ISSN: 2160-0473 Vol. 5, No. 1, January 2015

Scientific Research Publishing

Journal of Transportation Technologies

ISSN: 2160-0473

www.scirp.org/journal/jtts

Journal Editorial Board

ISSN 2160-0473 (Print) ISSN 2160-0481 (Online)
http://www.scirp.org/journal/jtts

Journal of Transportation Technologies, 2015, 5, 1-54
Published Online January 2015 in SciRes. http://www.scirp.org/journal/jtts

Scientific Research Publishing

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Volume 5 Number 1 January 2015

Journal of Transportation Technologies (JTTs)

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Journal of Transportation Technologies, 2015, 5, 1-8
Published Online January 2015 in SciRes. http://www.scirp.org/journal/jtts
http://dx.doi.org/10.4236/jtts.2015.51001

Building Evacuate Module for Urban Underground Passages: Subway Station in Turkey

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Received 16 October 2014; revised 8 November 2014; accepted 29 November 2014

Abstract

The primary goal of crowd evacuation in urban underground passages or subways is to evacuate as many evacuees as possible to safe areas in the shortest time when emergency events occur. This paper chooses the underground passages of one metro in Istanbul, Turkey as research object, and uses a study method which combines by sites investigation, field test and computer simulation of the creating new software. It is called Building Evacuate Module software. We present a depth analysis of the related factors which include the number and width of passage, channelization setting and the number of pedestrians with the evacuation time. And the influential effect of public opinion is explained by using big data technology. In addition, pedestrians evacuation condition are recorded in three evacuation period, the morning peak, common and evening peak by the observation and statistic obtained with video, and build the model to simulate the change of evacuation time with pedestrians. So it reveals when the number of pedestrians reaches to more than 200, evacuation time increases significantly and the field experiment and simulation condition are consistent basically.

Keywords

Transport Planning, Building Evacuate Module, Crowd Evacuation, Metro Station

1. Introduction

At present, the crowd evacuation of underground passages has become an indispensable link in urban emergency evacuation of Turkey, but studies in this subject are not enough. However, the study of the aspect is not so much, of which the relevant theoretical basis is still relatively weak, even is very difficult [1] [2]. Therefore, the

How to cite this paper: Erkan, İ. and Hastemoglu, H. (2015) Building Evacuate Module for Urban Underground Passages: Subway Station in Turkey. *Journal of Transportation Technologies*, **5**, 1-8. http://dx.doi.org/10.4236/jtts.2015.51001

impact study on the large-scale crowd evacuation when there's an emergency event in urban underground passages, so as to improve the ability of the crowd evacuation, has become a key subject that can make a far-reaching implication on the urban safety and social stability [2] [3].

Crowd management, control and evacuation are very new method for Turkey. Computer simulation technology developed overseas is commonly applied in working out safety management scheme [4] [5]. These simulations can be used to analyze the evacuation of buildings, subways, metros, stadiums and traffic networks and in the process of planning, simulation model provides the assessment network clearance time or detects bottleneck problems for emergency evacuation [5]. When researchers pass through the streets safely by underground passages, studies show that pedestrians have subjective conditions worse than objective conditions [6]. Capote, *et al*. [7] present a real-time model integrated in a Decision Support System for emergency management in road tunnel. The main difference is that the proposed model can provide results faster than real-time (less than 5 s) while the run time of the other models is really higher. A novel approach is to represent space, which called the "Hybrid Spatial Discretisation", in which all three spatial representations can be utilized to represent the physical space of the geometry within single integrated software [8]. To test the predictive capabilities of different evacuation modeling approaches to simulate tunnel fire evacuations, the study is based on the a priori modeling vs. a posteriori modeling of a set of tunnel evacuation experiments performed in a tunnel in Stockholm, Sweden [9]. Without crowding within the aisle, it would reduce the evacuation time by optimal design for the width of the entrance, opening exits and layout of escaping passages [10].

Therefore, how to calculate the ability of emergency evacuation accurately in underground passages or subway tunnels and to analyze its bottleneck are the basis of improving the efficiency of emergency evacuation and preventing crowd casualties in accidents. And they are also taking the important part in planning, designing and organizing passengers flows for underground passages or subway system.

2. Analysis of Impact Factors

It was clear from the results of crowd evacuation cases of underground passages or subway station, evacuation time has great relationship with factors of the "number of passage", "width", "canalization setting" and the "number of pedestrians". In addition, the influential effect of public opinion is also significant after emergency event.

2.1. The Number of Passage Exit

The number of exit is an important indicator which can influence evacuation of people. In this case, we assume a total of 10,000 people are evacuated, in the area of 10,000 square meter, we set the exit width to 3 meter and the number of the exit is respectively 4, 6, 8 and 10, and with a velocity of 1.2 m/s. The scenario of evacuation simulation is shown in **Figure 1**.

Figure 2 shows the increase of the number of evacuating exits directly improves the efficiency of the evacuation.

When there're 4 evacuating exits, evacuation time is 798 s, however, when the number of evacuating exits increases to eight, evacuation time is 388 s. This means that when the number of evacuating exit multiplies, evacuation efficiency doesn't increase in equal proportion. The decline of the number of pedestrian out of each exit directly increases the degree of order of pedestrian evacuation. However, when the number of exits increases to a certain amount, the efficiency of evacuation cannot be improved anymore. Therefore, the number of exits of the building facilities should be set rationally according to the maximum capacity of venues.

2.2. The Width of Passages Exit

The effective width of the passage is an important factor which can influence evacuation ability of the pedestrian crossing [11] [12]. According to Code of Design on Building Fire Protection and Prevention (GB50016-2006), the width of safety exit is obtained from the expression in Equation 1.

$$W = S \cdot D \cdot E \tag{1}$$

where W is calculative width of the safety exit (m), S is the area of Business hall (m^2), D is the person density of Business hall (person/ m^2), E is the safety exit width index (m/100 person).

The model is established that there's a total of 10,000 people are evacuated and four exits, which respectively are 3, 6, 8 and 10 meters in this case and with a velocity of 1.2 m/s.

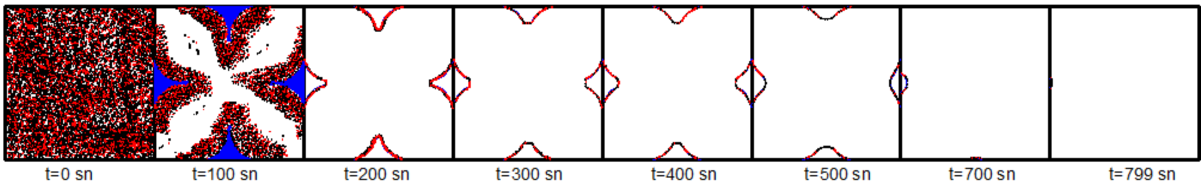

Figure 1. Simulation scenario of four exit gate.

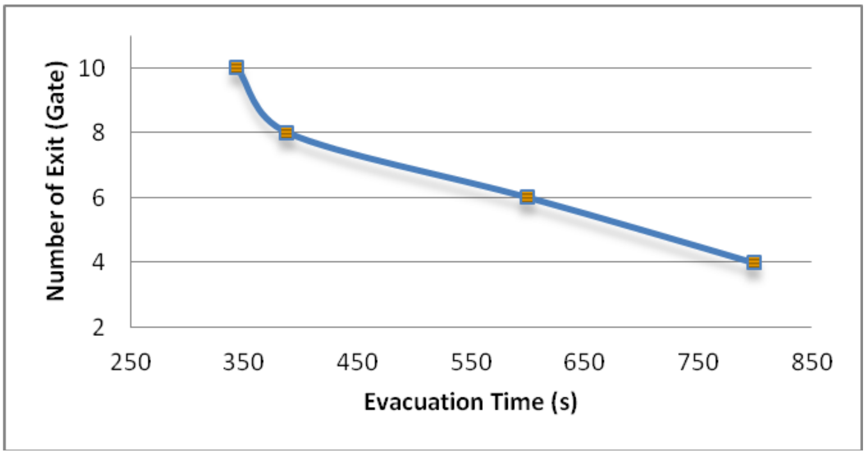

Figure 2. Number of exit-evacuation time.

Figure 3 shows that the increase of the evacuation exit width directly improves the efficiency of the evacuation.

When exits width is 3 m, evacuation time is 798 s, however, when the width increases to 6 m, evacuation time is 396 s. This means that when the width of evacuation exit multiplies, evacuation time doesn't decrease in equal proportion, but need more time. Therefore, the exit width of the building facilities should be set rationally according to the need of venues.

2.3. Passages Canalization Setting

Evacuation speed and the interference among pedestrians can be influenced by the width and the number of evacuating exits; in addition, the reasonable passage canalization set also can increase pedestrians' evacuation efficiency. Stimulating a situation that the evacuation door width is 1 m, and the number of evacuation is 100 people, and with a velocity of 1.2 m/s. We set up four kinds of circumstances, in which pedestrian evacuate respectively on their own, one passage canalization being set, two passage canalization being set, and three passage canalization being set **Figure 4**. shows that when the emergency evacuation happen, setting effective channelized diversion objects at the entrances and exits, can reduce the evacuation conflict among pedestrians and also can increase the speed and evacuation order, in order to improve the efficiency and safety.

When too many channelized objects are set up in evacuating exits, it will go too far and the evacuation efficiency will be reduced.

2.4. The Number of Pedestrians

The number of pedestrians is also an important factor. In this case, we assume 50, 100, 150, 200, 250, 300 people separately are evacuated at 1.2 m/s , across the underground passage with length of 20 meter and the width of 2 meter. And the scenario of evacuation simulation is shown in **Figure 5** at Building Evacuate Module (BEM).

The relation of number of pedestrians and evacuation time in **Figure 6.**

Figure 6 shows that the evacuation time is rising with the number of pedestrians increasing. However, the trend graph indicates that the value of evacuation time is not increasing in proportion to the number of pedestrians. The more increase of the demand of the number of evacuated pedestrians, and the higher congestion in

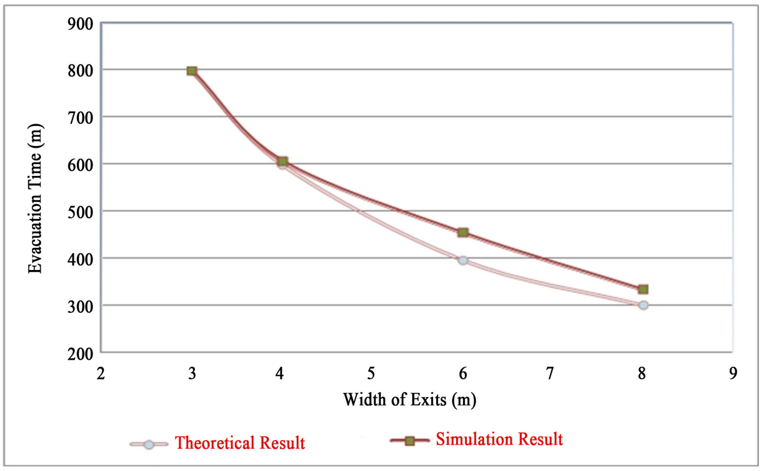

Figure 3. Relation width of exits and evacuation time.

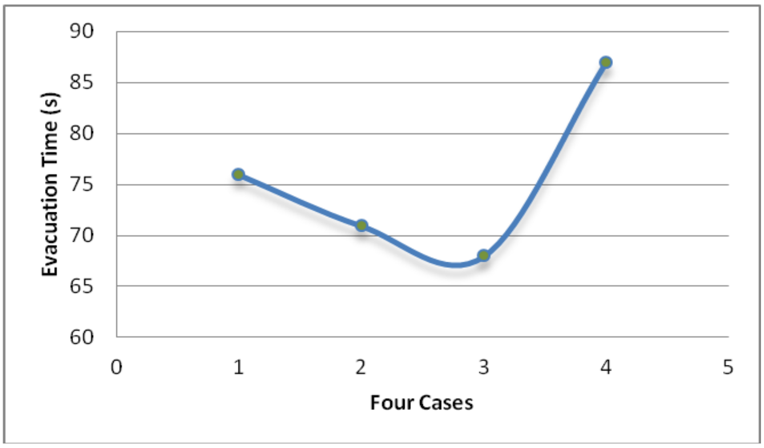

Figure 4. The four kinds of passages canalization setting and evacuation time.

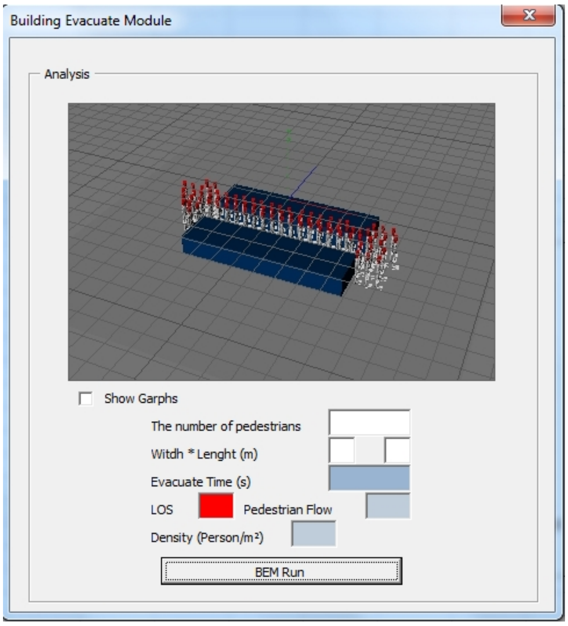

Figure 5. Interface of BEM.

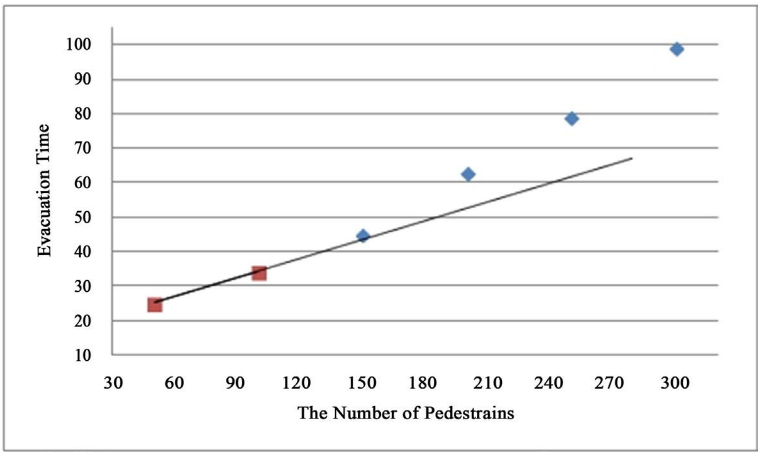

Figure 6. The relation of number of pedestrians and evacuation time.

the passage, results in a decline in the efficiency of the pedestrian evacuation, especially when the number of pedestrians gets reach to more than 200, evacuation time increases significantly. Besides, the impaired disabled are also led to a decline of the evacuation efficiency [13]. So the related management departments should strengthen control of the number of pedestrians in passages in order to reduce the accident interference in the process of evacuation.

2.5. Effect of Public Opinion

Emergency monitoring in underground passage or subway refer to that of the related network public opinion, especially when group emergency incidents occur. It's difficult for the department of administration to make judgments and decisions of the information because of so many changing factors of emergencies, complex internal relationship, unpredictable developing trend and complicated relevant information. Incidents of this kind have intense abruptness, strong social influence and short think time for policy makers and the consequences will be serious if you can't get the accurate information and make judgments in good time. However, collection, sorting and discrimination of all the information can't be handled leisurely for policy makers under great pressure, some valuable information may be omitted or ignored, so that the decision-making of treatment is misleading. New opportunities and prospects for emergency management in urban area have been brought in big data era. The bigger the scale of data about city underground passage or subway station, the more difficult to handle, but the better value may be got from the data mining. In crisis situations, department of emergency management can understand the needs, demands and feelings of public by collecting and analyzing public opinion using big data technology, they can also monitor hot issues and track the source of all information with text messages, microblog, wechat and search engine. Therefore, it's an important influence factor in evacuation of underground passage or subway station in urban area for public opinion.

3. Service Level

The characteristics of pedestrian traffic and the factors of physiological and psychological in Turkey have a greater difference. Therefore, with the research results from abroad and the pedestrian's characteristics and investigation, classification indexes of service level for pedestrians proceeding are brought forward as shown in **Table 1**.

Under general condition, pedestrian density of the crowded underground passages should be controlled according to the corresponding value of C level of service. While pedestrian density of the peak can reach to D level of service in a short time, admissible to E level at moment.

4. Evacuation Model

4.1. Field Test

One underground passage of subway station in Turkey as study object in the paper, has the unidirectional width of 2 meters.

In the field test, the number of evacuees each one minute of an interval is recorded in three evacuation period, the morning peak, common and evening peak by the observation and statistic obtained with video, as shown in **Table 2**.

From **Figure7** it is clear that the number of pedestrians is within 90 in the common period (note: the width is 2meter), so pedestrian density range of the underground passage can be controlled, service level between B and C by obtained from **Table 1**.

However, in the evacuation period in morning peak and evening peak, the number of pedestrians of the underground passage is more than 120, and it is relatively crowed, the service level has reached the E, and even up to F in some time.

From above, the E level of service is admissible at moment. However, the underground passage is overcrowding with a long time, so the department of metro or transport should be caused take seriously, to take measures so that the traffic jams stampede.

Table 1. The recommends table of the standard for pedestrians service level in Turkey for subway and underground.

Service Level	Density (person/m²)	Per Capita Space (m²/person)	Pedestrian Flow (Person/min·m)	Velocity (m/s)
A	<0.2	>5	25	1.1-1.5
B	0.2-0.8	3.5-5	32	0.9-1.1
C	0.28-0.5	2-3.5	45	0.8-0.9
D	0.5-0.83	1.2-2	62	0.7-0.8
E	0.83-2.5	0.4-1.2	90	0.5-.0.7
F	>2.5	<0.4	-	<0.5

Table 2. The number of evacuees in the three periods (Morning peak, common and evening peak).

