Simulation of Voluntary TDM scenarios on road service level in corridor of Nicolau dos Reis Lobato-Kolmera, Timor-Leste

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Abstract. Nicolau dos Reis Corridor Lobato-Kolmera is one of the corridors in the center of Dili City with the dominance use of office, trade and services activities. This effects a high trip attraction, so the level of road service in this corridor starts to be unstable especially during peak hour. At present there is no policy to deal with congestion issues in terms of managing travel demand. Therefore, this study aims to develop Voluntary-based Travel Demand Management (TDM) scenarios that can improve road service in the Nicolau dos Reis Lobato-Kolmera Corridor. Scenario is developed through simulation of multiple linear regression models and calculation of degree of saturation (DS). The results show that the TDM scenario in the form of Vanpool is considered more effective in improving road level services compared to Carpool and Flextime scenarios. The scenario of Vanpool and Flextime can be developed in office activities, while in trade and service activities require a combination of Carpool and Flextime policies to significantly reduce DS values.

1. Introduction

The increase of vehicles number in urban areas is the dominant factor congestion problem at peak hour. Various efforts to solve congestion have been carried out, but most of the practices in cities in Indonesia put forward supply side rather than demand side [1]. This causes an imbalance between the provision of road networks and car-based travel demand. An approach that has often been applied in most cities in the world is the concept of Travel Demand Management (TDM). According to Ferguson [2], TDM is a concept which aims to increase the need for movement or the need for transfer in different space and time. TDM focus on people/goods mobility rather than vehicles movement. By TDM, transportation demand is managed through various strategies to avoid travel at the same time and / or occur at the location or place that is done simultaneously (Ferguson, 2000). In implementing TDM, a variety of specific strategies that have been developed in accordance with existing transportation in the city through four major strategies, namely time shift, route shift, modal shift, and location displacement [3].

Dili is the capital of the State of the Republic of Democracy of Timor-Leste (RDTL), which is currently the centre of activities for both government, offices and trade and services. Based on data from the Direcção Nacional Transportes e Terrestres (2015), in 2010 to 2013 the growth of motorized fleets increased rapidly where three quarters (3/4) of all vehicles were motorbikes which reached 31%. In addition, at the end of 2014 the number of private car vehicles reached 9,518 units and motorcycles reached 60,579 units. This is normal if there is congestion in the city of Dili, especially at peak hour.
This phenomenon often occurs in several roads in the Vera-Cruz sub-district (west of Dili), especially on the Nicolau dos Reis Lobato road and the Kolmera road section.

The problem of congestion can be reduced by providing a range of TDM strategies that can provide mobility options for travellers [3]. According to Ferguson (2000), the taxonomy of TDM consists of Voluntary, Market and Regulation. TDM Voluntary emphasizes changes in travel behaviour through various choices made voluntarily in the short term. Alternative modes and alternative time strategies are part of this TDM Voluntary [5]. In implementing the Voluntary TDM strategy, incentive efforts rather than disincentive efforts such as those proposed by Meyer (1999) regarding TDM strategies are grouped as carrot and stick strategies to influence travel behaviour. The same thing was stated by Taylor (2007) how the application of TDM Voluntary in Australia is effective in influencing changes in travel behaviour through an incentive mechanism (carrot approach) rather than a disincentive (stick approach) [6]. The results of studies in the US show that the effectiveness of Voluntary TDM implementation in the form of Vanpool and Carpool strategies can be seen from the reduction in the number and cost of travel [7]. One of the best practices from the TDM strategy that has been successfully implemented is in the city of Alameda, California, namely the strategy of transit (transit use and carpooling). Since 2006 in Alameda City, California has managed to offer an incentive approach for residents to change their daily travel patterns using bicycles, public transport and Carpools. The application has succeeded in changing travel behaviour using private vehicles reduced by 14%, public transport users have increased to 34% and 5% Carpooling. In addition, TDM has also been successfully implemented in other cities in the world, such as the cities of Cambridge, Singapore, Perth, Beijing, Dublin, Greater Vancouver Region, London, Trondheim, Portland and Auckland. The successful implementation of the TDM strategy can be seen from the decreasing level of travel length (VMT-Vehicle Miles Travelled), reduction of congestion (reduction in vehicle volume on roads), emission reduction, shifting mode choices, and so on [1].

The various effectiveness of TDM implementation is influenced by various factors, namely the level of public acceptance, coerciveness, the combination of strategies, the existence of political support and the level of publications / campaigns to the community [8][1]. In general, the TDM strategy without coercion is more easily accepted by the public rather than the TDM strategy by force [9]. TDM Voluntary is generally related to the TDM approach without coercion, meaning that travellers move voluntarily based on the choice of TDM strategies offered without limiting their freedom to use private vehicles. The TDM Voluntary strategy will be easier to implement in terms of public acceptance. Therefore, this study aims to identify various types of Voluntary TDM strategies that can be applied in the Nicolau dos Reis Lobato and Kolmera Corridors, and how this TDM Voluntary scenario affects the level of road services. The results of this study are expected to provide a new perspective on the handling of transportation issues in the territory of Timor-Leste using transportation management on demand side.

2. Research method

In this study using a type of quantitative descriptive research. Descriptive research aims to describe the nature of a situation that is temporarily running at the time the research was conducted and examine the causes of a particular symptom [10]. In collecting and expressing various problems and objectives to be achieved, this research uses a quantitative approach. According to Sugiyono (2009), quantitative research methods can be interpreted as research methods that are based on rationalistic philosophy, used to examine certain populations or samples [11]. Therefore, in this study using samples of 185 workers whose travel destination is corridor of Nicolau dos Reis Lobato and Kolmera. This sample size has met the requirements for data adequacy at an error rate of 10% on the basis of the absence of information on population in this corridor [12]. The sampling technique used is the purposive sampling where respondents was selected are those who have regular working movement in the study area.

There are three stages were carried out in this study. First, identification of respondent’s preference to the kinds of Voluntary TDM strategy that is most appropriate. The second stage, the analytical method used in this study is multiple linear regression and calculation of road’s Degree of Saturation. The
multiple linear regression method is used to determine the relationship pattern between trip attraction of various types of land use and traffic volume in the study area. Furthermore, the method of calculating the degree of saturation is used to determine road’s level of service (LOS) through a comparison of traffic volume with road capacity. The Voluntary TDM scenario simulation in this study was carried out by examining the Voluntary TDM options and their effect on trip attraction and traffic volume in the corridor of Nicolau dos Reis Lobato and Kolmera.

3. Result and discussion

3.1 Identification of worker’s preference to Voluntary TDM strategy

At first stage, this study identify the preference of travellers to Voluntary TDM options to be applied in the corridor of Nicolau dos Reis Lobato and Kolmera. Voluntary TDM options are Vanpool and Carpool as mode shift alternatives and option of Flextime, Staggered Shift dan Compressed Work Week as time shift alternatives. The options was cross tabulated with land-use and vehicle type. Table 1 shows the result of worker’s preference tabulation where workers in office activity are more agreeing to the TDM option using Vanpool by 79% to go to work. Meanwhile, those who worked in the type of trade and service activity preferred with changes in mode using Carpool by 65%. In addition, to change the time or time-shift of both office workers choose Flextime option by 54% as well as those who work in trade and services activity chose Flextime option of 67% in order to reduce congestion. Most of travellers disagreed with option of Staggered-shift and Compressed work week to be applied in the corridor of Nicolau dos Reis Lobato and Kolmera.

Table 1. Cross tabulation between traveller’s preference on Voluntary TDM Options with land-use and vehicle type

| Voluntary TDM Option | Office Activity | | | | Service and Trade Activity | | | |
|---|---|---|---|---|---|---|---|---|
| | Mode Shift | | | | Time-Shift | | | |
| | | Light Vehicle | Motorcycle | | Light Vehicle | Motorcycle | | |
| | | Agree | Disagree | Agree | Disagree | Agree | Disagree | Agree | Disagree |
| Vanpool | 77% | 8% | 42% | 13% | 100% | 5% | 20% | 40% | 35% | 100% |
| Carpool | 14% | 31% | 26% | 29% | 100% | 20% | 5% | 45% | 31% | 100% |
| Flextime | 26% | 19% | 28% | 27% | 100% | 18% | 7% | 39% | 26% | 100% |
| Staggered-shift | 8% | 37% | 18% | 37% | 100% | 4% | 21% | 32% | 44% | 100% |
| Compressed work week | 8% | 37% | 17% | 38% | 100% | 8% | 16% | 22% | 53% | 100% |

Note: 
- Selected TDM option
- Not selection TDM option

3.2 Simulation of Voluntary TDM’s effect on level of road service

At this stage, multiple regression model was developed to catch the pattern of relationship between trip attraction and road level service. Trip attraction was calculated on each land-use type by traffic counting on weekday and weekend. Figure 1 shows the trips number of trade and service activity tends to stable every hour, but number trips of office activity are more bigger and tends to fluctuate.
Furthermore, this study developed multiple regression model of trips number and road’s degree of saturation. Saturation degree was calculated through traffic volume divided with road capacity. The highest traffic volume on Nicolau Labota-Kolmera road reached 1.745.8 pcu/hour with the capacity is 2.100.3 pcu/hour. The result shows that the saturation degree reached 0.83 or road’s level of service reached D category which means unstable traffic flow. Using Pearson Correlation technique, this degree of road’s saturation has significant relation with trips number of office activity, which the correlation value is 0.730 at p-value of 0.011. Furthermore, regression model of saturation degree and trips number as following equation:

\[ Y = 0.589 + 0.004(X1) + 0.00042(X2) \]  

where \( X1 \) is trips number of office activity; \( X2 \) is trips number of trade and service activity; \( Y \) is saturation degree (DS). This model has R-square of 53.4%. Based on the equation 1, simulation of TDM scenario aims to analysis of scenario effect on trips number change and also the change of road’s Degree of Saturation (DS) and Level of Service (LOS). The following table describes simulation of Vanpool option at office activity and its effect on DS and LOS change. DS and LOS change were also simulated based on Carpool option at trade and service activity and on Flextime option at both type of land use.

| Time       | Existing DS | Existing LOS | Estimation of Trips Number Change if Vanpool applied (pcu/hour) | DS Change | LOS Change |
|------------|-------------|--------------|-----------------------------------------------------------------|-----------|------------|
| 07.00-08.00| 0.57        | A            | 16.8                                                             | 0.67      | B          |
| 08.00-09.00| 0.81        | D            | 13.3                                                             | 0.66      | B          |
| 09.00-10.00| 0.63        | B            | 3.1                                                              | 0.61      | B          |
| 10.00-11.00| 0.69        | B            | 3.5                                                              | 0.61      | B          |
| 11.00-12.00| 0.81        | D            | 21.7                                                             | 0.69      | B          |
| 12.00-13.00| 0.78        | C            | 15.2                                                             | 0.67      | B          |
| 13.00-14.00| 0.83        | D            | 18.1                                                             | 0.68      | B          |
| 14.00-15.00| 0.65        | B            | 8.1                                                              | 0.63      | B          |
| 15.00-16.00| 0.64        | B            | 3.8                                                              | 0.62      | B          |
| 16.00-17.00| 0.81        | D            | 19.5                                                             | 0.69      | B          |
| 17.00-18.00| 0.75        | C            | 11.9                                                             | 0.65      | B          |
Table 3. LOS Change based on simulation of carpool strategy at trade and service activity

| Time       | Existing DS | Existing LOS | Existing number of trips at Office Activity (pcu/hour) (X1) | Estimation of Trips Number Change if Carpool applied (pcu/hour) (X2) | DS Change | LOS Change |
|------------|-------------|--------------|------------------------------------------------------------|---------------------------------------------------------------|-----------|------------|
| 07.00-08.00 | 0.57        | A            | 30                                                         | 21.5                                                          | 0.73      | C          |
| 08.00-09.00 | 0.81        | D            | 40.2                                                       | 15.8                                                          | 0.77      | C          |
| 09.00-10.00 | 0.63        | B            | 9.2                                                        | 12.7                                                          | 0.63      | B          |
| 10.00-11.00 | 0.69        | B            | 8.8                                                        | 19.3                                                          | 0.64      | B          |
| 11.00-12.00 | 0.81        | D            | 50.8                                                       | 13.5                                                          | 0.82      | B          |
| 12.00-13.00 | 0.78        | C            | 36.8                                                       | 25.2                                                          | 0.76      | D          |
| 13.00-14.00 | 0.83        | D            | 36.4                                                       | 13                                                            | 0.76      | C          |
| 14.00-15.00 | 0.65        | B            | 23.2                                                       | 22.9                                                          | 0.70      | C          |
| 15.00-16.00 | 0.64        | B            | 5.4                                                        | 18.8                                                          | 0.62      | B          |
| 16.00-17.00 | 0.81        | D            | 43.2                                                       | 18.3                                                          | 0.79      | C          |
| 17.00-18.00 | 0.75        | C            | 29.8                                                       | 27.2                                                          | 0.73      | C          |

Based on table 2 and 3, Vanpool option is more effective to change road’s level of service rather than Carpool strategy. Implementation of Vanpool strategy at office activity is more possible to support the worker’s travel pattern. In terms of providing transportation mode, government can supply the vehicles and require Vanpooling for workers in government sector. Different with Carpooling strategy, it is more difficult to be applied for workers in private domain. Flextime strategy which is applied at both type of land use can change LOS better rather than Carpool option as following table 4.

Table 4. LOS Change based on simulation of flextime strategy at both type of land use

| Time       | Existing DS | Existing LOS | Estimation of Trips Number at Office Activity if Flextime applied (X1) | Estimation of Trips Number at Trade and Service Activity if Flextime applied (X2) | DS Change | LOS Change |
|------------|-------------|--------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------|-----------|------------|
| 07.00-08.00 | 0.57        | A            | 35                                                              | 24.52                                                                           | 0.74      | C          |
| 08.00-09.00 | 0.81        | D            | 35.2                                                            | 13.68                                                                           | 0.73      | C          |
| 09.00-10.00 | 0.63        | B            | 9.2                                                             | 16.8                                                                            | 0.63      | B          |
| 10.00-11.00 | 0.69        | B            | 24.16                                                           | 26.68                                                                           | 0.80      | D          |
| 11.00-12.00 | 0.81        | D            | 35.44                                                           | 12.72                                                                           | 0.78      | C          |
| 12.00-13.00 | 0.78        | C            | 38.38                                                           | 34.6                                                                            | 0.76      | C          |
| 13.00-14.00 | 0.83        | D            | 34.82                                                           | 11.4                                                                            | 0.73      | B          |
| 14.00-15.00 | 0.65        | B            | 23.2                                                            | 26.6                                                                            | 0.69      | B          |
| 15.00-16.00 | 0.64        | B            | 18                                                              | 25.94                                                                           | 0.67      | B          |
| 16.00-17.00 | 0.81        | D            | 30.6                                                            | 19.66                                                                           | 0.71      | C          |
| 17.00-18.00 | 0.75        | C            | 29.8                                                            | 42                                                                              | 0.75      | C          |
Figure 2. Comparation DS Change between Existing DS (orange line) and DS with Vanpool (blue line), Carpool (purple line), Flextime (red line)

Figure 2 describes that Vanpool option is most appropriate to change road’s degree of saturation (DS) comparing with existing condition. Therefore, this option can change road’s level of service (LOS) become better than initial condition, from D category change to B (stable flow) at peak hour. LOS change with Vanpool option is significant at any observed time of movement. Based on this simulation result, there are various strategies which appropriate to be implemented on each land use type as following:

1. In office activities, the scenario that is appropriate to be applied is Vanpool option. Workers can use a share vehicle that provide by government so that the use of private car can be reduced. In addition, the flexible time set in Flextime option encourage workers to shift depart and arrive time in corridor of Nicolau dos Reis Lobato and Kolmera. This flexible time keep considers the rule of working time which is eight hours per weekday.

2. In trade and service activities, the appropriate scenario to be applied is Carpool and Flextime. Because of DS and LOS change is low and only occur at certain time, it is necessary to combine those options in implementing Voluntary strategy. Depart and arrive time is arranged flexibly, but workers which the origin is close should travel using shared-car.

4. Conclusion
Voluntary TDM options which is preferred to be applied in corridor of Nicolau dos Reis Lobato and Kolmera are Vanpool, Carpool and Flextime. Time shift strategy with Staggered Shift and Compressed Work Week option is not suitable with the characteristic of worker’s movement pattern. In office activity, only mode shift strategy is appropriate with applying Vanpool. Different with trade and service land use, both type of mode shift (Carpool) and time shift (Flextime) is suitable to be implemented. Work trip number in office activity are significant correlated with road’s degree of saturation in corridor of Nicolau dos Reis Lobato and Kolmera. The effect of work trip total in office activity is greater than trade and service activity. Therefore, regression model of road’s degree saturation (DS) formulates the coefficient of trip attraction number in office activity is greater than trade and service activity. This regression model is then used to simulate the change of road’s DS and level of service (LOS). This study results that Vanpool scenario have significant effects on DS and LOS change rather than Carpool and Flextime scenario. At peak hour, Vanpool scenario can reduce the initial DS value by 0.83 to 0.68 or LOS of D to B (stable flow). Meanwhile, Flextime can only reduce the DS value to 0.75 and reach DS to 0.76 with Carpool. In the improvement of the road’s level of service in corridor of Nicolau dos Reis Lobato and Kolmera, it is necessary to develop Vanpool and Flextime strategy in office activities. While in trade and service activities, a combination of Carpool and Flexible Time policy is needed to significantly reduce DS value.
5. Reference

[1] Kusumantoro, I. P., Handayeni, K. D. M. E., Syabri, I., & Kipuw, D. (2009). Level of effectiveness of the implementation of transport demand management (TDM) strategy in Indonesian cities. In Proceedings of the Eastern Asia Society for Transportation Studies Vol. 7 (The 8th International Conference of Eastern Asia Society for Transportation Studies, 2009) (p. 38).

[2] Ferguson, E. (2000). Travel Demand Management and Public Policy. Ashgate.

[3] Tamin, O. Z. (2000). Perencanaan dan Pemodelan Transportasi. Bandung: Penerbit ITB.

[4] Meyer, M. D. (1999). Demand management as an element of transportation policy: Using carrots and sticks to influence travel behavior. Transportation Research Part A: Policy and Practice. Vol 33, Issues 7-8, pp 575-599

[5] Meyer, M. D. (2016). Travel Demand Management. In Transportation Planning Handbook.

[6] Taylor, M. A. P. (2007). Voluntary travel behavior change programs in Australia: The carrot rather than the stick in travel demand management. International Journal of Sustainable Transportation. Vol 1, pp 173-192

[7] Wayne, B., & Laurel, R. (1997). Travel demand management in the USA: context, lessons learned and future directions. Energy Policy, 25(14–15), 1213–1215

[8] Gärling, T., Eek, D., Loukopoulos, P., Fujii, S., Johansson-Stenman, O., Kitamura, R. Pendyala R., Vilhelmson, B. (2002). A conceptual analysis of the impact of travel demand management on private car use. Transport Policy. Vol 9, pp 59-70

[9] Steg, L., Dreijerink, L., & Abrahamse, W. (2006). Why are energy policies acceptable and effective? Environment and Behavior, 38(1), 92–111. Available from: https://doi.org/10.1177%2F0013916505278519

[10] Sugiyono. (2008). Statistika untuk Penelitian. Bandung: CV. Alfabeta.

[11] Sugiyono. (2009). Metode Penelitian Bisnis (Pendekatan Kuantitatif, Kualitatif, R&D). Bandung: Alfabeta.

[12] Lemeshow, S., Hosmer, D. W. J., Klar, J., & Lwanga, S. K. (1990). Adequacy of Sample Size in Health Studies. England: John Wiley&Sons Ltd.