in the city. The Trolebús corridor began its operation in 1995, has 31 stops, 2 transfer stations and 2 terminals. The Ecovía corridor began operating in 2002, has 15 stops, one station and two terminals. These two BRT transport systems circulate through exclusive corridors. On the other hand, the built environments of these corridors have been analysed in previous studies (Rodríguez and Vergel, 2013, Vergel, 2014).

Another relevant issue for this study is the delimitation of the service area of the Trolebús and Ecovía corridor stops. For this delimitation, this paper considers the choice of critical service distance in relation to the demand capture in the built environment and the pedestrian route through the network. In this particular case, the critical service distance of 300 meters is established for the stops and 600 meters for the terminals. These thresholds correspond to the maximum distances of the sample of pedestrian routes registered in the environments near the stops in October 2016. These distances are similar distant identified in studies of the Metro Madrid, Spain (Gutiérrez et al. , 2010). The network analyst (tools GIS) is used for pedestrian distance. In this way, we intend to work with the actual distances travelled through the road (Gutiérrez et al., 2012).

Using overlays of layers within the delimited served areas, we calculated the urban variables. In the first part of the study, we analysed the variable density the variable density of non-resident population in 44 stops, 3 transfer stations and 6 terminals of the corridors of the Trolebús and the Ecovía in relation with ridership. This study also includes two variables, on the one hand the dummy because the stops and the terminals have different behaviour and on the other the distance of the stops in relation to the centre of activities of the city (Rodríguez and Estupiñan, 2008; Vergel, 2014; Gutierrez Et al., 2010). The second part analyses the relationship between the ridership and the attributes of the built environment, in this case the diversity indicator is calculated dividing the number identified in the service area for the total number of uses established and multiplied by 100. Finally, for the design variable, it calculated the road density within the service area (Rodríguez and Estupiñan, 2008; Vergel, 2014; Gutiérrez et al., 2010).

6 DESCRIPTION AND ANALYSIS OF RESULTS

In the first part of the model we consider the ridership relation to the density of the nonresident population in the service areas, with this variable it obtains R2 0.149. Table 2 describes the results of the model fitted with the first factor analysed, which includes the distance to the stops, service stations and terminals and the dummy, with these variables it obtains R2 0,43

Variables	Coefficient	Std error	P-value
Dummy	0,43	0,131	0,000021
Centrality	-0,02	0,091	0,004405
Density	0,189	0,008	0,001774
N	53		
R2	0,44		

Table 2 Multiple regression model (N = 53)

Yi= PoFlot Density + Centrality +Dummy
Y = ridership at each station i
PoFlot Density = not-resident population in the service area
Centrality = Distance between stops to the centre of activities of the city
Dummy = terminal BRT = 1; 0 = other type.

The second part of the model analyses the relationship between ridership, land use and design.

Yi = Dummy + Diversity + DenRed
Diversity = variable number of uses divided by the total number of uses multiplied by 100.
Dummy = terminal BRT = 1; 0 = other type.
DenRed = Road density

Variables	Coefficient	Std error	P-value
Dummy	0,14	0,095	0,09
Centrality	-0,019	0,007	0,008
Density	0,08	0,048	0,07
Land use	0,05	0,001	0,0019
Road Density	0,07	0,022	0,0010
N	53		
R2	0,66		

Table 3 Regression model of station boarding

Table 3 shows the bivariate correlation coefficients obtained between each of the independent variables studied and the number of passengers recorded in the stops. The results show a significant statistical correlation between the variables, except for the variable density of the network. The coefficients have low values, with significance values below 0.01.

7 CONCLUSIONS

This proposed model shows the information of the users volume that could have the station of simple way. Relating the variables in the Geographic Information System, we analyse a direct estimate of the demand for BRT transport at the station level. This model involves the variables of the built environment known as the 3D (Density, diversity and design). Variables become important when explaining the use or not of the BRT transport system because the built environment is the pedestrian connector to the transport system.

To estimate the demand, the multiple regression model has been adjusted, where the dependent variable is ridership at stops, stations and terminals, and the independent variables reflect the characteristics of the built environment in the service areas delimited with the networks analyst tool of the GIS, reaching R20.66. The procedure allows to make estimates of demand quickly facilitating to the transport planners. In addition, it is a tool of interest to planners when establishing urban plans. Despite the goodness of the model, there are weaknesses and one of the main is that, it considers the pedestrian movements in the stations and it is not applicable in the stations and terminals where the access can be through feeders.

The adjustment of Bus Rapid Transit model in the city of Quito (R20.66) confirms that urban variables are explanatory in relation to the number of passengers at stops, stations and terminals. Although this study has not been considered the resident density, because it has little explanatory value. However, the incidence of no-resident density can be identified as a variable with greater explanatory value and not applied in other works. This variable acquires greater value when integrating the variables distance to the centre of economic activities and Dummy.

The distance from the stations to the city centre is also a variable that has an explanatory value in relation to ridership. The stations near the activities of the city tend to catch more passengers than in the peripheries. This information is a tool at the time of planning both to predict future demand for new peripheral stations and to restructure the distribution of existing activities in the city. Including the variables land use road diversity, the results confirm the importance of the 3D the time to explain the demand of the Bus Rapid Transit. The design in this model is identified only through the road density. Under the criterion that the increase of the density of the network directly affects an increase of the area of coverage to the stops. A dense road facilitates the pedestrian mobility of the population. In spite of this assertion, to define that they comply with characteristics to be spaces known as pedestrian-friendly spaces, other variables are required that will be considered in the next stage of the investigation.