EVACUATION PERIOD	PEOPLE				
	First 1 minute	Second 1 minute	Third 1 minute	Fourth 1 minute	Fifth 1 minute
Morning Peak	**132**	**168**	**184**	**153**	**128**
Common	**86**	**90**	**66**	**54**	**89**
Evening Peak	**128**	**144**	**136**	**166**	**153**

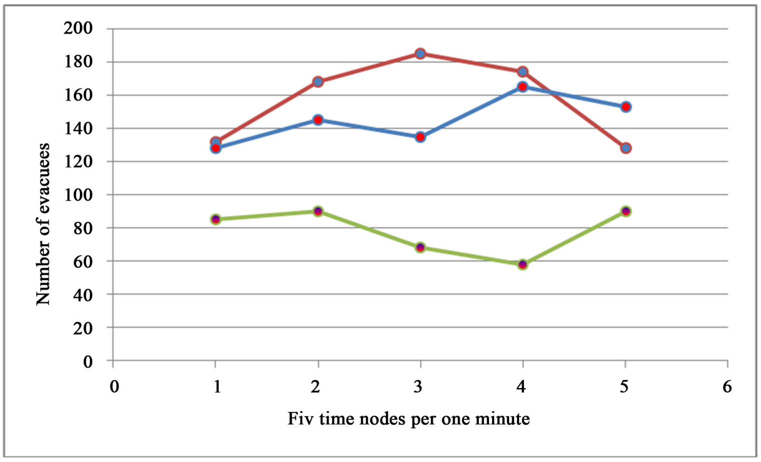

Figure 7. The underground passage of subway station in Turkey.

From above, the E level of service is admissible at moment. However, the underground passage is overcrowded in a long time, so the department of metro or transport should take seriously attention, to take measures to prevent the traffic jams and even stampede accidents or other emergency events caused by it.

4.2. Simulation

The model is built according to the same parameters with the underground passage, and with a velocity of 1.2 m/s, to conduct the walking velocity and the evacuation simulations as shown in **Figure 8** and **Figure 9** by setting 10 groups with different intensity of pedestrian flow from 30 to 300 pedestrians are passing the underground passage in one minute.

Figure 8 and **Figure 9** show that a decline in the walking velocity of the pedestrian evacuation is brought about, along with the increase of the demand of pedestrian evacuation and the degree of crowding of the passage. The number of pedestrian evacuation increases with the enlarging of demand, however, passage evacuation capacity reaches the limit to certain intensity; the number of evacuation does not continue to increase accordingly. And the simulation results are consistent basically with field test.

Therefore, pedestrian passages should be evaluated when evacuation passageways are set up in combination with evacuation flow intensity ,in the meantime, we suggested considering not only the limit of the passage evacuation capacity ,but also the suitable evacuation walking speed and the time crossing the evacuation passageway, in order to reduce interference of the emergency in the process of evacuation.

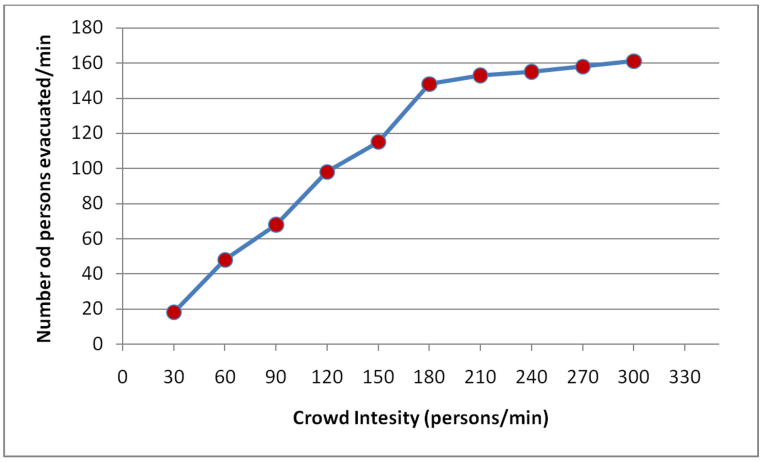

Figure 8. Relation of crowd intensity and the number of pedestrians per minute.

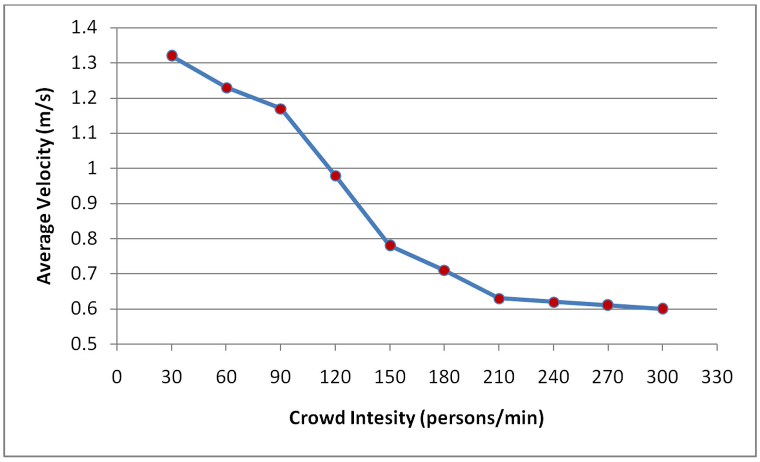

Figure 9. Relation of crowd intensity and average walking velocity.

5. Conclusion

In this paper we have presented a comprehensive study approach and considered many factors to make a plan for pedestrian evacuation in urban underground passages or metros in Turkey. The number and width of passages for pedestrians are two important parameters related to affect the evacuation capability. So building facilities should be set rationally according to the maximum capacity of venues. The demand for quantity of evacuees has a prodigious impact on the evacuation efficiency. So effective analysis of the relationship between quantity of evacuees and evacuation speed is conducive to provide a reference basis for emergency evacuation in a place which has high-density public, and also take examples for the safeguard mechanisms in big public buildings. The influence factors of pedestrian speed are so many, which also have the large range. According to the results of domestic and international research relevant, it shows that due to the differences of pedestrian age, physiology (height, weight, etc.) and investigating locations, the pedestrian speed is usually from 1.0 m/s to 1.4 m/s. It is extremely important for improved mechanism of public opinion monitoring, timely and effective collection and analysis of public opinion information, and a comprehensive grasp of various kinds of information closely related to the event in emergency events.

Acknowledgements

The authors would like to acknowledge the Suleyman Demirel University Scientific Research Project, which collectively funded this project.

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Journal of Transportation Technologies, 2015, 5, 9-23
Published Online January 2015 in SciRes. http://www.scirp.org/journal/jtts
http://dx.doi.org/10.4236/jtts.2015.51002

Crash Modification Factors for Dynamic Speed Feedback Signs on Rural Curves

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Received 22 October 2014; revised 18 November 2014; accepted 2 December 2014

Academic Editor: Mingxin Li, University of Delaware, USA

Abstract

A large number of crashes occur on curves even though they account for only a small percentage of a system's mileage. Excessive speed has been identified as a primary factor in both lane departure and curve-related crashes. A number of countermeasures have been proposed to reduce driver speeds on curves, which ideally result in successful curve negotiation and fewer crashes. Dynamic speed feedback sign (DSFS) systems are traffic control devices that have been used to reduce vehicle speeds successfully and, subsequently, crashes in applications such as traffic calming on urban roads. DSFS systems show promise, but they have not been fully evaluated for rural curves. To better understand the effectiveness of DSFS systems in reducing crashes on curves, a national field evaluation of DSFS systems on curves on rural two lane roadways was conducted. Two different DSFS systems were selected and placed at 22 sites in seven states. Control sites were also identified. A full Bayes modeling methodology was utilized to develop crash modification factors (CMFs) for several scenarios including total crashes for both directions, total crashes in the direction of the sign, total single-vehicle crashes, and single-vehicle crashes in the direction of the sign. Using quarterly crash frequency as the response variable, crash modification factors were developed and results showed that crashes were 5% to 7% lower after installation of the signs depending on the model.

Keywords

CMF, Curve Warning, Dynamic Speed Feedback Sign, Bayesian Modeling, Horizontal Curve, Rural Curve, Speed Warning, Rural Safety

*Corresponding author.

How to cite this paper: Hallmark, S.L., Qiu, Y., Hawkins, N. and Smadi, O. (2015) Crash Modification Factors for Dynamic Speed Feedback Signs on Rural Curves. *Journal of Transportation Technologies*, **5**, 9-23.
http://dx.doi.org/10.4236/jtts.2015.51002

1. Introduction

1.1. Background

Horizontal curves are a particular safety concern since they have a disproportionate number of crashes compared to tangent sections. Glennon *et al.* [1] reported that curves have approximately three times the crash rate of tangent section and the majority of those crashes are lane departures. Preston [2] reports that 25% to 50% of severe road departure crashes in Minnesota occur on curves, even though curves account for only 10% of the system mileage. Shankar *et al.* [3] evaluated divided state highways without median barriers in Washington State and found a relationship between the number of horizontal curves per kilometer and median crossover crashes. Farmer and Lund [4] evaluated single-vehicle fatal and injury rollover crashes using logistic regression and found that the odds of having a rollover on a curved section were 1.42 to 2.15 times that of having a rollover on a straight section.

Curve crashes are predominantly roadway departures. A total of 76% of curve-related fatal crashes are single vehicles leaving the roadway and striking a fixed object or overturning. Another 11% of curve-related crashes are head-on collisions [5]. The frequency and severity of curve-related crashes have been correlated to a number of geometric factors including radius, degree of curve, length of curve, type of curve transition, lane and shoulder widths, preceding tangent length, and required speed reduction [6]-[10]. Findley *et al.* [11] found that more closely spaced curves have fewer predicted crashes than curves that are farther apart.

Although curve-related crashes are correlated to geometric factors, driver factors are the main contributors to roadway departure in general and curve related crashes in specific. Driver distraction, impairment, and speed are the primary contributing factors.

Driver speed is a major factor in whether drivers will be able to negotiate a curve successfully. Council *et al.* [12] evaluated National Highway Traffic Safety Association (NHTSA) Fatality Analysis Reporting System (FARS) data and found that 29.5% of all fatal crashes were speeding-related. The researchers conducted several different types of analyses and found that single-vehicle run-off-road crashes were more likely to be speeding-related compared to multi-vehicle crashes. Crashes on curves were more likely to be speeding-related compared to tangent section and nighttime crashes. In addition, FARS data indicated that 54% of speeding-related rollover/overturn, jackknife, or fixed object crashes were on curves.

Fatality Analysis Reporting System (FARS) data were evaluated to determine characteristics of speeding-related fatal roadway departure crashes. FARS data from 2010 to 2012 were examined by the authors. Crashes in FARS were coded as "speeding-related" if the driver was charged with a speeding-related offense or if an officer indicated that racing, driving too fast for conditions, or exceeding the posted speed limit was a contributing factor in the crash [13]."

Roadway departure crashes are identified using the most recent definition provided by FHWA defined as a crash where a vehicle crosses an edge line, centerline, or leaves the traveled way.

Around 40% of roadway departure crashes are speeding-related. Thirty eight percent of vehicles involved in fatal roadway departure crashes were coded as being on a curve. Vehicles involved in fatal roadway departure crashes on curves were indicated as being speeding-related 47.3% of the time compared to only 30% on tangent sections.

1.2. Effectiveness of General Rural Curve Treatments

A number of speed management countermeasures have been employed to reduce speed and subsequently crashes on curves. Design solutions, such as paved shoulders, have generally been effective [9] [14] [15]. However they are also expensive and may need to be programed into rehabilitation or reconstruction activities.

Mixed results have been demonstrated for raised pavement markers (RPMs). Decreases in crashes of up to 33% have been found while a few studies have reported increases [16]-[18]. Additionally some concern has been raised about RPMs becoming dislodged from the pavement surface and creating a safety hazard.

Pavement markings treatments such as on-pavement curve signing, wider edge lines or centerlines, transverse markings, etc. have been applied with reasonable success. Change in crashes due to wider edge/centerlines have ranged from a decrease of 62% to an increase of 5% [19] [20]. However, several studies indicated no change in crashes [21]-[24]. Transverse markings (*i.e.* optical speed bars, converging chevrons) have been applied in a limited number of applications on rural roadways. Most studies have reported speed reduction rather than crash reduction with mean speed reductions ranging from a decrease of −5.9 mph to an increase of 4.2 mph. On pavement curve signing has resulted in decreases in mean speed of up to 4 mph [25]-[27].

The main drawback to pavement markings is regular maintenance. Additionally pavement markings can become obscured during winter weather events.

Vertical delineation, such as post mounted delineators (PMDs) or additional reflective material on chevron posts, have had mixed results. PMDs have reduced speeds in several studies by up to 8.7 mph [28] [29]. In some cases speeds have increased by up to 3.1 mph. Full-post reflective treatment added to chevron posts has a range of effectiveness from decreases up to 2.2 mph to increases of 1.2 mph [27] [28].

Rumble strips and stripes provide audible and vibratory alerts to drivers when their vehicles depart the travel lane and notify drivers that a steering correction is needed. A number of studies have been conducted about the effectiveness of both centerline and shoulder rumble strips with most studies indicating substantial reductions in crashes [30]-[33]. A few studies did show increases in crashes [31]-[33]. The main drawbacks to rumble strips are cost, potential noise issues, and possible danger to bicyclists and horse drawn vehicles. Some concerns have been raised about pavement performance with grooving as well. Additionally shoulder rumble strips require some amount of paved shoulders which many rural 2-lane roadways do not have.

1.3. Effectiveness of Dynamic Speed Feedback Sign Systems

Dynamic speed feedback sign (DSFS) systems are one type of traffic control device that has been used to reduce vehicle speeds successfully and, subsequently, crashes in applications such as traffic calming on urban roads. DSFS consist of a speed measuring device, which may be loop detectors or radar, and a message sign that displays feedback to those drivers who exceed a predetermined speed threshold. The feedback may be the driver's actual speed, a message such as SLOW DOWN, or activation of some warning device, such as beacons or a curve warning sign.

DSFS systems have been tested and proven effective in urban applications such as school zones. They can be installed reasonably quickly and can be moved to other location if not effective at a particular location. One of the main advantages is that DSFS are set to activate only when drivers are exceeding a set speed threshold which targets only problem drivers. Although DSFS are promising, their effectiveness for rural applications, such as rural curves has not yet been well explored.

Several studies have looked at the effectiveness of DSFS in rural settings. Bertini *et al.* [34] studied the effectiveness of a DSFS at a curve on Interstate 5 in Oregon. Results indicated that, after installation of the DSFS system, passenger vehicle speeds were reduced by 2.6 mph and commercial truck speeds were reduced by 1.9 mph, with the results being statistically significant at the 95% confidence level.

Tribbett *et al.* [35] evaluated dynamic curve warning systems for advance notification of alignment changes and speed advisories at five sites in the Sacramento River Canyon on Interstate 5 in California. The roadway has high traffic volumes (7650 to 9300 vehicles per day/vpd), mountainous terrain, and a number of heavy vehicle crashes. The signs were 10 by 7 foot full-matrix LED panels that could be programmed to display a variety of messages. Messages used by the researchers included curve warnings and driver speed feedback. Data were collected before and at several periods after installation of the signs. In general the researchers found decreases in mean truck speeds up to 5.4 mph and decreases of up to 4.5 mph in passenger speeds. Passenger speeds increased at one location with increases up to 7.8 mph.

The City of Bellevue Washington installed and evaluated a number of DSFS systems, including two which were used as curve advisory warnings [36]. Both were on urban arterials (35 and 25 mph speed limits). Speeds were collected before and between 18 months and two years after installation of the signs. One sign showed a 3.3 mph reduction in 85th percentile speed and the other showed a 3.5 mph reduction.

Mattox *et al.* [37] looked at the effectiveness of a DSFS system on secondary highways in South Carolina. This system consisted of a radar device and a 4 by 4 foot yellow sign with 6 inch lettering reading: YOU ARE SPEEDING IF FLASHING. In addition, there were two 1 by 1 foot orange flags and a type B flashing beacon light. Results showed that overall mean speed and 85th percentile speeds were reduced by approximately 3 mph.

A study by the 3M Company [38] evaluated driver speed feedback signs in the United Kingdom. Signs were tested at various locations in Doncaster, including semi-rural roadways. The signs displayed the approaching driver speed. The sites had speed limits of 40 mph and reductions up to 7 mph in 85th percentile speeds were noted.

Three vehicle-activated curve warning signs were placed on curves on two-lane roads in Norfolk, Wiltshire, and West Sussex [39]. The sign displays were blank when the driver was under a specified speed threshold and displayed the curve sign when a driver exceeded the threshold (50th percentile speed). Mean speeds were reduced by 2.1 to 6.9 mph. Crash data were available for two sites, and the researchers found that crashes decreased by 54% and 100%.

Santiago-Chaparra *et al.* [40] studied the effectiveness of a dynamic speed feedback sign on a rural two lane highway in Wisconsin. The DSFS displayed a flashing speed reading when an approaching vehicle was above the speed limit and provided a steady display when the approaching vehicles speed was below the speed limit. Speed trajectories were collected upstream and downstream of the DSFS. They found that the signs were the most effective 1200 to 1400 feet upstream of the sign and that the impact began to wane 300 to 500 feet past the DSFS.

All of the studies described above showed a decrease in speed suggesting the utility of DSFS in rural applications. However, all of the studies cited above had limited sample sizes. In most cases only one or two signs were evaluated. Additionally, several were tested on freeways and were typically overhead signs which are not practical for rural two-lane applications. Finally, only one study evaluated the crash impacts of the signs. And only a simple before and after comparison of two sites was available.

Another drawback to most of the above studies is that data were only collected for a short period after installation of the DSFS. Drivers often acclimate to treatments and as a result, treatments may become less effective over time.

As a result, the goal of this research was to provide a more robust assessment of the crash impacts of DSFS on rural curves than has previously been available. The study had sufficient resources to evaluate several sites in multiple states as described in the following sections.

1.4. Research Project Objectives

Driver speed is a major factor in curve related crash risk. A number of speed management countermeasures have been employed to reduce speed and subsequently crashes on curves. Design solutions, such as realignment, are expensive. Pavement markings require regular maintenance and rumble strips cause potential noise issues.

Dynamic speed feedback sign (DSFS) systems are traffic control devices that have been used to reduce vehicle speeds successfully and, subsequently, crashes in applications such as speed management on urban roads. Several studies have evaluated their effectiveness in rural setting but most have only evaluated the speed impacts and most have a very limited sample size. Although DSFS systems show promise for rural applications, they have not been fully evaluated in rural settings and most studies which have evaluated their effectiveness have assessed the effectiveness for speed management than crash reduction.

To better understand the effectiveness of DSFS systems on safety risk at rural two-lane curves, a national field evaluation was conducted. Twenty-two DSFS signs were placed in seven states and their effectiveness in reducing speed and crashes were evaluated using before and after analyses. The signs were generally very effective in reducing speed as reported by Hallmark *et al.*, (2013). Crash modification factors were also developed using a Bayesian analysis and are the focus of this paper.

2. Site and Sign Selection

2.1. Description of Site Selection

The objective of this research project was to conduct a national evaluation of the effectiveness of DSFS systems on rural curves. The team made every effort to obtain geographic diversity in selecting states where the signs would be tested. Potential sites were selected in seven states (Arizona, Florida, Iowa, Ohio, Oregon, Texas, and Washington) in conjunction with the local or state agency. During site selection, crash data were collected for three years prior to the request. Information about initially recommended sites were reviewed in the office and sites for each state with the largest number of crashes that did not have any adverse geometry or conditions that would have made the site infeasible, such as a railroad or major intersection within the curve, were identified.

Next, site visits were made to each state and the potential sites were field surveyed. During site visits, the team conducted a brief speed study using a radar gun to ensure that a speeding problem existed (defined as mean or 85th percentile that was 5 or more mph over the posted or advisory speed). After the site visits, the team selected final sites based on the number and type of crashes, whether a speeding problem existed, and other site suitability factors. A total of 51 viable sites across the seven study states resulted.

A set number of signs were allocated to each state so the researchers randomly selected sites within each state for treatment. Two to four signs were installed in each state for a total of 22 test sites in seven states. The remaining 29 sites served as control sites for the crash analysis.

Tangent speeds ranged from 50 to 75 mph and advisory speeds ranged from 15 mph to no advisory speed. Crashes ranged from 0.7 to 5.2 crashes per year with an average of 1.9 crashes per year.

2.2. Description of Sign Selection

A DSFS consists of a speed measuring device (loop detectors or radar) and a message sign that displays feedback to drivers who exceed a predetermined speed threshold. The feedback may be the driver's actual speed, a message such as "SLOW DOWN," or activation of some warning device, such as beacons or a curve warning sign.

When selecting DSFS systems, the team focused on the type of feedback provided by the variable message sign. The most common variable message sign simply displays a vehicle's speed when it is exceeding a set threshold. The sign can also activate a flashing beacon when the speed threshold is exceeded. Several sign type can also display a static message. Common messages include "SLOW DOWN" or "TOO FAST". More complex signs allow programming of a message, with the message being limited only by the number of alphanumeric characters that can be displayed on the sign.

To select final DSFS systems, the research team developed a set of minimum criteria, which included the following:

- Have the capability to be permanently mounted on a standard wood or metal pole
- Have the ability to display a warning and/or a simple message (e.g., XX mph, TOO FAST)
- Be durable enough to survive the two-year study period and perform in different climates
- Have self-contained power (e.g., A/C or solar)
- Cost less than $10,000 per sign (including installation, support, and maintenance)
- Metal l applicable Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways [41] requirements or could be approved
- Project a clear, bright, non-glare, easily readable message to motorists

2.3. Sign Displays

Two different types of DSFS systems were selected for evaluation. One displays a curve warning sign (**Figure 1**) and the second displays vehicle speed (**Figure 2**). It should be noted that, in all cases, the signs were considered supplementary traffic control devices.

The curve display sign was dark (not illuminated) for drivers traveling at or below the 50th percentile speed for the site. The 50th percentile speed was determined using speed data collected before each sign was installed. For drivers traveling over the 50th percentile speed, the sign displays the corresponding MUTCD curve advisory sign, which is based on the type of curve (*i.e.*, W1-2 sign).

The speed display sign was also blank for drivers traveling at or below the 50th percentile speed. The sign displayed actual vehicle speed (YOUR SPEED XX) for drivers traveling over the 50th percentile speed up to 20 mph over the posted speed limit. Drivers traveling 20 or more mph over the speed limit received a "SPEED LIMIT XX" message. This was done to avoid having drivers use the sign to test their speed.

2.4. Sign Installation and Maintenance

Once sites were selected, signs were ordered by the team and then installed in conjunction with the corresponding agency. The first set of signs were installed in July 2008 and the last four signs were installed in April 2010.

One sign was installed at each site. As a result, each sign was visible to drivers in only one direction. The direction of travel where the most speed-related crashes had occurred was selected as the direction for installation. In all cases, this turned out to be the direction in which vehicles were traversing the outside of the curve. The sign was installed at the PC for the selected direction.

Speed data were collected at various intervals over the course of 2 years. As a result, the team were able to

Figure 1. Curve warning display sign used in the study.

Figure 2. Speed feedback display sign used in the study.

periodically check sign functionality. Additionally, the corresponding agency monitored the signs and alerted the team when a sign was not functioning. In several cases, signs were vandalized. In most cases, the signs were fixed or replaced as soon as possible after problems were noted. The time period when a sign was not functioning was also noted.

3. Method

During site selection, crash data for three years before installation of the signs were requested from the corresponding state or county agency. Once the signs were installed for at least two years, the team contacted the corresponding agency again and requested crash data for the intervening period from the original data request before sign installation up to the most recent available data. In all cases the team received a list of individual crashes with characteristics such as date, direction of crash, etc. The installation date for each curve was used to establish the before and after period.

When signs were installed early in the study, this typically resulted in more than two years of after data and when signs were installed later in the study, this resulted in more than three years of before data. As a result, crash data were collected for up to four years before and up to three years after sign installation depending on the state.

3.1. Covariates

Several models were developed that included different types of crashes. In all cases, quarterly crash frequency was the response variable used. The year and quarter when each crash occurred was derived from the crash data. Crashes were aggregated to quarters rather than years due to the limited amount of after period data available. The use of quarters allowed the quarter in which installation occurred to be filtered from the analysis without having to exclude the entire installation year. In addition, if a malfunction occurred and the sign was inoperable, the quarter in which the signs were non-functional could also be excluded from the analysis.

The use of quarters also allowed season to be included as a covariate. A relationship between crashes and season is expected, given more crashes may occur during a particular season. Quarters were aggregated to months with similar weather as follows:

- Winter (December, January, February)
- Spring (March, April, May)
- Summer (June, July, August)
- Fall (September, October, November)

In addition, use of season as a covariate allowed differences that may have occurred due to an unequal distribution of quarters in the before and after period to be accounted for. Four different models were developed:

Total crashes for both directions of travel

Total crashes in the direction of the sign for treatment sites or outside of curve for control sites

Single-vehicle (SV) crashes for both directions of travel

SV crashes by direction in the direction of the sign for treatment sites or outside of curve for control sites

Crashes for vehicles traveling in the direction of the DSFS sign were evaluated separately given the sign was most likely to reduce crashes for vehicles traveling in that direction. A model was also developed for crashes in both directions (total crashes) given that slowing vehicles in one direction may have some impact on vehicle speeds in the opposite direction.

As noted in Section 2, one sign was installed at each site in the direction in which most crashes had occurred. In all cases, this was the direction in which vehicles were traversing the outside of the curve. As a result, the primary direction for control sites was vehicles traversing the outside of the curve. When aggregated by direction, crashes for single vehicles traveling in the primary direction and multi-vehicle crashes where one or more vehicles were traveling in the primary direction were included.

In addition, an attempt was made to develop a model for fatal crashes. However, the number of fatal crashes per site was low and there were not sufficient data to develop a reliable model.

Annual average daily traffic (AADT) was used as a measure of exposure. Given the study period was fairly short-term, in most cases AADT was the same or similar for the before and after periods.

When possible, the team requested crash data for only the curve of interest (treatment or control curve). However, states geolocate crashes differently so, in some cases, the agency provided crashes for a section that may have included adjacent curves and some tangent sections. In all cases, the same section was used for the before and after period. To account for differences in curve and section length, section length was also modeled as a covariate.

Table 1 describes the covariates included in the models. Roadway width and shoulder type were similar across sites (11 to 12 foot lanes, earth/gravel shoulders), so these variables were not included in the analysis.

3.2. Development of Crash Modification Factors Using a Full Bayes Model

A before-and-after analysis was conducted using a full Bayes (FB) model to develop crash modification factors (CMFs). Expected crash rates are represented by safety performance functions (SPFs) that relate the expected crash rate to traffic and road characteristics.

The Bayesian method accounts for regression-to-the-mean effects that result from the natural tendency to select treatment sites with high observed crash frequencies. Control sites were similar to treatment sites in terms of traffic volume, geometry, location, and crashes. (A discussion of how treatment and control sites were selected is provided in Section 2.)

In the literature, SPF estimation in the context of before-and-after analysis has been conducted via the empirical Bayes (EB) approach in conjunction with negative binomial model structure [42]-[44]. The estimated SPF is used to predict treatment site crash rates that would have occurred without the treatment [45].

Table 1. Description of covariates.

Name	Description	Range	Categorical value	
Site ID	Unique identifier for each site, used to account for repeated observations			
Volume	Annual average daily traffic	400 to 8400 vpd		
Season	Season of the year	Categorical		Winter
				Spring
				Summer
				Fall
Sign Type	Type of sign	Categorical	0	Control site
			1	Speed display sign
			2	Curve display sign
Tangent	Posted speed limit	50 to 65		
Advisory	Curve advisory speed limit	None and 15 to 50		
Speed Diff	differential of posted and advisory speed	0 to 40 mph		
Curve Type	Type of curve	Categorical	0	Isolated Curve
			1	S-curve*
			2	Several closely spaced*
Length	Length of treatment or control section; accounts for different section lengths	0.40 to 2.0 miles		
Period	Installation period	Categorical	0	Control
			1	Before installation of sign
			2	Install quarter or quarter when signs were not functioning
			3	After sign installation
Radius	Radius of curve	138 to 5953 feet		
Year-2004	Year after 2004, included to show trend over time	Categorical		

*About 500 feet or less spacing between curves.

The predicted crash rates are then compared with the observed crash counts during the after period to develop CMFs. Although many studies have employed an EB approach, the team felt that a full Bayesian (FB) approach was more appropriate. The advantages of the FB as compared to the EB approach are noted as follows:

Takes into account all uncertainties in the analysis
Provides more detailed causal inferences [46]
Requires fewer data

- Has more flexibility in selecting crash count distributions [47]

3.2.1. Model Development

The dataset included 624 observations for control sites and 492 observations for treatment sites. Year was considered as covariate in the regression term to account for changes over time. Correlations between observations, from the same section, were accounted for as within-subject errors in the model.

As noted in Section 3.1, four separate models were developed: total and single-vehicle crashes in both directions and in the direction of the treatment/outside of curve. Quarterly crashes were the response variable. Crash counts across years and sites were expressed by the following general model [48]:

$$\text{Crash counts} = \text{trend} + \text{regression term} + \text{random effects}$$

where trend counts for the effect of time, the regression term is of the same form as SPFs used in EB studies [43] [49], and random effects account for latent variables across the sites. Correlations between observations from the same section were accounted as the within-subject errors in the model.

3.2.2. Model Form and Selection Criteria

To find the appropriate model for the FB analysis, several models were tested. A zero inflated model (ZIP and ZINB) was evaluated against the plain count model (Poisson and Negative Binomial) followed by the Vuong test. Both zero inflated Poisson and Poisson-Gamma (NB) models were selected. Then, after applying the FB method, deviance information criterion (DIC) was used to compare the different Bayesian hierarchical models with a difference of more than 10 indicating incomparable of one with DIC [50].

The models were developed using the following where $Y_{i,t}$ is the observed number of crashes at site i in year t, $\lambda_{i,t}$ is the expected number of crashes at site i in year t, ε_i is the multiplicative random effect at site i, Xi, and t is the corresponding covariates such as traffic and road conditions. The expressions of all models compared are as follows:

$$\text{Model } A\ (ZIP): Y_{it} \sim ZIP\left(\pi_{i,t}, \varepsilon_i l_{i,t}\right)$$

$$\text{where } \ln l_{i,t} = a1 + X1'_{it}\beta_1 + \gamma_1(t-2004) \text{ and } \log it\left(\pi_{i,t}\right) = a_2 + X2_{i,t}\beta_2 + \gamma_2(t-2004)$$

$$\text{Model } B\ (ZINB): Y_{i,t} \sim ZIP\left(\pi_{i,t}, \varepsilon_i l_{i,t}\right)$$

$$\text{where } \ln l_{i,t} = a_1 + X1'\beta_1 + \gamma_1(t-2004), \log it\left(\pi_{i,t}\right) = a_2 + X2'\beta_2 + \gamma_2(t-2004) \text{ and } \varepsilon_i \sim \text{Gamma}\left(\phi, 1/\phi\right)$$

3.2.3. Prior Choices for FB Methodology

Prior distributions for parameters $(\alpha_1, \alpha_2, \beta_1, \beta_2, \gamma_1, \gamma_2)$ are assumed non-informative N(0, 10^3) to reflect the lack of precise knowledge of the value of the coefficients. The prior distribution for parameter ϕ is assumed *Gamma* (1,1). The posterior distributions were calibrated using Monte Carlo Markov Chain (MCMC) methods [51] [52] using all data from the control sites and the before period data for the treated sites.

3.2.4. Development of CMFs

The CMFs were calculated as follows (Equation (1)):

$$CMF = \frac{\sum_{i=1}^{n}\sum_{t=T+1}^{T+m} Y_{i,t}}{\sum_{i=1}^{n}\sum_{t=T+1}^{T+m} \lambda_{i,t}} \tag{1}$$

where n is the number of treated sites, m is number of years after treatment, T is the last year before treatment, and λ_i, t is expected crashes without treatment for intersection i in year t in the after period. The corresponding standard error (STDE) for the CMF was calculated using Equation (2):

$$STDE(CMF) = CMF \times \sqrt{\frac{Var\left(\sum_{i=1}^{n}\sum_{t=T+1}^{T+m} Y_{i,t}\right)}{\left(\sum_{i=1}^{n}\sum_{t=T+1}^{T+m} Y_{i,t}\right)^2} + \frac{Var\left(\sum_{i=1}^{n}\sum_{t=T+1}^{T+m} \lambda_{i,t}\right)}{\left(\sum_{i=1}^{n}\sum_{t=T+1}^{T+m} \lambda_{i,t}\right)^2}} \tag{2}$$

4. Results

4.1. Model Statistics

The safety effect of installing the DSFS was developed using the described methodology. As noted in Section 3, four different models were developed. Results for each model are presented below. The best model for each of the four scenarios was chosen with 95% significant covariates using DIC. **Table 2** shows the parameter estimates for the best fit model for all crashes in both directions.

Table 2. Parameter estimations for ZIP model for total crashes in both directions.

Parameter	Posterior mean	P-value
Intercept	−7.4295	<0.0001
Log (volume)	0.6456	<0.0001
Length	0.6784	<0.0001
Speed Diff	0.0432	<0.0001
S-curve vs. single curve	−0.3602	0.0174
Multiple vs. single curve	0.1819	0.0002
Spring vs. winter	−0.1159	0.3239
Summer vs. winter	−0.3105	0.0202
Fall vs. winter	−0.3247	0.0128
2005 vs. 2011	1.3004	<0.0001
2006 vs. 2011	1.0324	<0.0001
2007 vs. 2011	1.0054	<0.0001
2008 vs. 2011	0.8083	0.0005
2009 vs. 2011	0.4502	0.0693
2010 vs. 2011	0.8056	0.0005
Parameters for probability model		
Intercept	−3.9830	0.0002
Speed Diff	0.1219	0.0003

Table 3 shows the parameter estimates for the best fit model for total crashes in the direction of the DSFS for treatment sites and control sites.

Table 4 shows the parameter estimates for the best fit model for single-vehicle crashes in both directions.

Table 5 shows the parameter estimates for the best fit model for single-vehicle crashes in the direction of the DSFS for treatment sites or control sites.

4.2. Crash Modification Factors

Table 6 lists the CMFs and associated parameters for the four models that were developed.

Based on the estimated coefficients, predicted crashes per year after installing the DSFS were calculated as shown in **Table 6**. The predicted number of crashes was calculated by estimating crashes for each quarter for each treatment site and summing the predicted crashes for the after period. CMFs were calculated by dividing the observed crashes by the predicted values.

For total crashes in both directions, for example, the CMF is calculated as 52.1/54.6 = 0.95. In other words, total crashes for both directions are expected to decrease by 5% and all crashes in the direction of the DSFS are expected to decrease by 7%. Single-vehicle crashes in both directions are expected to decrease by 5% and single-vehicle crashes in the direction of the sign are expected to decrease by 5%.

To determine whether the reduction due to the treatment was significant or not, 95% confidence intervals (CIs) for the CMFs were calculated and are shown in **Table 6**. For example, the 95% CI for all crashes in both directions is [0.95 ± 1.96 × 0.01] = [0.93, 0.97], not containing 1, so the crash reduction for all crash types is statistically significant.

Results of the statistical analyses indicate that the DSFS results in a crash reduction ranging from 7% to 5%.

5. Conclusions

The study developed crash modification factors for dynamic speed feedback signs that were installed on rural two-lane curves at 22 sites across seven states. Control sites with similar characteristics were included in the

Table 3. Parameter estimations for ZIP model for total crashes in one direction.

Parameter	Posterior mean	P-value
Intercept	−8.0551	<0.0001
Log (volume)	0.6992	<0.0001
Length	0.7602	<0.0001
Speed Diff	0.0278	0.002
S-curve vs. single curve	0.1061	0.5443
Multiple vs. single curve	0.4392	0.0463
Spring vs. winter	−0.3236	0.0460
Summer vs. winter	−0.3088	0.06604
Fall vs. winter	−0.5034	0.004
2005 vs. 2011	1.2227	<0.0001
2006 vs. 2011	0.9846	0.0005
2007 vs. 2011	0.9411	0.0009
2008 vs. 2011	0.5879	0.0476
2009 vs. 2011	0.2842	0.3684
2010 vs. 2011	0.6984	0.0158
Parameters for probability model		
Intercept	−1.1540	0.006

Table 4. Parameter estimations for ZIP model for SV crashes in both directions.

Parameter	Posterior mean	P-value
Intercept	−7.5668	<0.0001
Log (volume)	0.5629	<0.0001
Length	0.7287	<0.0001
Speed Diff	0.0382	<0.0001
S-curve vs. single curve	−0.3182	0.0578
Multiple vs. single curve	0.2889	0.0003
Spring vs. winter	−0.0413	0.6621
Summer vs. winter	−0.3927	0.0117
Fall vs. winter	−0.2790	0.0542
2005 vs. 2011	1.7834	<0.0001
2006 vs. 2011	1.5176	<0.0001
2007 vs. 2011	1.3917	<0.0001
2008 vs. 2011	1.2045	<0.0001
2009 vs. 2011	0.8893	0.0048
2010 vs. 2011	1.2391	<0.0001
Parameters for probability model		
Intercept	−4.3494	0.0053
Speed Diff	0.1238	0.0025

Table 5. Parameter estimations for ZIP model for SV crashes in one direction.

Parameter	Posterior mean	P-value
Intercept	−7.7523	<0.0001
Log (volume)	0.5269	<0.0001
Length	0.7984	<0.0001
Speed Diff	0.0329	<0.0001
S-curve vs. single curve	0.2163	0.2721
Multiple vs. single curve	0.6136	0.0398
Spring vs. winter	−0.3131	0.0936
Summer vs. winter	−0.3916	0.0502
Fall vs. winter	−0.5374	0.0071
2005 vs. 2011	1.6955	<0.0001
2006 vs. 2011	1.4447	<0.0001
2007 vs. 2011	1.2980	0.0005
2008 vs. 2011	0.8900	0.0226
2009 vs. 2011	0.6567	0.1093
2010 vs. 2011	1.0992	0.0040
Parameters for probability model		
Intercept	−1.3295	0.0336

Table 6. Results for calculation of crash modification factors.

Crash Type	Direction	Observed Crashes	Estimated Crashes	CMF (SE)	95% CI
Total	Both	52.1	54.6	0.95 (0.01)	0.93, 0.97
Total	Toward sign/outside of curve	32.5	34.8	0.93 (0.02)	0.89, 0.97
Single-vehicle	Both	38.6	40.7	0.95 (0.01)	0.93, 0.97
Single-vehicle	Toward sign/outside of curve	22.3	23.4	0.95 (0.02)	0.91, 0.99

analysis. Two different signs were evaluated. One shows speed for vehicles traveling over the 50th percentile speed and the second displays the corresponding curve warning sign.

A full Bayes analysis was used to develop the CMFs. Results indicate that crashes were 5% to 7% lower after installation of the sign depending on type and direction of crash. No difference was noted between sign type.

Results of a speed analysis, which was discussed further by Hallmark *et al.* [53], indicated that significant reductions in speed resulted and that the reductions were sustained for the most part over the two-year analysis period.

Although the signs were effective in reducing both speed and crashes, the signs were relatively expensive (approximately $10,000 per sign installed). As a result, agencies should continuously consider trade-offs and advantages and disadvantages of site specific safety countermeasure when implementing safety strategies.

Acknowledgements

The authors would like to thank the Federal Highway Administration, the Midwest Transportation Consortium, the Iowa Department of Transportation, the Iowa Highway Research Board, and the Texas Department of Transportation for sponsoring this research. We would also like to thank the corresponding state and local agencies who worked with us to select and install treatments. The Center for Transportation Research and Education also thanks the Texas Transportation Institute and Portland State University for their partnership on this research.

Highlights

Dynamic speed feedback signs were installed on rural two-lane curves at 22 sites across seven states.
Crash modification factors for dynamic speed feedback signs were developed using a full Bayes analysis.
Results of the statistical analyses indicate crash reductions ranging from 5% to 7%.
Although the signs were effective in reducing both speed and crashes, the signs are relatively expensive.

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Journal of Transportation Technologies, 2015, 5, 24-36
Published Online January 2015 in SciRes. http://www.scirp.org/journal/jtts
http://dx.doi.org/10.4236/jtts.2015.51003

Evaluation of the Environmental, Social Effects for the Egyptian National Railways Restructuring

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Received 23 December 2014; accepted 10 January 2015; published 16 January 2015

Abstract

This paper presents the main findings of the environmental and social impact assessment (ESIA) for the Egyptian national railways restructuring. This paper consists of the two parts: 1) modernizing the signaling system on the Arab El Raml-Alexandria Line and creating a Central Traffic Management Center in Tanta; and 2) renewing 200 km of track in Lower and Upper Egypt. The purpose of this evaluation is to identify and examine the potential socio-cultural, economic, and physical impacts of the railway restructuring, and propose measures to mitigate its adverse impacts, and develop plans for managing and monitoring the environmental aspects of the railway restructuring. This paper describes outlines of the environmental and social sensitivities of the railway restructuring area, potentially significant impacts of the proposed project and plans for their mitigation. Detailed information on the environmental and socio economic settings of the railway restructuring, components and activities of the proposed project and the results of the environmental and social impact assessment studies are presented in the body of the paper.

Keywords

Railway, Railway Restructuring, Environmental, Quality, Socio Economic, Volume of Populations

1. Introduction

The Egyptian National Railways (ENR) is worked on developing a program for modernization investment from 2007 to 2011, which will finance improvement of signaling and telecommunications facilities and replacing certain sectors of the tracks in upper and lower Egypt. A comprehensive study was undertaken in 2005 to define

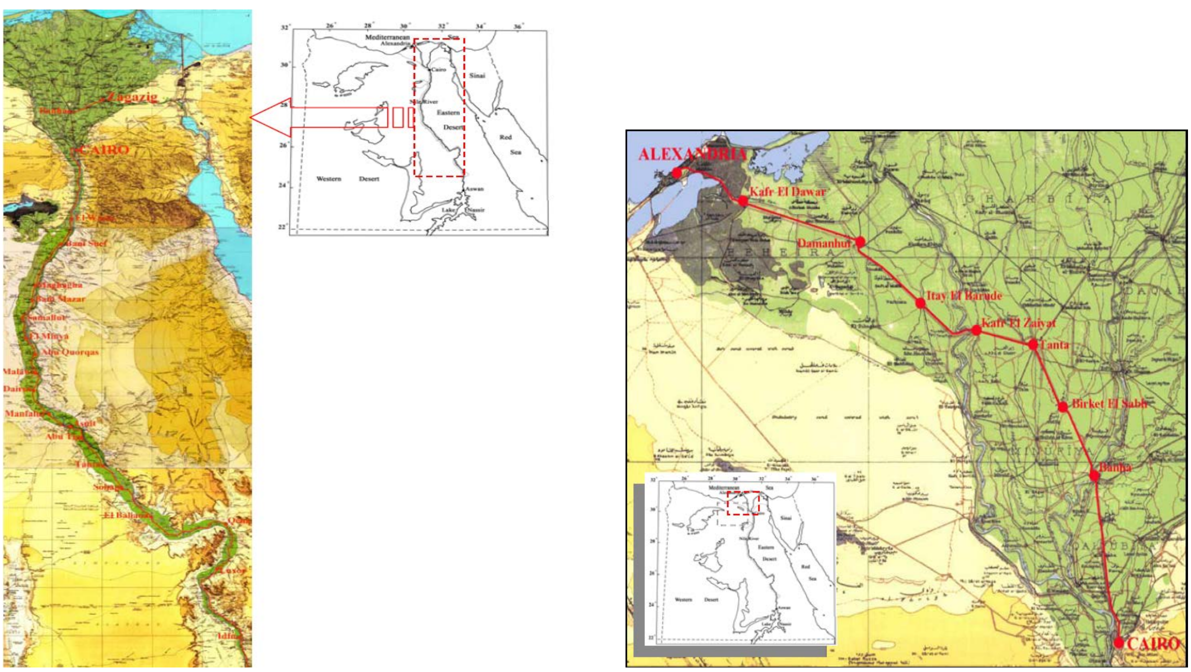
How to cite this paper: Ali, M.A.M. and El Sayed, M.A. (2015) Evaluation of the Environmental, Social Effects for the Egyptian National Railways Restructuring. *Journal of Transportation Technologies*, **5**, 24-36.
http://dx.doi.org/10.4236/jtts.2015.51003

the strategy and scope for the required modernization. The proposal of the railway restructuring, which is covered by the (ESIA), has been developed on the basis of that strategy [1]. It consists of the following two components:

***Part* 1:** This part of the Egyptian national railways restructuring will consist of the signaling systems from Arab el-Raml to Alexandria and centralized traffic control (CTC) for that section and Cairo-Banha (on the Cairo-Alexandria line). The section was selected on the basis of a multi-criteria assessment of the network giving special attention to congestion levels and safety situation. When completed, this section will be the most modern part of the Egyptian railway network in terms of signaling and safety standards.

The Cairo-Alexandria railway line, 208 km long, is one of the main lines of ENR. Now ENR service operates on the Northeast Corridor similarly to other Northwest Corridor regional services. Each major city has a central train station. In Cairo, it is Ramses Square; and in Alexandria, it is Sidi Gaber and Masr station. The daily number of passenger trains operating on the line is 65 in each direction. Some of these 32 are express trains (air-conditioned trains, mixed trains, and those that are not air-conditioned) that operate on the whole distance between Cairo and Alexandria. The other 33 are local trains that operate between one point and another on the line [2]. The line has the highest passenger density (200 to 214 thousands passenger per day) of the entire ENR lines. It can be seen that the all number of trains from Cairo to cities locate in the Cairo/Alexandria corridor. However, there are about 30 trains passing between Cairo to Alexandria.

Modernize the signaling system on the Arab El Raml-Alexandria line and create a Central Traffic Control Center in Tanta (CTC) (**Figure 1**). This component of the part consists of modernization of basic elements of the signaling systems. It includes introducing a modern Electronic Interlocking System (EIS) to replace the existing electromechanical system. The component also includes the upgrading of Central Traffic Management Center in Tanta, which will control all operation of the entire line. The Tanta Traffic Control Tower will be linked with 11 dispatcher towers along the line (including four new towers) through a network of optic fibers for transmission of telecommunication signals. The new, computerized CTC facility will be provided with two 11 kV power supply units, with auxiliary diesel generators for all control towers of the line. The system will include the modernization of automated counter flow junctions and signaling. It will also include the automation of level crossings to improve the safety and operation efficiency through the introduction of automatic, visual and audio signaling and gate operation and an automatic train approach control system. Also communication and power cables will run parallel to the tracks and no less than two meter on either side. The cables will be placed at least



(a) (b)

Figure 1. Geographical locations of the Part 1 and Part 2.

one meter below the ground surface. The process for laying the cables will be largely automated and highly efficient requiring only limited interruption in the operation of the line and its facilities. Cables will also run under water to cross the Nile and Major Irrigation canals at five locations.

In addition, the Egyptian national railways restructuring will be under this component, a computerized CTC, offering sophisticated information to railway staff, including: 1) command and monitoring of train circulation; 2) a presentation-of-train graph; 3) event recording, and 4) dispatcher communications.

***Part* 2:** the second part of the Egyptian national railways restructuring is track-replacing works for 200 km of track tracks in upper and lower Egypt (**Figure 1**). Track section is along the Cairo-Aswan line in upper Egypt (149 km on four sections of track) and the Benha-Port Said line in lower Egypt (51 km on two sections of track), and supervision of those works [3]. Railway ballast track to be renewed have been identified based on the current conditions, traffic levels, and contiguity with track in similar condition. The track structure of the identified sections will be fully renewed; including construction of the new track, *i.e.*, consist of U-I-C 54 rails of continuous-welded rail, concrete sleepers, elastic fastenings, and ballast. The renewal of track system could be helpful to significantly decrease the risk of derailments and decrease track maintenance cost, therefore increasing train speed (notably through elimination of speed restrictions due to the best quality of track).

The Egyptian national railways restructuring project is intended to enhance the efficiency and safety of operation of the Egyptian railway system. The impact factors of the project that affect the fulfillment of these objectives, and their environmental cost are therefore considered in this analysis. Areas to be mostly affected by the project are based upon the relative advantage of the new facilities introduced into the railway lines in terms of efficiency of use of existing conventional lines, increasing train speed and reduction of trip time, improvement of operation safety, and reduction of noise level.

2. Objectives and Description of the Egyptian National Railways Restructuring

Railway system was established in 1852 and has since played a major role in transporting passengers and cargo throughout Egypt's various governorates and districts. The Egyptian railway was designed for the movement of passenger and single car-shipments over a network connecting all of Egypt's major cities and traffic generators. The system, for the most part, serves the Nile Valley and the delta. Because of the deserts and seas surrounding Egypt, the railway operates as an isolated system. The Egyptian Railway Authority was established in 1956 as a semi-autonomous agency responsible to the Ministry of Transport and Communications, whereas the railway was previously operated as a government department.

The railway sector plays a significant role in the Egyptian economy and is an essential mode of transport for low-income people. Railway sector in Egypt is managed and operated by Egyptian National Railways created in 1980. It is responsible for managing the railway infrastructure and operates railway transport services on the entire network. In 2010, the railway network measures about 5195 km of track line between cites, and serves the main activity and population centers in Egypt, consisting entirely of standard gauge track. The railway also carried heavy passenger traffic, especially in Lower Egypt. In many cases, lines operated close to their design capacity, and freight services suffered the effects of severe congestion. Furthermore, passenger traffic was growing more rapidly than freight. Nevertheless, freight revenue, which was once as great as passenger revenue was only half as great in the mid-1980. However, in the year 2004 the revenue of passenger traffic increased more than 2/3 from the freight revenue [3]. Egyptian National Railways consider the largest in transportation of passengers and freight, and is considered the backbone for transportation people in Egypt, where the volume of passenger transport by rail about 1.5 million passenger daily, and 12 million ton of freight [4]. Railway operations became a matter of deep concern to the Government due to several issues, in particular, acute safety issues, deteriorating quality of service, and the significant impact of the sector on the public budget.

At the present time, the entire network of transportation is covered with a microwave telecommunication system allowing voice communications between dispatchers (located in ten regional traffic control centres) and train drivers, and between regional offices and the headquarters in Cairo. An electric color-light, **Table 1** the Automatic Block Signaling System is installed on the railway lines for the part of Arab El Raml-Alexandria Line [5].

While most of the network operates by outdated mechanical traffic control systems, the following lines are equipped with central traffic control systems (**Table 1**):

- Cairo/Qaluib.d

Table 1. Automatic block signaling system in the Arab El Raml-Alexandria Line.

From/to	Distance (km)	Installation
Cairo/Alexandria	208	Installed in 1980 and 1978
Giza/Beni Suef	125	Installed in 1990
Cairo/Giza/Bortos	31	Installed in 1984
Asyut/Sohag	90	Installed in 1962 and modified for double track in 1990
El Manashi/Etay El Baroud	122	Installed in 1986
Abu Qir line	19	Installed in 1988
Kobri El Limoun/El Tawdeeb	5	Installed in 1998
Qaliub/Shibin El Qanater	18	ELS system under construction

- Qaluib/Benha
- Cairo/Giza/Bortos.
- El Manashi/Etay El Baroud.
- Giza/Beni Suef.

In addition, certain sectors of the railway tracks in both upper and lower Egypt have been in service beyond their safe operation age according to the ENR standards. The deteriorating conditions of the tracks in these sectors pose an operational risk that requires reducing train speed and their frequent repair needs contribute to train delays. ENR is currently developing a 2007 to 2011 modernization investment program, which will finance improvement of signaling and telecommunications facilities and replacing certain sectors of the tracks in upper and lower Egypt.

3. Analysis of Alternatives Proposed

There are two levels of analysis of alternatives have been undertaken of the railway restructuring for each part component. First scenario is considered, implementation alternative and the no action alternative. The two alternatives will be analyzed and discussed. At the second level of analysis, the preferred alternative is subjected to further analysis of alternatives. In this analysis the relative environmental and social merits of elements and activities of the selected project alternative are considered. These alternatives are evaluated and compared, and the optimal one selected. These may include alternative designs, construction methods, building material, and management systems, as appropriate

***Part* 1:**

Alternative I: non-implementation of the project

To continue operating the Cairo-Alexandria line with the existing signaling system, with its frequent breakdowns and inefficient operational capabilities places a major additional burden on the ENR's efforts to improve its services to the public and to overcome its major financial difficulties. Many of the present financial difficulties also stem from the frequent breakdowns of the existing systems, and the resulting uneconomical use of the lines and its equipment. It is expected that difficulties facing ENR will grow worse if not addressed now and will become more difficult and more costly to resolve without the implementation of the proposed project. Without the project, the railway service on the Cairo-Alexandria line will further deteriorate affecting the millions of users of that vital line.

Alternative II: Implementation of the proposed project

The railway restructuring project will provide the badly needed modernization and replacement of elements of the outdated electromechanical signaling system along this most important railway line in the Egyptian railway network. The implementation of the project will benefit the very large number of users of that line, which averages of close to 120 million passengers per year [6]. Once completed, the project will improve the railway service of the Cairo-Alexandria line considerably. Positive impacts of the project on the railway service include the following:

- Improved train operation safety.

- Improved operation safety of level crossings.
- Reducing trip time as a result of increased train travel speed,
- Will allow more trains to safely use the line per unit time, and will reduce operational delays.
- Increase comfort as a result of smoother train movement and reduced noise levels.

Although the economic cost of the proposed project is relatively high, the ENR that the modernization of the existing, outdated system is highly justifiable to ensure the safe and efficient operation of the railway service along that line. On the other hand, the ENR sees the modernization of the signaling system as an inevitable action that has to be undertaken sooner or later. The operation of the highly efficient modern system will also reduce cost of operation per traffic unit and will contribute to the ENR's efforts to reduce loses and increase revenue generating potential. But there are many a number of negative impacts are expected during the construction phase of the railway restructuring project.

3.1. The First Project Component

Modernizing the signaling system on the Arab El Raml-Alexandria Line and creating a Central Traffic Management Center in Tanta, this component of the project consists of modernization of basic elements of the signaling systems covering the following components (**Figure 2**):

a) Full new automatic block signaling system (with contraflow signaling) with color light signals between Arab El Raml and Alexandria.

b) Remote control of signaling equipment

c) Electronic Interlocking Systems

d) Full new automatic level crossings, not including civil works, between Arab El Raml and Alexandria

e) Assembling of Cables and cabling equipments related with all signaling and telecommunication systems

f) CTC computer based Command Center, including definition of non-proprietary "CTC interface protocol"

g) Diagnosis systems for all components

h) Tests of system and put into service of the system

i) Complete power supply system with SCADA (Supervisory Control and Data Acquisition) management system

j) Preventive maintenance (level 1, level 2 and level 3)

k) Training of operation and maintenance staff

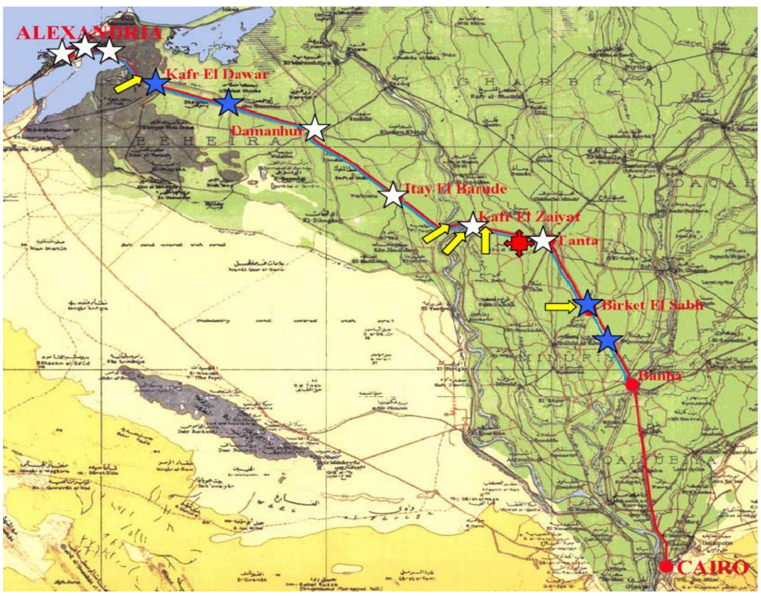


Figure 2. The Cairo-Alexandria railway line (red line) and the Arab El Raml-Alexandria signaling system upgrading sector (blue line), showing the approximate locations of existing dispatcher towers ( ), proposed dispatcher towers ( ), draw bridges ( ) and the Tanta traffic control center.

The following concepts and main requirements will be used for the elaboration of the preparation of the functional specifications and the preliminary design of the signaling system on Arab El Raml-Alexandria corridor.

- Signaling system, protection systems in level crossings, train and security brake systems to be established will be in conformity with 160 km/hour train speed
- Signal system will be SSI (Solid State Interlocking) and will be designed in modular systems
- CTC center and Local Command Console functions (command and monitoring, evaluation, presentation of train graph, information event recording system, dispatcher communication system, uninterrupted power supply, etc.)
- Main characteristics of track circuits (type of track circuits to be used, ballast impedance, detection of complete section rail broken) and of switch engines (mode of connection to interlocking to provide a safe locking, type of operating energy, manual operation included, etc.)
- Main characteristics of protection system of level crossing standards, adjustable and synchronous informing time to be maintained according to train speed and/or train existence, lighted and noised warning devices to be used in all level crossing protection systems, for level crossings determined by ENR barrier handled protection devices to be used, etc.)
- Energy of signal equipment between stations will be provided from uninterrupted power source;
- Energy of CTC and stations shall be provided from two independent sources. In case of interruption of the main power system, CTC and stations (vital functions) shall be fed by uninterrupted power source over buffer charged accumulators that can give steady energy
- Main characteristics of communication cables (fiber optic option to be evaluated) and of signal cables will be described
- Transmission and communication systems main characteristics to provide voice and data transmission on fiber-optic cable for telecommunication and signaling installations and computer systems
- Diagnosis system for controlling the status of all components and reporting to the maintenance center (**Figure 3**)

At the present time, there are seven dispatcher towers. These are the Tanta, Kafr El Zaiyat, Itay El Barude, Damanhour, Sidi Gabir, El Hadra and Alexandria towers. Four additional towers will be constructed in Qowesna, Birket El Sabh, Abu Homos and Kafr El Dawar. The new, computerized train tracking system will be capable of tracking train by number, type, location, and speed and detecting delays and operation malfunctions. The system will also include the modernization of automated counter flow junctions and signaling.

The system will also include the automation of 53 level crossings to enhance the safe and efficient operation of these vital elements of the railway line. This will include the introduction of automatic, visual and audio signaling and gate operation. The automated level crossing systems will also include the introduction of automatic-train approach control systems. Draw bridges along the line (five bridges) will also be equipped with automated signals to replace the existing electromechanical signaling system.

This new electrolysis system will significantly improve considerably the safety of operation of the Cairo-

Figure 3. The Tanta traffic control center.

Alexandria railway line and is expected to reduce accidents caused by human error or failure of the existing, outdated signaling system. It is also expected to allow a much safer operation of the large number of level crossings along this line. As trains average travel speed is expected to increase following the operation of the new signaling system (maximum speed may be as high as 160 km/hour), accidents which cannot be completely eliminated will have much more destructive consequences. This is particularly true with the often lax control of traffic across level crossings and the frequent, illegal pedestrian crossing of the railway tracks.

***Part* 2**

Alternative I: non-implementation of the project

For the second part of the railway restructuring project, not doing anything is absolutely unacceptable. Because all parts of the railway line that had been identified to be replaced, where these parts of the railway are is a major obstacle on the railway operations and ENR it must be avoid this obstacle. Also the Egyptian railways had been contraction, more than 150 years on the Nile Delta and there is chronic underinvestment. Infrastructure and equipment

Alternative II: Implementation of the proposed project

The replacement of track sections is a necessary procedure in the normal maintenance of railway lines. According to ENR representatives and railway experts, the replacement of some of the sections is long overdue. As a precautionary measure, the ENR operates the trains at slower speeds in track sections based on their conditions. This often results in longer trip times and considerable delays, particularly when large sections of the tracks are in poor conditions as is the case of the Cairo-High Dam and the Banda-Zagazig lines. The adoption of the slow train travel speed tactics along the deteriorating lines adversely affect the economics of the use of the line as fewer trains can use it per unit time. Replacing the sections will allow the trains to operate at the track design speed and hence a more efficient use of the tracks by allowing more trains to use the tracks per day. It will also contribute to allowing passengers, faster, safer, less noisy and more comfortable train service. Replacing track sections is an absolute necessity that is unavoidable in the normal operations of any railway system. But temporary impacts are expected to occur during the construction process. Most of these impacts can be mitigated, and the expected improvements in the rail service as a result of the proposed project greatly outweigh any expected residual impacts.

3.2. The Second Project Component

Replacing 200 km of the tracks in Upper and Lower Egypt, track sections to be replaced through this component of the project are shown in **Table 2**. This includes sections of the Banha-El Zagazig line in Lower Egypt (23.9 km westbound and 27.3 km eastbound) and 148.7 km in the different sections of the Cairo-High Dam Line in Upper Egypt.

The existing conventional tracks on the Banha-El Zagazig line (construction period 1989-1990) was constructed a ballasted track, *i.e.*, UIC 54 welded rails with concrete sleepers. In the Cairo-High Dam Line (construction period 1983-1988), the existing conventional track was also constructed a ballasted track, *i.e.*, UIC 54 welded are welded rails with wooden or concrete sleepers. The rails will be replaced in these sections with new UIC 54 rails on pre-stressed concrete sleepers using the K-Type rail fastening system, *i.e.*, electrically insulated. The component of old tracks such as (rails, sleepers, etc.) had replaced by the new one and then it was transported by a freight train to ENR storage yards for subsequent storage and disposal. New ballast of basalt gravel will be added to a depth of 30 cm. This layer will be mechanically packed according to the technical specifications until reaching the final designed level. The quantities of ballast required for the replacement of the track sections has not been specified in the project material provided. The project document does not specify the expected source of that relatively large quantity of basalt. However, basalt quarries are found at several areas in the Egyptian desert and have been in use for centuries. The largest are the Abu Zahbal Quarries located just northeast of Cairo, which produce most of the basalt used in the Greater Cairo area. Officials of the ENR clearly stated that new basalt will be used for all construction work of this project.

ENR engineers stated that the normal procedure for track replacement work includes the transportation of old rails and sleepers using flat cars to the ENR storage yards to be subsequently sold. Standard, 18 m rail sections or pre-welded tracks of 252 m length will be used. Track segment of (18 m) was transported to the assembly yards in Tanta and Minia. The track segment will then be transported by an assembly train, equipped with flat cars to the installation site. Following the rail installation and the mechanical leveling and packing of the embankment to the design levels, trains will be allowed to run on the new tracks several times before the rails sec-

Table 2. Track lengths and locations to be replaced.

Railway line	From (km/m)	To (km/m)	Distance
Banha-Zagazig	7/828	31/716	23.888 km—westbound
Banha-Zagazig	1/100	29/148	27.348 km—eastbound
Cairo-High Dam	104/930	126	21.070 km—southbound
Cairo-High Dam	207/500	187/500	20.00 km—northbound
Cairo-High Dam	467/500	528/500	61.00 km—southbound
Cairo-High Dam	541/197	467/500	46.694 km—northbound

tions are welded in a pre-stressed position. Welding of the 18 or 252 meter rail segments will be carried out with the rails in place Rail welding ensures a smoother, less noisy train movement on the tracks.

The replacement of these tracks sections is necessary for the safe operation of the Cairo High Dam Railway Line [7]. The present condition of the tracks in these sections represents an operational hazard to the trains and the adjacent communities. To minimize the potential hazard caused by these old track sections, the ENR adopts operation protocols that include reducing train speed at these sections, which in turn results in longer trip times and a considerably reduced total passenger capacity of the line. This project component, therefore, will alleviate this potential operational hazard and maximize the operation efficiency of the line.

As shown in **Figure 4** the all part of the track replacement section in the railway restructure of the Upper Egypt. **Figure 4(a)** and **Figure 4(b)** show the track replacement section in the Banha-Zagazig line, and the Cairo-Bani Suef respectively. **Figure 4(c)** shows the part of replacement section in Maghagha-Samalut sector of El Minia city, and **Figure 4(d)** shows the last section of replacement between Abu Tig-El Baliana of the Asyut and Sohag cities.

4. Significant Impacts for Restructuring

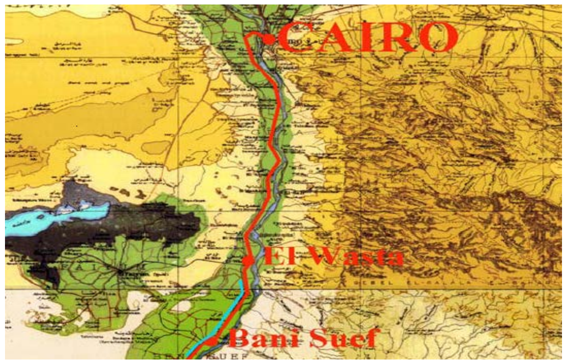
The railway lines of both components of the project run through the most densely populated regions of Egypt. The socioeconomic make-up of the influence area of the project is extremely diverse, and is in fact as varied as that of the Egyptian society. These include affluent communities of high economic sectors of Cairo and Alexandria, as well as poorest of the poor of the Egyptian society in informal urban areas and in remote villages of Upper Egypt. Although the greatest part of the railway tracks run through rural areas where the main economic activity is agriculture, considerable portions of the lines pass through urban areas with highly diverse economic activities.

The railway track corridor cuts across most of the towns it serves, creating a physical barrier that often divides a town into two socio-economically distinct sections. This is caused by the fact that the railway lines were originally placed just outside cites. As cities grew, often informally, the poorer sectors of the urban society gradually settled on the side of the track opposite of the formal town. Informal neighborhoods eventually appeared, conveniently close to the formal city yet separated from it by the railroad embankment. The railway corridor, which is often walled within cities, allow traffic and people crossing at relatively few level crossings,. These level crossings invariably form traffic bottlenecks, particularly in larger, more crowded area. Informal crossings created by breaching the protective walls are extremely common and create a major hazard to its users and the passing trains.

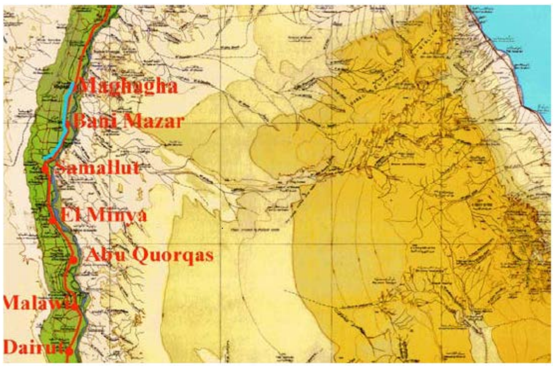
The Cairo-Alexandria railway line runs through the Nile Delta, one of the most densely populated areas in the world, linking the largest population centers in Egypt and several of the country's larger towns. The line provides a railway linkage for the capital cities of six governorates and a total human population of approximately 31 million [2], most of whom live in the urban areas of Cairo and Alexandria and delta towns. It provides a key transportation service for passengers, goods and mail service. **Table 3** shows the governorates transected by the Cairo-Alexandria railway line [8].

The Cairo-High Dam railway line links the largest population centers in Upper Egypt to Cairo. The line provides a railway linkage for ten governorates with a total human population about of more than 41 million, a little than one half of whom live in urban areas. **Table 4** shows the governorates transected by this line. The line represents the most important transportation service for passengers including tourists traveling archeological attractions of Upper Egypt [9]. The line is also a key transportation artery for cargo within Upper Egypt and be

Banha-Zagazig line



Cairo-Bani Suef sector



Maghagha-Samalut sector

Abu Tig-El Baliana sector of the Cairo-High Dam line

Figure 4. Track replacement sections (blue line) in railway restructure of the upper Egypt.

Table 3. Governorates transected by the Cairo-Alexandria railway line and the size of their urban and rural populations.

Government	Urban	Rural	Total
Cairo	7,786,640	-----	7,786,640
Alexandria	4,110,015	-----	4,110,015
Qalioubiya	1,599,230	2,637,773	6,874,776
Menofia	668,703	2,601,701	3,270,404
Gharbia	1,200,752	2,809,546	4,010,298
Beheira	907,300	3,829,826	4,737,126
TOTAL	16,272,640	11,878,846	30,789,259

tween Upper Egypt and Lower Egypt and Cairo.

4.1. Environmental and Social Impacts

Most of these impacts are expected to be affecting both the local populations close to the construction sites as well as the general users of the railway line regardless of where they live. Impacts on the operation of the railway lines during construction will affect larger sectors of the society, particularly those using the train. Impacts on the physical environment and the ecology of the project area appear to be minor.

Accordingly, the Egyptian national will investigate more closely the socio-economic impacts of the construction process and activities of both components of the project. The Egypt railways restructuring covers two impact groups. These are the impacts on users of the train lines (including daily commuters and other passengers), and those that will affect communities residing or working near the construction sites. Accordingly, two types of impacts will be considered in the assessment

Table 4. Governorates transected by the Cairo-High Dam railway line and the size of their urban and rural populations.

Governorate	Urban	Rural	Total
Cairo	7,786,640	------	7,786,640
Giza	3,676,034	2,596,953	8,869,524
Beni Sweif	5,232,539	1,757,988	6,990,527
Fayoum	564,596	1,948,196	2,512,792
Minya	787	3,392,728	3,393,515
Assiut	906,864	2,534,733	3,441,597
Sohag	801,360	2,945,017	3,746,377
Qena	643,097	2,358,397	3,001,494
Luxor	213,819	237,499	451,318
Aswan	502,863	681,579	1,184,442
Total	20,328,599	18,453,090	41,378,226

1) Generalized impacts: these are widespread impacts that will affect most or the entire influence area of the project component. Examples of such impacts are train delays resulting from construction activities, which will affect the great majority of the commuters and other users of a train line. Assessment of generalized impacts covers, the Cairo-Alexandria and the Cairo-High Dam Lines.
2) Site-specific, local impacts: these impacts will be restricted to specific sites and communities along the railway lines (such as access restriction during construction at certain level crossings, noise, air and water pollution generated during extended construction activities at certain sites.

However, construction work is expected to have a number of adverse impacts on physical elements of the environment which in turn will have significant socio-economic impacts. This construction work will also directly affect large sectors of the populations by affecting the operation of the railway service and its associated elements such as the level crossings. Elements of construction activities that are expected to adversely affect the environment and their direct and indirect impacts are shown in following components:

4.2. Potential Environmental and Social Impacts

Activity	**Direct impacts**	**Indirect impact**
Construction activities at areas accessible to the public.	-Safety risk to public at or near construction sites. -Generation of dust and noise from construction activities, vehicles and equipment -Hazardous emissions (e.g. asphalting, rail welding, operation of vehicles and other equipment) -Improper transportation, disposal and/or decontamination of old ballast basalt may result in local pollution and visual nuisance	-Safety risk to construction crews and public at or near construction sites and along material transportation routes. -A major nuisance to communities near work site, particularly if taking place at night. -Threat to public health in areas adjacent to work site.
Reduction of train speed at work sites	-Longer train trip time -Unexpected train delays	-Train delay may result in delayed arrival to work or business, schools, etc. -Unexpected delay is more difficult to deal with. -Some train passenger might have to resort to other, often more expensive modes of transportation.
Construction at level crossings (Partial or complete closure of the crossing to pedestrian and vehicle traffic)	-Increased traffic congestion at certain level crossings -Interrupting normal movement of people and goods. -Increased illegal track crossing.	-Traffic flow problems at areas in the general neighborhood of the level crossing. -Difficult accessibility to certain areas -Difficulties of access to emergency services and vehicles. -Delay to work, business or schools.

4.3. Socio and Economic Impact

Socio-economic impacts of the project affect the three sectors of potentially impacted communities by. Where expected impacts affecting each one of these communities are covered in this section.

- Local residents of communities adjacent to the train corridor
- Train users
- Level crossing users

During construction, the main potential project impacts are socio-economic impacts of three groups: train users, local residents of communities adjacent to the train corridor, and frequent users of level crossings. Potential socioeconomic impacts on train users include expected delays due to construction work and the potential need to use other modes of transportation during the construction period and impacts related to the operation difficulties resulting from construction work are among the most important impacts of this project. Interruption of the normal operations of the trains directly and indirectly affects a large number of people who depend on trains as a cheap, safe and reliable mode of transportation. Potential impacts on level crossing users include the need to identify and use alternative crossing pathways during construction. Safety of pedestrians and vehicular traffic crossing the tracks at level crossings (or at informal crossing sites) is also an issue that should be taken into consideration. There is certain public safety risks associated with the construction process. These will include those related to the use of heavy construction equipment in areas accessible to the public, as well as the transportation and handling of construction material and larger items such as rails and sleepers through public area. Potential socioeconomic impacts on the local residents of communities adjacent to the train corridor include that noise generated during certain construction activities (e.g., mechanical shaking and sifting of ballast gravel of basaltic fragments during ballast replacement work) will exceed permissible levels. Similarly, certain construction activities (e.g., rail welding, excavation of foundations and cable trenches, etc.) are expected to generate some air pollutants.

4.4. Impact Reduction of Train Speed at Construction Sites

Impacts associated with these activities are longer train trip time and unexpected train delays. Some train users may become forced to use other, more costly modes of transportation. In addition, shifting to other transportation modes will reduce the number of train passengers, reducing demand on goods and services offered by businesses in the vicinity of train stations.

4.5. Construction at Level Crossings, with Partial or Complete Closure of the Crossing to Pedestrian and Vehicle Traffic

Impacts associated with this activity are increased traffic congestion at certain level crossings, interrupting normal movement of people and goods, and increased illegal track crossing. Impacts also include traffic congestion or reduced traffic flow in areas leading to or from level crossings. This, in turn, will temporarily increase noise and air pollution with vehicle emission of slow moving vehicles. It will also cause problems due to delay in arrival to work, schools, etc.

4.6. Operation and Maintenance Phase Impacts

Operation of trains at increased travel speeds as expected following the completion of the signaling modernization and the replacement of old tracks will increase the risk of accidents at level crossings. Risk of accidents will particularly increase to pedestrians crossing at informal crossings which occur in many places all along the lines. This is particularly the case at areas where deteriorating track or signal conditions have, for years required that trains travel at much reduced speeds. Users of informal crossings at these areas who have grown accustomed to the slow train speeds will be exposed to a much great risk with the faster trains. Awareness raising effort will be essential to reduce this risk.

4.7. Noise

With the extremely varied activity profile of areas along the two railway lines covered in this study, ambient noise levels and air quality are expected to be equally varied. These levels are expected to vary considerably from one area to another along the hundreds of kilometers of railway corridors covered by this project. These values are also expected to change during different seasons and even times of day. In certain areas the ambient levels of noise and air pollutants exceed national permissible standards. It is expected, however, that noise generated during certain construction activities will exceed permissible levels. Noise related to the removal and installation of the tracks, particularly the working of the basalt fragment ballast will be particularly high.

Similarly, certain construction activities (e.g. welding, asphalting, excavation of foundations and cable trenches, etc.) are expected to generate dust and other forms of air pollution. Although these pollutants are expected to be of relatively small quantities, that will quickly disperse and become diluted, community members living very close, or downwind of the work site may potentially be affected. These impacts will also affect construction crews at the worksite. Although these impacts are all temporary in nature, occurring only during the actual construction work, which will mostly be undertaken mostly for a few hours to few days at any given site, mitigation measures are considered to be necessary. **Table 5** will be show that, the railway is the second significant source of noise in Egypt cities (road traffic is the first significant source of noise in the city) [10]. Measurements have been carried out to determine levels of railway noise in Egypt City and the effects on the railway noise of: 1) distance between train and receiver; 2) speed of train; 3) height of receiver; 4) length of train; 5) using a barrier; 6) a ban on horn use. So, **Table 5** shows the permissible noise levels in different land use areas in Egypt.

5. Conclusions and Remarks

On the basis of this study, the Egyptian national railway agency should run resistance to the environmental and social impact and noise control. The adverse impacts of the railway restructure occur during the construction, operation and maintenance phases. Elements of the environmental/social impact mitigation plan are described in detail below.

- Excavation and construction material should be covered so as to minimize spillage and generation of dust.
- As much as practically possible, construction material martial and waste should be transported to and from construction sites using cargo trains.
- Vehicles delivering construction material to, or removing construction waste from the work sites, should be covered to avoid material spillage.
- Vehicles uploading material should maintain the lowest possible fall height to reduce noise and dust generation.
- All construction activities should be carried out during the day time hours to minimize noise disturbance to communities near work sites.
- Workers exposed to noise exceeding permissible levels (e.g. ballast uploading) should wear hearing protection.
- Construction waste should be disposed at dumpsites designated by local governments
- Storage of construction material should be allowed only at ENR designated sites or ENR's storage yards in a

Table 5. Maximum permissible noise levels in different land use areas in Egypt.

Type of area	Permissible limit for noise intensity decibel					
	Day		Evening		Night	
	(7 am - 6 pm)		(6 - 10 pm)		(10 pm - 7 am)	
	From	To	From	To	From	To
Commercial, administrative and downtown areas	55	65	50	60	45	55
Residential areas in which can be found some workshops or commercial establishments or located on a main road	50	60	45	55	40	50
Residential areas in the city	45	55	40	50	35	45
Residential suburbs with low traffic	40	50	35	45	30	40
Residential rural areas, hospitals and gardens	35	45	30	40	25	35
Industrial areas (heavy industries)	60	70	55	65	50	60

way that will not affect traffic or pose any risk to communities adjacent to the railway corridors.

- Construction scheduling should be discussing to reduce the delay of train delays and associated adverse impacts. A construction schedule based on restricting work to one of a number of predetermined construction sector at one time should be a scheduling requirement. The expected "scheduled trip delay" should not exceed about 30 minutes.
- Train re-scheduling should be undertaken, taking into account the expected delays and showing new departure and arrival times during the construction work
- Work should be so planned as to avoid the complete blockage of any level crossing, as much as practical.
- Concentrating work in level crossings during times of reduced traffic, possibly during the night, as long as noise level can be kept at a legally permissible level.
- Management of vehicle and pedestrian traffic at level crossings should be improved.
- Protective walls of railway corridor in densely populated area should be repaired and regularly inspected and maintained to prevent informal crossing.
- A public awareness campaign on railway safety should be designed and implemented.

The noise grants should be offered to improve the sound insulation of facades to ensure low noise indoors. The noise abatement programme must be based on priority schemes ensuring that houses with the highest noise impact must be given priority. A ban is on using horns on trains passing inside the city and we can increase the typical distance between track centerline of train and the nearest noise sensitive buildings. Other noise control countermeasures could include operational countermeasures such as re-routing or a limitation on night traffic, rolling stock improvement with composite brake blocks or optimized wheels, rail grinding, and tuned absorbers on tracks.

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Journal of Transportation Technologies, 2015, 5, 37-45
Published Online January 2015 in SciRes. http://www.scirp.org/journal/jtts
http://dx.doi.org/10.4236/jtts.2015.51004

Arequipa's Population Perception in Regard to the Infrastructure of the Avenues Venezuela and Daniel Alcides Carrión

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Received 2 January 2015; accepted 18 January 2015; published 23 January 2015

Abstract

The present study corresponds to a descriptive research, whose objective seeks to determine the level of satisfaction of the population of Arequipa city, in respect of public works infrastructure executed in the Avenues Venezuela and Daniel Alcides Carrion. We designed a survey questionnaire which was applied to 384 people randomly for convenience, in the areas surrounding the road interchange. The results showed that a 65.10% believed that the infrastructure works had a positive impact, in addition to a 52.86% and 7.29% of people who were satisfied and very satisfied respectively, with the vial exchange carried out in the Avenues Venezuela and Daniel Alcides Carrion.

Keywords

Public Works, Infrastructure Works, Vial Exchange, Satisfaction, Population

1. Introduction

In the last ten years, Peru has had a sustainable growth in its economy. This is due to economic policies determined by the government, in addition to the momentum and promoting of the private investment. But Arequipa is not an alien to this growth; during the 2013 Arequipa posted growth in Gross Domestic Product of 6% [1], quantity above the national average.

This growth is also reflected in the increment of the population [2], at the end of the 1990s and 2000, appeared in Peru a social aspect called centralism[1]. This is why the government applied a strategy for decentralization, which entailed and generated a regional centralism in the major cities of Peru, Arequipa and Trujillo, that now represent important economic growth. Nowadays Arequipa receives immigrants from different parts from the

[1]Centralism in Peru: economic activity concentrated in the capital Lima.

How to cite this paper: Ramos Polanco, Y.F. (2015) Arequipa's Population Perception in Regard to the Infrastructure of the Avenues Venezuela and Daniel Alcides Carrión. *Journal of Transportation Technologies*, **5**, 37-45.
http://dx.doi.org/10.4236/jtts.2015.51004

south of Peru, like Tacna, Moquegua, Cusco and Puno; being approximately one million habitants as we can see in **Table 1**, becoming the region with the highest number of habitants after Lima and Callao.

Arequipa increases their economic growth thanks to the development of different sectors such as mining,

Table 1. Projected population to June 2013.

Most Populous Provinces		
Department	**Province**	**Population**
Lima	Lima	8,617,314
Prov. Const. del Callao	Prov. Const. del Callao	982,800
Arequipa	**Arequipa**	**947,384**
La Libertad	Trujillo	928,388
Lambayeque	Chiclayo	843,445
Piura	Piura	744,659
Loreto	Maynas	554,705
Junín	Huancayo	499,432
Cusco	Cusco	435,114
Ancash	Santa	430,925
Cajamarca	Cajamarca	375,227
Ucayali	Coronel Portillo	370,098
Ica	Ica	353,611
Piura	Sullana	312,307
Tacna	Tacna	307,608
Huánuco	Huánuco	304,487
Lambayeque	Lambayeque	291,006
Puno	San Román	282,043
Ayacucho	Huamanga	266,390
Junín	Satipo	254,488
Puno	Puno	245,925
Lima	Cañete	226,260
Lima	Huaura	215,138
Ica	Chincha	212,643
Cajamarca	Jaen	198,661
Junín	Chanchamayo	196,791
Lima	Huaral	185,076
San Martin	San Martín	181,946
Cusco	La Convención	179,670
Cajamarca	Chota	166,757
Apurímac	Andahuaylas	165,165
Ancash	Huaraz	162,889
Tumbes	Tumbes	161,257

Source: INEI National Institute of Statistics and Informatics.

trade, construction, and services which promote employment generation, economic stability and improvement in the quality of life. Because of this, many citizens took advantage of this "economic boom" to invest in capital good, buying homes, cars, etc. This created serious problems due to the increase of the automotive park [3] (**Table 2**). The Regional Government and the District Governments had to take the initiative to redesign and rebuild many main roads, to facilitate and decrease the traffic congestion that was reflected by these problems [4].

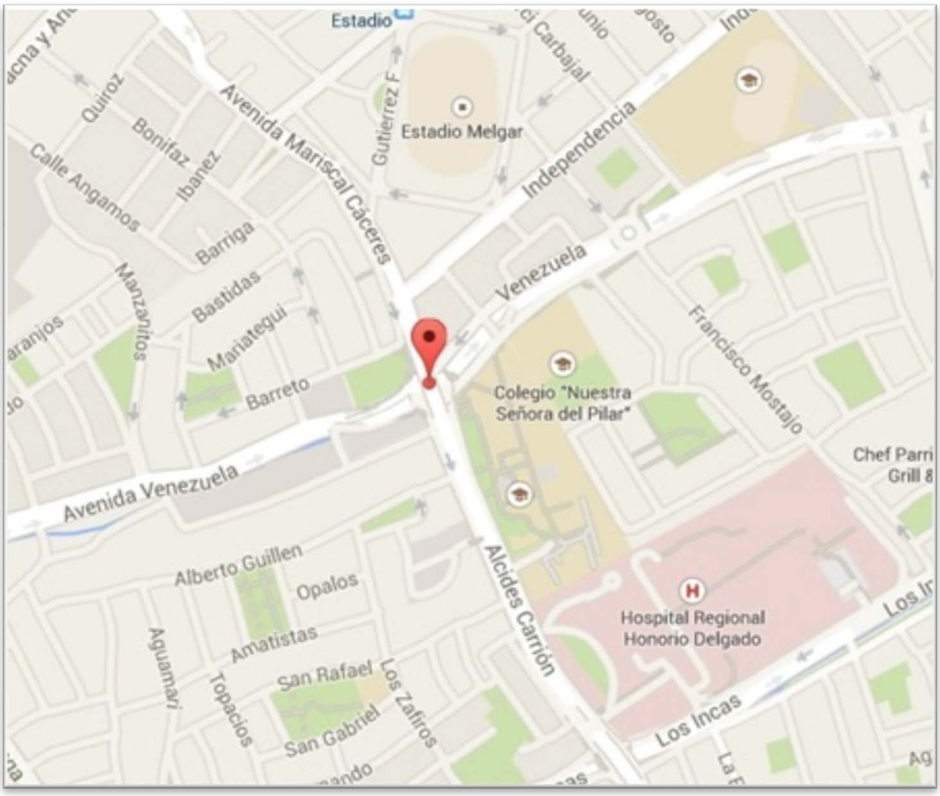
One of the main roads is the vial exchange of the avenues Venezuela and Daniel Alcides Carreon, which are parts of the first road ring in the structure of the Master Plan of Metropolitan Arequipa. This is because both avenues will become a quick way to achieve a fluidity in the vehicular transport and particular mass urban. This vial exchange is located in the Arequipa City, in the following coordinates (16˚24'44.1"S, 71˚32'07.3"W) as shown in **Figure 1**.

Venezuela avenue is part of the first ring in the structure of the Master Plan of Metropolitan Arequipa [5]; along it there are already 4 exchanges vials, the same that were built in different periods, and therefore were not planned on a holistic basis. These avenues should already be on the fast track to achieve a fluidity in the vehicular

Table 2. Increase in the automotive fleet by departments in units.

Department	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	1,361,403	1,440,017	1,473,530	1,534,303	1,640,970	1,732,834	1,849,690	1,979,865	2,137,837	2,387,964
Amazonas	1975	2020	2103	2168	2218	2292	2390	2407	2400	2681
Ancash	19,293	19,382	19,757	20,354	21,001	21,309	22,086	23,322	25,418	28,392
Apurímac	3730	3816	3879	3916	3934	3973	3969	3966	4039	4512
Arequipa	78,858	79,544	81,293	84,829	91,674	98,270	106,521	118,985	134,533	150,273
Ayacucho	3882	3919	3969	4153	5404	5572	5716	5784	5941	6636
Cajamarca	8882	9501	10,256	11,255	12,383	13,563	15,107	17,320	19,673	21,975
Cusco	35,342	35,705	36,204	37,592	39,688	42,175	45,090	48,491	53,675	59,955
Huancavelica	1043	1061	1080	1103	1216	1291	1319	1317	1323	1478
Huánuco	10,968	10,886	10,836	10,892	11,255	11,382	11,864	12,576	13,476	15,053
Ica	22,692	22,753	22,834	23,170	25,498	25,691	26,135	26,419	26,551	29,657
Junín	43,468	43,648	44,454	46,091	47,769	49,404	51,094	53,118	56,237	62,817
La Libertad	97,590	153,777	152,847	153,251	155,411	156,646	158,672	162,026	167,325	186,902
Lambayeque	37,967	38,263	38,744	39,930	41,920	43,689	45,881	49,440	53,902	60,209
Lima	866,881	885,636	912,763	957,368	1,036,850	1,106,444	1,195,353	1,287,454	1,395,576	1,558,858
Loreto	5336	5286	5215	5154	5132	5089	5089	5211	5313	5935
Madre de Dios	823	819	827	870	913	941	986	1027	1062	1186
Moquegua	9417	9622	10,394	11,418	12,202	12,692	13,348	14,003	14,608	16,317
Pasco	4772	5232	5514	6075	6807	7187	7351	7292	7238	8085
Piura	31,731	31,734	31,828	32,314	33,497	34,650	36,367	39,099	42,404	47,365
Puno	25,642	25,874	26,452	28,062	29,889	31,645	34,169	37,074	40,543	45,287
San Martín	10,277	10,156	10,033	9969	9917	9977	10,151	10,418	10,926	12,204
Tacna	30,549	31,119	32,011	33,944	35,911	38,457	40,465	42,318	44,430	49,628
Tumbes	2958	3009	3025	3042	3040	3054	3086	3119	3257	3638
Ucayali	7327	7255	7212	7383	7441	7441	7481	7679	7987	8921

Source: MTC Ministry of Transport and Communications.



Source: Google Maps

Figure 1. Location Avenues Venezuela and Daniel Alcides Carrion-Satellite Map.

transport and particular mass urban. The oldest one of these exchanges is the av. Venezuela—av. Alcides Carrion, subject of this study and where the "Arequipa Bus" will circulate, along the corridor exclusive of transport.

Venezuela avenue is part of the first ring in the structure of the Master Plan of Metropolitan Arequipa 2002-2015. The sharing road is called "Palomar". The exchange Palomar was designed in anticipation that the Av. Venezuela becomes, in the future, on a fast track ("zanjón"). It has three levels: an underpass crossing, a bridge—roundabout at the ground level—and another bridge at high altitude for the Exclusive Broker. The work in av. Alcides Carrion—Venezuela is valued at approximately 17 million 347 thousand soles. The municipal authority announced that the three road interchanges would require four months; however, only El Palomar, according to initial studies, would require up to 7 months for its execution.

This research seeks to analyse the perception of the population of the city of Arequipa with respect to the infrastructure works to study, by determining the level of satisfaction of the population as a percentage.

2. Methodology

2.1. Sample

For the calculation of the sample, it was considered as population the number of units of the fleet in the city of Arequipa to the year 2013[2], obtaining the sample of 384 persons, who were elected by non-probabilistic methods for convenience. Subsequently we proceeded to identify the person to survey based on the following standards:

a) Admit only people between 18 and more years, because the questions need to be answered in a mature way and consciously.

b) Identify places with high turnout of people and that are surrounding the Road Exchange.

c) Make an affixation of the sample proportional to the size of the total population.

d) Random distribution for convenience of the places to survey.

We surveyed a total of 384 people, with ages ranging from 18 to 65 years, of both sexes who live in the city of

[2]Presupuesto, M. d.-O. (s.f.). *Ministerio de Transportes y Comunicaciones.* Obtenido de www.mtc.gob.pe

Arequipa and pass through the interchange road.

2.2. Instrument

We made a questionnaire survey, which collects data such as the frequency of transit and-or usage, number of time and to figure out why they use the exchange vial by determining a relation of alternatives:

a) Work
b) Recreation
c) School of their children
d) Visit a relative/friend
e) University/Studies
f) Procedures
g) Health centers/Clinics
h) Shopping/Go to a mall
i) Way of daily use
j) Others

In addition to determine the level of satisfaction with population, questions were developed using a Likert-type scale, taking as response options on the level of satisfaction:

a) Very dissatisfied
b) Dissatisfied
c) Indifferent
d) Satisfied
e) Very satisfied

As the same time, the questionnaire collected data from control as the sex and age of the participants.

2.3. Procedure

The process of data collection began with the election of the places and time of interviews, by determining the following places, for convenience:

a) Market: "El Palomar"
b) Shopping center "ParqueLambramani"
c) Shopping center "Mall Aventura Plaza"
d) National San Agustí University
e) Hospital: Honorio Delgado
f) Health center Daniel Alcides Carrión
g) Av. Salaverry, Instituto del Sur

These locations were selected in order to the following standards:

a) Place with high traffic of people and vehicles
b) Due to its location, surrounding and close to the Road Exchange.
c) Because they are public places where you can do the surveys without any problem or inconvenience.

Also an schedule for the interviews was determined considering the hours of highest traffic of people and vehicles, 7:00 am - 9:00 am and 4:00 pm - 7:00 pm. The implementation of the survey was conducted during the month of February of 2014 and lasted approximately 5 minutes and was conducted by 5 staff, trained in interviews and data collection. When the stage of gathering information was completed, the information was processed in the SPSS statistical software, to obtain the results.

3. Results

We surveyed 384 people between the ages of 18 and 65 years, of which 185 are female, representing a 48.2% and 199 are male representing a 51.8%, all of them citizens of Arequipa which often pass through the exchange of the avenues Venezuela and Daniel Alcides Carrión. The frequency of transit and/or use of this exchange vial is quite high as you can see in **Figure 2** and **Figure 3**, a 47.66% of the population passes between 1 to 5 times, from Monday to Friday, while a 64.06% on the weekends.

In order to the reason for which people pass through the interchange road, we can observe that the most salient

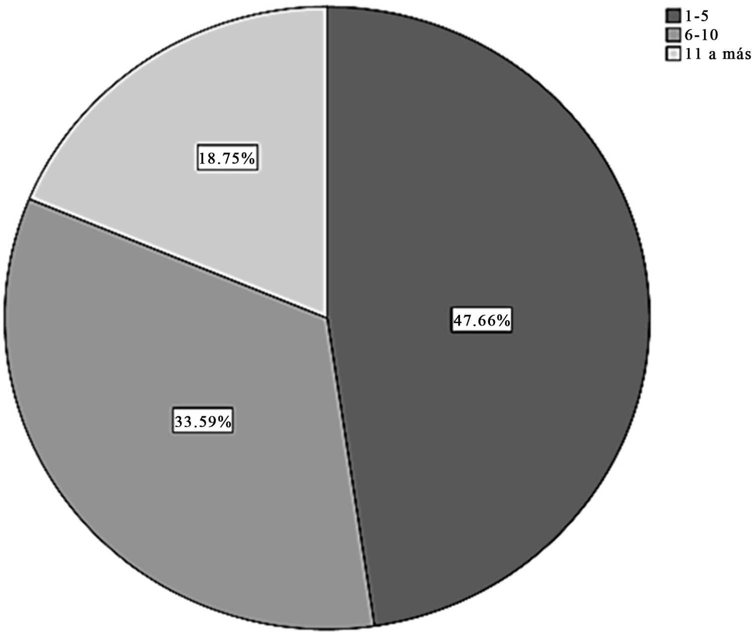


Figure 2. Frequency of transit of persons from Monday to Friday; How often transits the road interchange, Monday to Friday?

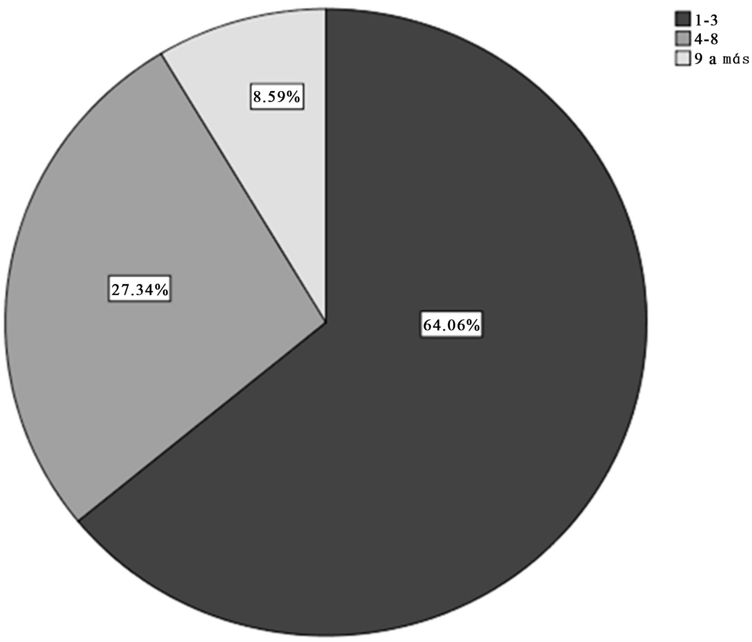


Figure 3. Frequency of transit of persons on weekends; How often transits the road interchange, Saturday and Sunday?

and important are: working with a 27.20%, followed by commercial centers 19%, universities or research centers 12.6% and medical centers 8.5% (**Figure 4**).

The perception of the population regarding to the impact of these public works infrastructure in their quality of life, the 65.10% believes that the impact is positive, while only the 14.06% thinks that it is a bad thing, on the other hand a 20.83% is indifferent to the impact or influence generated by this vial exchange (**Figure 5**). Another significant result is the impact on travel times using this fast track, where a significant 69.27% responded that this fast track reduce traveling time from one place to another, on the other hand a 12.76% said that the time has

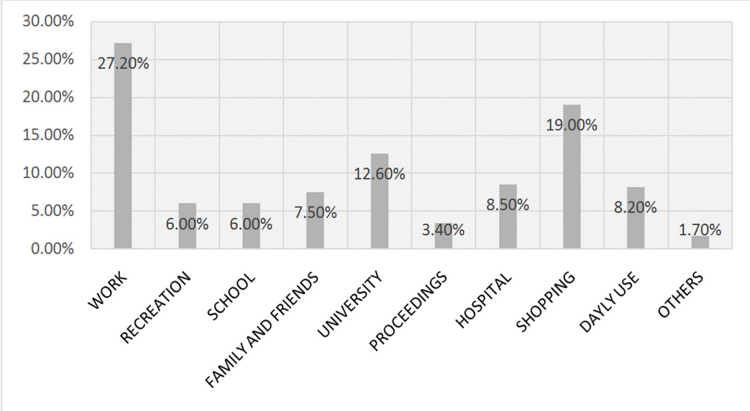


Figure 4. Reasons for using the exchange vial.

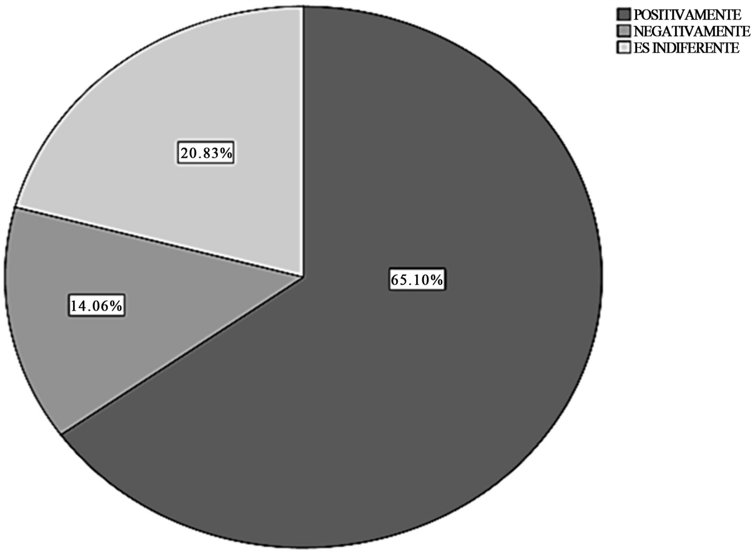


Figure 5. Impact on the quality of life of the exchange vial; How do affects the vial interchange at quality of life?

increase and 17.97% of the remaining population believes that the travel times remained the same (**Figure 6**).

As the most important result and giving response to the objectives of this study, we discovered that the perception of the population of the city of Arequipa regarding to public works in the exchange vial executed in the avenues Daniel Alcides Carrion and Venezuela is the following: the 52.86% is satisfied and 7.28% felt very satisfied with this infrastructure work. However the is a percentage which is very dissatisfied and unhappy as you can see in **Figure 7**.

In addition to the descriptive processing, we did a correlational analysis using the test of Kendall Tau-b. The results show that there is a strong correlation between people who frequently travel through the exchange road from Monday to Friday with the people passing on weekends; we can say that they live nearby. Another interesting result that present the study talks about travel times in connection with the satisfaction and subsequent recommendation to use the interchange road, because with lees time for transfer, higher degree of satisfaction, presenting a correlation of $r = -5.24$ and with less time for transfer, greater recommendation of the service, with a correlation of $r = -0.431$. Both results are significant and offer moderate inverse correlations. We can also say that to a greater degree of satisfaction, grater recommendation and when the traffic follow is better, the transfer time decrease, having a correlation of $r = -0.454$. To conclude we can say, in order to the results presented, that the degree of satisfaction and the potential recommendation to use the vial exchange are related to several factors, mainly on the fluidity of the traffic and the time to transfer. See **Table 3**.

4. Discussion

Arequipa is a city with great economic growth, above the average country; however this growth is mainly driven by the private sector. We can see more shopping centers, businesses, factories, industries and mines in the region, which generate employment generating an economic cycle. But this economic growth is not supported by the public sector; we do not have the infrastructure or the support of airports, terminals, ports, roads and avenues to support and collaborate with this economic growth. Therefore we can conclude that while it is true Arequipa is having an economic growth; we are still far from being able to talk about social development.

By observation we can see that the perception of the population in relation to a public works is always negative, before and during the execution of the project, but the results of this study show that once a project is completed, the perception of citizenship is good, demonstrating satisfaction levels quiet high. In conclusion we can say that it is important to invest in access roads to the city of Arequipa and thus contribute to the growth

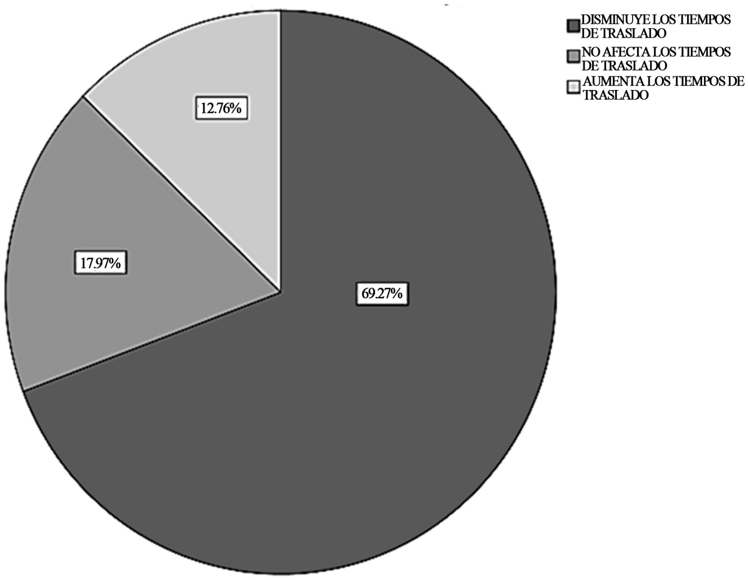


Figure 6. Impact on the travel times of vial exchange; How do affects the vial interchange at travel time?

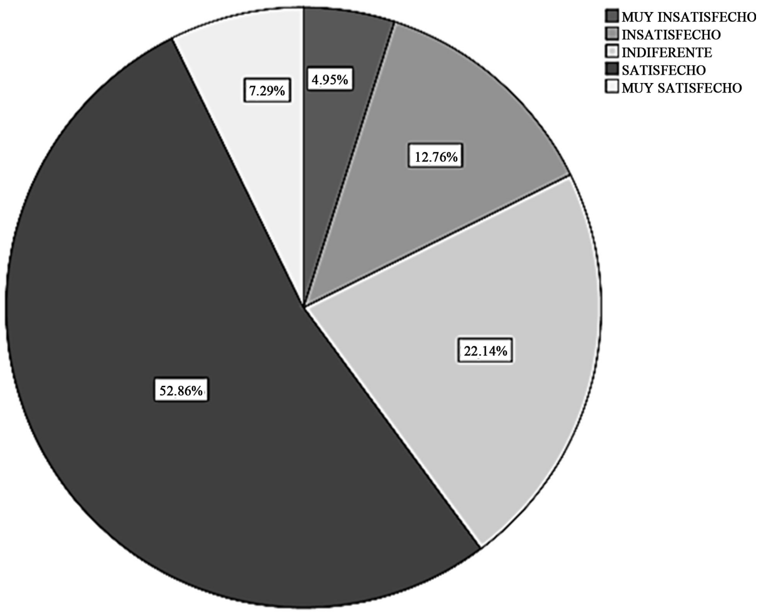


Figure 7. Degree of satisfaction in percentages.

Table 3. Correlational analysis.

	Transit frequency Monday to Friday	Transit frequency Saturday and Sunday	Time of Transfer	Level of Satisfaction	Recommend for Use	Lighting	Flow of traffic
Transit frequency Monday to Friday	1.000	0.533**	−0.038	.068	0.089*	0.105*	0.011
Transit frequency Saturday and Sunday		1.000	−0.061	0.107*	0.105*	0.012	-0.065
Time of Transfer			1.000	−0.524**	−0.431**	−0.227**	−0.454**
Level of Satisfaction				1.000	0.523**	0.295**	0.427**
Recommend for Use					1.000	0.243**	0.424**
Lighting						1.000	0.266**
Flow of traffic							1.000

*$p < 0.05$; **$p > 0.01$.

and development.

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Journal of Transportation Technologies, 2015, 5, 46-54
Published Online January 2015 in SciRes. http://www.scirp.org/journal/jtts
http://dx.doi.org/10.4236/jtts.2015.51005

Fuzzy Comprehensive Evaluation Research of Goal Attainment of Green Transportation Development Policy

—Take Dongguan "Motorcycle Ban" Policy as an Example

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Received 8 January 2015; accepted 26 January 2015; published 29 January 2015

Abstract

Launching the evaluation research of green transportation can grasp the green transportation implementation accurately and diagnose the existing problems. From the perspective of green transportation, this research chose Dongguan "motorcycle ban" policy as the research object, and constructed secondary evaluation index system in transportation and environmental harmony, transportation and future harmony, transportation and society harmony, transportation and resource harmony, four dimensions. Then it used fuzzy comprehensive evaluation model to do the evaluation and found that the policy's positive effect on the Dongguan green transportation development was average. Finally, based on the evaluation results, measures and advices were proposed.

Keywords

Green Transportation, Motorcycle Ban Policy, Fuzzy Comprehensive Evaluation

1. Introduction

The amount of private cars see a dramatically increase in Chinese large cities nowadays, especially in those metropolises that have more than two million population, which narrows the space of cities and deteriorates traffic congestion. Meanwhile, the excessive use of private cars has brought a series of problems, such as ecosystem deterioration, environment pollution, resources shortage, social crime and so on. As a result, how to guide the transportation system to enable it to coordinate with the environment, health, safety and efficiency has attracted

How to cite this paper: Song, P.L. and Zhong, C.Q. (2015) Fuzzy Comprehensive Evaluation Research of Goal Attainment of Green Transportation Development Policy. *Journal of Transportation Technologies*, **5**, 46-54.
http://dx.doi.org/10.4236/jtts.2015.51005

the concern by government officers, professors and residents. Finally, green transportation appears when facing the urgent problems.

The idea of green transportation is introduced from oversea, but it is quite appropriate with our national conditions; specifically, green transportation emphasizes the eco-friendly of transportation, which means solving traffic congestion, reducing environment pollution, promoting social equality and controlling consumption of resources. The essence of this idea is to construct the sustainable system of city transportation, meet people's needs of traveling and spend least social cost to achieve maximum transportation efficiency. In recent years, quite a few scholars have carried out wide and deep research of green transportation, mainly focusing on the definition, importance, content of green transportation and construction of index of green transportation system. For example, Liu Dongfei believes that green transport is the key to building healthy and sustainable urban transport system [1]. Then domestic scholar Xu Fang took the principal component analysis to conclude the influencing factors of green travel behavior as five aspects: the idea of green travel behavior, family character, level of transportation management, level of travel service and travel character [2]. Besides, Jiang Yuhong *et al*. established a green traffic evaluation index system, and valued it by valuation function; also, they explained the feasibility of the presented urban green traffic planning evaluation system with an example [3]. However, there are few studies about the green transportation development policy, and the existed studies focus on the whole enforcing and implementing policies, lacking a comprehensive and completed study about one typical policy. Consequently, there are lacking cases to draw on and use as references when enforcing and launching transportation policies in some cities.

This paper took the perspective of green transportation and chose Dongguan "motorcycle ban" policy as the research object, then constructed secondary evaluation index system in transportation and environmental harmony, transportation and future harmony, transportation and society harmony, transportation and resource harmony, four dimensions. Next it used fuzzy comprehensive evaluation model to do the specific evaluation for providing governments with beneficial implication on how to promote the development of green transportation system and construction of ecological civilization.

2. The Method and Model of Evaluation

Public policy evaluation is a political behavior that uses to evaluate the benefit, efficiency and value of policies according to certain standard and procedure, which is considered as one of crucial stage in policies process [4]. The purpose of public policy evaluation is to examine the operation effect of policies, direct the future effort of policies and promote scientific policies enactment. Particularly, the operation effect of policies refers to the goal that whether one specific policy reach expected results [5].

2.1. The Models of Policy Evaluation

There are a variety of different evaluation models in the development of policy evaluation. According different evaluation objects, targets and methods, it should adopt different evaluation models, and the combination of several evaluation models has become the main trend. A Chinese scholar called Qiang Yan concluded ten evaluation models by the sequence in the evolvement of policy evaluation, such as measurement-oriented, goal-oriented, decision-oriented and etc. [6]. However, his conclusion was too wide and could not be distinguished different evaluation models accurately. On the other hand, foreign scholar William Dunn distinguished three evaluation models: pseudo-evaluation, formal evaluation and decision-theoretic evaluation by different value criteria. Apart from this, E. R. House also summarized eight models: systematic analysis model, behavior goal model, decision enactment model, non-goal model, technical comment model, expertise conclusion model, quasi-law model and case study model [7]. But his classification was so specific that it was difficult to find totally appropriate policies in the practice. Similarly, Vedung E conducted the evaluation models in detail by value criteria as well, but he proposed the concept of organizer and concluded three evaluation models in the effect of policies intervention by organizers: effective models, economic models and professional models. The effective models included goal-attainment evaluation, side-effects evaluation, goal-free evaluation, comprehensive evaluation, client-oriented evaluation and stakeholder model [8]. Comparing with other scholars, Vedung E's policy evaluation model achieved more recognition and was applied more extensively. This research will adopt Vedung E's goal-attainment evaluation to evaluate "motorcycle ban" policy.

According to Vedung E's explanation, goal-attainment evaluation is to examine traditional methods of evaluation problems and take policy goal as the only criteria that is made up of two parts: 1) Goal attainment—focusing on results whether are in conformity with policy goal or not; 2) Impact evaluation—focusing on the outcomes from policies. The application of goal attainment model has three stages: 1) Know the policy goal clearly (understand the real meaning, rank goals and transfer them into measurable objects); 2) Measure the extent on how goals can be achieved; 3) Figure out the extent on promoting policy or hindering goal attainment. There are three main points in the goal attainment model: the priority is democracy, which means that the policy takes the consideration of political democracy in the procedure of policy enactment fully as well as that they will give importance to people's interest because of the sense of responsibility. The second point is to offer objective evaluation criteria, because this model takes established policy goal to evaluate policy results to avoid value preference by those who do the assessment. The third point is simple and feasible. This model considers only two problems—whether results are in conformity with policy goal and whether the outcomes come from the policy. Although the above advantages of this model, the disadvantages is apparent—ignoring cost, difficult to apply in ambiguous goals, ignoring the unexpected effect, ignoring the impact of hidden agendas in the policy enactment and ignoring the policy implementation [8].

This paper chose the goal evaluation model mainly because the evaluation of Dongguan "motorcycle ban" policy only focused on the aspects of green transportation, which was explicit and enable the research to carry out conveniently, and the purpose of this paper was to assess the implementation effect of "motorcycle ban" policy.

2.2. The Methods of Policy Evaluation

In terms of different content of policy evaluation, we can choose different evaluation methods. The main policy evaluation methods include quantitative methods such as cost-effectiveness analysis, fuzzy comprehensive evaluation and so on, and qualitative methods such as value critique, causal analysis, goal analysis, policy Delphi, brainstorming and so on. Since the "motorcycle ban" policy has many ambiguous boundaries and involves various factors interaction that cannot be described precisely, this research takes the fuzzy comprehensive evaluation methods to quantify the ambiguous factors in the effect evaluation of "motorcycle ban policy" and do the assessment of existed fuzzy phenomenon and concepts of this policy.

3. Study Design

3.1. The Definition of Green Transportation

Green transportation refers to those travel modes that create no pollution or small pollution to our environment. It is not only a new transportation system, but also a new principle. This research adopted the definition of green transportation proposed by Professor Xiaoguang Yang of Tongji University, a theory that includes four aspects: 1) transportation and environmental harmony (ecological, psychological); 2) transportation and future harmony (appropriate of future development); 3) transportation and society harmony (safety, human-oriented); 4) transportation and resource harmony (spend least cost and resources to sustain transportation need) [9].

3.2. Sample Design

This paper chose Dongguan "motorcycle ban" policy as study object, because Dongguan is a typical second tier city that has a large population of migrant workers. After the global finance crisis in 2008, Dongguan city proposed the aim of economic and social reforming and started to explore the path of "accelerate reforming and upgrading", build "happy Dongguan". The reforming in this city may provide those developing cities with good reference and strong example.

As there were both subjective index and objective index in our evaluation system, we took questionnaire investigation and literature study methods to collect data. After the consultation of experts in the transportation field and pre-investigation in a town called Qiaotou in Dongguan, we modified related descriptions and items of the scale and got the formal questionnaire. There are mainly three parts of overall 37 questions in the formal questionnaire. The first part is about the basic information of respondents. The second part is the green transportation scale that uses Likert five-point scale that was made up of 19 descriptions about the impact of green transportation after banning motorcycles (the specific item can be seen in **Table 2**). There were 5 levels in each descriptions:

"strongly agree", "agree", "general", "disagree" and "strongly disagree", corresponding with the positive impact "strongly great", "great", "general", "weak" and "negative" respectively. The third part is about the comparison of transportation vehicles "before" and "after" the "motorcycle ban" policy. Then we adopted stratified sampling method to select Dongchen, Fenggang, Dalingshan, Qiaotou and Wangniudun five towns in Dongguan city by different economic growth to do the formal questionnaire investigation. After the data analysis by spss, the result shows in **Table 1**. The Cronbach's α of overall scale has high reliability, at 0.868. The Cronbach's α of other dimensions are above 0.7, which means their reliability is dependable. On the other hand, the objective data was acquired from 2005-2011 Dongguan statistical yearbooks (specific item can be seen in **Table 3**).

4. The Construction of Fuzzy Comprehensive Evaluation Model of the Impact of "Motorcycle Ban" Policy on Green Transportation

4.1. Construct the Evaluation Index System

According to the theory of green transportation development and the advice from transportation planning experts [10], it constructed the second level fuzzy evaluation index system in **Table 1**.

In the evaluation index system, part of the second grade impact degree index can be measured by objective index, such as the air pollution index, the traffic noise, the traffic accident and robbery of motorcycle. The other part of the secondary index can be only obtained by the citizens' subjective feelings, such as the travel modes and ideas, road environment. In order to ensure the accuracy of the policy evaluation, the fuzzy comprehensive evaluation of this study combines the objective and subjective index, above the evaluation index system, transfer the second index into measurable objective index, as **Table 2** shows.

4.2. Construct Evaluation Sets

$V = \{A, B, C, D, E|$ Strongly great positive impact, great positive impact, general positive impact, no positive impact, negative impact$\}$. The dummy variable of evaluation sets need to quantify into hundred-mark system, specifically, *A* refers to strongly great positive impact (75 - 100 scores), *B* refers to great positive impact (50 - 75 scores), *C* refers to general positive impact (25 - 50 scores), *D* refers to no positive impact (0 - 25 scores), *E* refers to negative impact (below 0).

4.3. Construct the Weight Sets of Evaluation Factors

This paper chose multiple comparison to define weight. According to data from experts who graded each weight, we got the weight of first level index: $A = (0.21, 0.27, 0.31, 0.21)$, the weight of second level index: $A_1 = (0.23, 0.35, 0.19, 0.23)$, $A_2 = (0.21, 0, 21, 0.16, 0.18, 0.14, 0.10)$, $A_3 = (0.18, 0.16, 0.16, 0.18, 0.14, 0.18)$, $A_4 = (0.32, 0.32, 0.36)$.

4.4. Construct Models of Fuzzy Comprehensive Evaluation

In order to unify dimension, we need to standardize the objective index. Among the 6 objective index in **Table2**, the air pollution index, the traffic noise, the amount of traffic accident, the amount of vehicles robbery and the consumption of fuels are inverse index, while the amount of public buses is forward index, so we chose linear interpolation method to standardize them, as follows:

$$X_+ = \frac{X - X_{\text{MIN}}}{X_{\text{MAX}} - X_{\text{MIN}}} \times 100 \qquad X_- = \frac{X_{\text{MIN}} - X}{X_{\text{MAX}} - X_{\text{MIN}}} \times 100$$

Therefore, we acquired the objective index data from 2007-2011 Dongguan statistical yearbooks, and after standardizing them, we got the following results:

Table 1. The reliability of scale.

	Dimension of Each Scale				
	The Overall Scale	Transportation and Environment	Transportation and Future	Transportation and Society	Transportation and Resources
Cronbach's Alpha	0.868	0.877	0.810	0.733	0.779

Table 2. The index system of impact of "Motorcycle Ban" policy on green transportation.

Evaluation	1st Index	2nd Index
Impact of "Motorcycle Ban" Policy on Green Transportation	B1 Transportation and Environment	B11. After banning motorcycles, the local air quality improved
		B12. After banning motorcycles, the local vehicle noise reduced
		B13. After banning motorcycles, the local roads condition improved
		B14. After banning motorcycles, the local traffic congestion reduced
	B2 Transportation and Future	B21. After banning motorcycles, your family and you prefer to travel by public buses or bicycles
		B22. After banning motorcycles, your family and you prefer to travel by private cars
		B23. After banning motorcycles, the local public buses speed improved
		B24. After banning motorcycles, public buses paths increased and extended
		B25. After banning motorcycles, it was beneficial to city sustainable development
		B26. After banning motorcycles, the local green coverage of roads increased
	B3 Transportation and Society	B31. After banning motorcycles, the traffic accidents reduced significantly
		B32. After banning motorcycles, your family travel fee increased
		B33. After banning motorcycles, your commuting time increased
		B34. After banning motorcycles, your travel safety increased
		B35. After banning motorcycles, your concept of green travel strengthened
		B36. After banning motorcycles, your expectation of public traffic increased
	B4 Transportation and Resources	B41. After banning motorcycles, your family fuel fee per month increased
		B42. After banning motorcycles, your local parking spaces increased
		B43. After banning motorcycles, city spaces became more spacious

Table 3. Second level index transfer into objective index.

2nd Index	Objective Index
B11. After banning motorcycles，the local air quality improved	The Air Pollution Index
B12. After banning motorcycles, the local vehicle noise reduced	The Traffic Noise
B24. After banning motorcycles, public buses paths increased and extended	The Amount of Public Buses
B31. After banning motorcycles, the traffic accidents reduced significantly	The Amount of Traffic Accident
B34. After banning motorcycles, your travel safety increased	The Amount of Vehicles Robbery
B41. After banning motorcycles, your family fuel fee per month increased	The Consumption of Fuels

Sometimes it is possible to meet many quantitative indexes that cannot be used in Likert scale directly, so we need to transfer these indexes to meet the requirement of Likert scale [11]. The method is to divide the value of indexes into five intervals and each interval corresponds to five value of Likert scale, thus it complete index conversion. We can divide the objective indexes into the following five intervals by the above evaluation grades.

From **Table 4** and **Table 5**, we got the membership matrix of objective indexes, while the membership matrixes of subjective indexes come from the data of questionnaire investigation. Eventually, the R_1, R_2, R_3 and R_4 evaluation matrix of four dimension are as followings:

$$R_1 = \begin{bmatrix} 0.75 & 0 & 0 & 0.25 & 0 \\ 0.5 & 0.25 & 0 & 0.25 & 0 \\ 0.106 & 0.215 & 0.331 & 0.273 & 0.076 \\ 0.129 & 0.217 & 0.293 & 0.235 & 0.126 \end{bmatrix} \quad R_2 = \begin{bmatrix} 0.192 & 0.351 & 0.255 & 0.134 & 0.068 \\ 0.073 & 0.177 & 0.328 & 0.301 & 0.121 \\ 0.104 & 0.247 & 0.374 & 0.202 & 0.073 \\ 0.75 & 0 & 0.25 & 0 & 0 \\ 0.177 & 0.364 & 0.298 & 0.126 & 0.035 \\ 0.114 & 0.253 & 0.361 & 0.184 & 0.088 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0 & 0.25 & 0.25 & 0 & 0 \\ 0.023 & 0.134 & 0.333 & 0.293 & 0.217 \\ 0.033 & 0.205 & 0.338 & 0.26 & 0.164 \\ 0.75 & 0 & 0 & 0 & 0.25 \\ 0.167 & 0.301 & 0.414 & 0.091 & 0.028 \\ 0.179 & 0.381 & 0.301 & 0.111 & 0.028 \end{bmatrix} \quad R_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0.035 & 0.179 & 0.28 & 0.301 & 0.202 \\ 0.146 & 0.255 & 0.278 & 0.225 & 0.096 \end{bmatrix}$$

Table 4. The standardization of Quantitative Index.

Quantitative Indexs	2007	2008	2009	2010
The Air Pollution Index	0.034	0.827	1	0.862
The Traffic Noise	0.023	1	0.955	0.068
The Amount of Public Buses	0.266	0.787	0.940	1
The Amount of Traffic Accident	0.466	0.714	0.907	1
The Amount of Vehicles Robbery	0.848	1	0.829	0
The Consumption of Fuels	−1	−0.316	−0.02	0

Table 5. The evaluation criteria of standardization value of Quantative Index.

Standard Value	Evaluation Criteria
$0.75 < X \le 1$	**Strongly Great Positive Impact**
$0.5 < X \le 0.75$	**Great Positive Impact**
$0.25 < X \le 0.5$	**General Positive Impact**
$0 < X \le 0.25$	**No Positive Impact**
$X \le 0$	**Negative Impact**

From $B_i = A_i \times R_i$, we can calculate the first level of fuzzy comprehensive evaluation sets B_1, B_2, B_3, B_4, then we multiplied the weight of second level index by it and got the second level fuzzy comprehensive evaluation results.

$$B = A \times \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = \left[0.21, 027, 0.31, 0.21\right] \times \begin{bmatrix} 0.397 & 0.178 & 0.130 & 0.251 & 0.043 \\ 0.243 & 0.227 & 0.305 & 0.160 & 0.065 \\ 0.290 & 0.210 & 0.265 & 0.121 & 0.115 \\ 0.064 & 0.149 & 0.190 & 0.177 & 0.419 \end{bmatrix}$$

$$= \left[0.252, 0.195, 0.232, 0.171, 0.150\right]$$

4.5. Result Analysis

Multiply the evaluation result matrix $B = (0.252, 0.195, 0.232, 0.171, 0.150)$ with corresponding scores of evaluation sets (87.5, 62.5, 37.5, 12.5, 0). The calculated results is: U = 87.5 × 0.252 + 62.5 × 0195 + 37.5 × 0232 + 12.5 × 0.171 + 0 × 0.150 = 45.075. According to the criteria of evaluation sets = {A = 75 − 100, B = 50 − 75, C = 25 − 50, D = 0 − 25, E < 0| Strongly great positive impact, great positive impact, general positive impact, no positive impact, negative impact}, the impact of "motorcycle ban" policy toward Donguan's green transportation development is general. Further, calculate each dimension scores:

$$U_1 = (87.5 \times 0.397 + 62.5 \times 0.178 + 37.5 \times 0.130 + 12.5 \times 0.251 + 0 \times 0.043) \times 0.21 = 11.325$$

$$U_2 = (87.5 \times 0.243 + 62.5 \times 0.227 + 37.5 \times 0.305 + 12.5 \times 0.160 + 0 \times 0.065) \times 0.27 = 13.205$$

$$U_3 = (87.5 \times 0.290 + 62.5 \times 0.210 + 37.5 \times 0.265 + 12.5 \times 0.121 + 0 \times 0.115) \times 0.31 = 15.467$$

$$U_4 = (87.5 \times 0.064 + 62.5 \times 0.149 + 37.5 \times 0.190 + 12.5 \times 0.177 + 0 \times 0.419) \times 0.21 = 5.087$$

The above scores suggested that the most significant influence of Dongguan "motorcycle ban" policy was on the dimension of transportation and society harmony next is transportation and future and transportation and environment, but the impact on transportation and resources was not significant. It is no doubt that 'motorcycle ban' policy is an effective way to deter robbing and stealing crime and reduce traffic accidents.

5. Conclusion and Policy Suggestion

Carrying out the evaluation of green transportation policy can perfect the development of city transportation system and improve accuracy of public policies enactment. This paper chose Dongguan "motorcycle ban" policy as the case study of green transportation policies, constructed the second grade evaluation index and used fuzzy comprehensive evaluation model to do the analysis. The results suggest that the impact of "motorcycle ban" policy toward Donguan's green transportation development is general. Further, the most significant influence of this policy was on the dimension of transportation and society harmony, next was transportation and future and transportation and environment, but the impact on transportation and resources was not significant. Thus, "motorcycle ban" policy can reduce city pollution effectively, deter social crime, reduce social congestion and promote public transportation system development.

This research also found that the "motorcycle ban" policy in Dongguan came out when the public transportation system was far behind than other cities. Only after this policy appeared, would the public transportation system improve gradually. Therefore, the implementation of "motorcycle ban" policy in Dongguan was far more difficult and tough than other cities, resulting that the impact on green transportation system was not outstanding. Thus, it can be concluded that "motorcycle ban" policy will perform the maximum effectiveness. Finally, this paper proposes following suggestions to promote positive impact of green transportation of "motorcycle ban" policy in Dongguan.

5.1. Develop Government Functions Fully

Firstly, governments should stick to enforcing "motorcycle ban" policy all the time. After "motorcycle ban" policy was enforced, the positive impact of this policy was greater than the negative impact, especially on the transportation environment and transportation safety. Besides, motorcycles that were regarded as a transition travel means in cities would disappear eventually with the improvement of public transportation system, thus, it is still necessary for Dongguan's government to implement this policy steadily. Another function of government is to be responsible for the participation and management of public transportation. Currently, public buses in Dongguan are supposed to continue to adopt bus route operation model, but it needs to strengthen the participation of government that requires both private companies and government to manage public buses operation. We can draw on the experience in Shenzhen, promoting moderate marketlization of public buses by adopting the integration of limited competition and open competition model and withdrawing part of operation rights to enhance government participation. What's more, government should strive to develop bus lane to boost the efficiency of buses travel and plan and optimize the bus path by utilizing lands and buses hubs to do transit-oriented development (TOD). Finally, the government also needs to make effort to propagate the idea of green travel, to be specific, it is vital for the citizens to realize the emergence and importance of developing green transportation in Dongguan and for locals to remove the old concepts of public transportation, resulting that everyone can take part in the development of green transportation actively. In terms of promotion of walk and bicycles, the government can organize some activities such as "Healthy Walking Day" and "Green Bicycle Travel Day" to propagate the benefits and meaningfulness of walking and cycling and encourage citizens to choose more walking and cycling to commute.

5.2. Limit the Use of Private Cars

The amount of private cars in Dongguan saw a dramatically increase after the implementation of "motorcycle ban" policy, so it is urgent for governments to enact some actions to regulate the use of private cars. Studies have proved that limiting the car population is of low efficiency, while limiting the use of private cars is the root to solve this problem. Dongguan may imitate the initiatives in Hongkong. For one thing, it is possible to enhance purchase fee and license annual fee of private cars and parking fee as well as that reducing the supply of parking spaces. For another, it is likely to enforce the odd and even number rule to encourage cars sharing, thereby relieving traffic congestion pressure.

5.3. Accelerate the Construction of Metro Traffic

Metro Traffic as a public transportation means has the advantages of big passenger transport volume, high speed and safety, low consumption and pollution. In view of the experience from foreign countries, metro traffic has accounted for more than 50% of the whole city passenger transport volume. As Dongguan's traffic development was limited by city-town-village administrative management system, there was "buses break" between the city center and towns. To tackle this problem needs the construction of metro traffic, because comfortable, convenient and punctual metro traffic is popular among middle class and top class groups. Once the metro traffic paths have built up, it can shorten the commuting time between towns and towns, and strengthen trade partnership as well, even can connect the metro traffic between Shenzhen and Guangzhou, which will bring much convenience for the citizens in Pearl River Delta.

There are three building metro traffic lines in Dongguan, but it is far not enough. Our suggestions are: 1) Investing more in the metro traffic building. Based on reasonable planning, government can offer more daily life need lines to meet citizen's demand, but it should pay attention to the coordination with other cities in Pearl River Delta when programming paths; 2) Integrating land development with metro traffic construction. We can draw on experience and ideas of TOD on Hongkong and Taiwan, then move the central function areas to suburbs when building the metro traffic, but we need to give importance to the effective connection among airports, bus stations and railway stations; 3) Choosing the metro traffic sites away from sensitive environment areas. For example, water resources protection areas and city scenery areas cannot be built with metro traffic. In the meanwhile, it is necessary to take some measures to reduce noise pollution for its adverse effect on environment [12].

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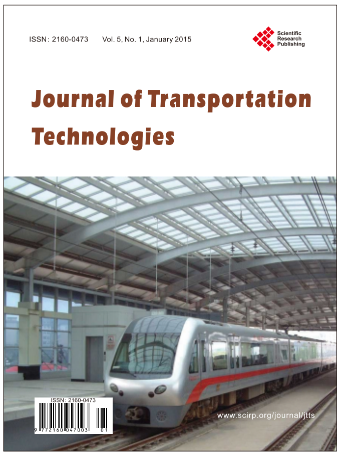

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