Finally, it is concluded that this model that relates the variables through the multiple regression analysed in the GIS contributes to strengthen the existing knowledge regarding the urban form and the demand of the

Bus Rapid Transit. From the point of planning it allows establishing future demands and also becomes a tool that can contribute information for the design of new development and the rehabilitation of existing ones.

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ID 1753 | REUSING HERITAGE: ACTIVIST PLANNING FOR PLACE-BASED REGENERATION PROCESSES

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ABSTRACT: The research aims at discussing the potential role of reusing abandoned built heritage as driver for place-based regeneration processes in inner areas. The study focuses on disused railway heritage in Italy because of its relevant size, the low percentage of effective initiatives, and its strategic position into the territory. In European context, successful initiatives show the considerable role of political agenda and economic programmes as well as shared interests among institutional subjects, associations, entrepreneurs and local communities to achieve common goals. In Italy, these necessary components are often lacking, especially in terms of strategic initiatives and dialogue between policy makers, activists and socio-economic stakeholders, although the National Railway Company (RFI) has promoted institutional initiatives in the last decades. In this field, could activist planning have a key role for regeneration processes by recycling unused heritage? Could activist planning contribute to new territorial metabolisms, especially in deprived and marginal areas? The Southern case of Campania Region has been selected taking into account that it is included among the regions that need support to promote development and reduce regional disparities in European countries, according to European Structural Funds and Cohesion Fund. In this region, on one hand, the potentiality of railway heritage has been recognised for its being an existent infrastructure network on the territory that could link cultural, historical and environmental resources; on the other hand, the crisis of 2008 has cut down investments addressing main of them to sustain market-led processes. This conflicting scenario has induced social reactions such as civic movements, new local associations and community-based initiatives that have a proactive role in carrying out bottom up planning initiatives. To discuss that, the researchers have selected a case study in the Campania Region – the historical *Avellino-Rocchetta Sant'Antonio* railway – to reflect on the process induced by activist planning in reusing railway heritage. Through the consultation of indirect sources, fieldwork sessions, interaction with local key actors of the selected case study, the research group aims at verifying if bottom-up reuse initiatives are able to trigger place-based regeneration processes, producing positive impacts in terms of social, economic and cultural dimension.

1 INTRODUCTION

In many Italian Regions, inner areas represent about 60% of the national territory, where 25% of people lives, plagued by growing depopulation and marginalisation conditions, as described in the National Strategy for Inner Areas. The National Strategy defines these areas « […] as territories substantially far from centres offering essential services and thus characterized by depopulation and degrade» but also « […] with a wealth of key environmental and cultural resources of many different kinds, which have been subject to anthropisation for centuries». The Strategy is funded by Community funding programme for the period 2014-2020, and by national funds (Stability Law) and actually implemented at regional scale. As result of abandonment and emptiness processes, nowadays the inner areas often present a capital of unused built and infrastructural heritage. According with the National Strategy, the starting point for a local regeneration process is enhancing the "territorial capital" (Camagni, Borri, & Ferlaino, 2009): the natural and cultural capital and the social capital and social cohesion. In this perspective, unused capital should be considered as a measure of development potential. The ongoing research is developing within the research project "Place-based Regeneration Strategies and Participatory Processes", coordinated by Gabriella Esposito De Vita, and funded by the Italian Research Council (CNR) and aimed at combining community engagement and participatory approaches within a cooperative and place-based regeneration process. A thematic focus regards abandoned heritage and reuse strategy as driver for local regeneration processes, analysing the role of bottom up initiatives ad social activation in implementing these processes. At present, the study deals with reusing abandoned railway asset in Italian inner areas as catalysts for valorising and networking environmental, historical, cultural and socio-economic resources, and guaranteeing a sustainable accessibility to the inner areas. What can be the opportunities arising from the railway network asset in the field of place-based regeneration processes? In this framework, what can be the proactive role played by local communities? The research deals with this heritage considering building stations and tracks as integrated parts of an infrastructural system for verifying if reuse strategies of this network can contribute to cope with the challenges of marginalization in inner areas through place-based regeneration processes. In particular, while in urban areas reusing railways can produce new opportunities in terms of urban mobility (Xu, 2011), in inner areas it can support local development strategy, improving accessibility of environmental, cultural and historical resources (Oppido & Ragozino, 2014). This research deals with the enhancement and valorisation of disused railway heritage taking into account a systemic logic, coherent with this heritage features and territorial characteristics. The main goal of this approach is to highlight relationships that this network has with the territory and the opportunity in linking environmental, cultural, historical as well economic and social existent resources (Oppido, 2014). The selected method to facing adequately this issue is the case study approach (Andrade, 2009; Yin, 2009), by selecting a case study located in an inner area of Southern Italy, the historical *Avellino-Rocchetta Sant'Antonio* railway in Campania Region. The case has been selected taking into account different criteria, among which: with regard to national average, the Region of Campania has an high level of soil consumption and this highlights a need of strategies for the reuse of dismissed or underutilised heritage (ISPRA, 2016); the extent in this Region of internal areas (63% counter to 60% of national average) and high rates of depopulation of the *Alta Irpinia* area; the extent of the track (119 km) with its historical and engineering value; and the high value of the landscape that the track crosses as well as environmental and cultural heritage that it captures. In this phase of the research, the case analysis has double objectives: