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Special Issue Transport Energy

PREFACE

Dear Readers,

Welcome to the 3rd issue, volume 2, of our online-peer-reviewed International Journal of the Society of Transportation and Traffic Studies. Four issues of the journal are published annually. This issue contains 4 technical papers: two on urban mobility issues, the first presents a study on how to maximize urban space and increase accessibility for pedestrians along a main boulevard in central Bangkok; the second presents a concept plan for transport infrastructure development for a medium-size city in India. One of the other two papers is about optimization of supply chain and selecting the optimal location for the warehouse by solving a vendor-buyer and facility location selection problem. The final paper deals with the identification of hazardous road locations which are enhanced by incorporating a tool called an accident clock.

The special issue features a timely topic of transport energy. The paper presents the lessons from fuel consumption management in transportation sector in Iran.

I trust you will enjoy reading this issue and find the information and research findings useful.

Pichai Taneerananon
Professor
Chair of Editorial Board

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ACCESSIBILITY IMPROVEMENT FOR DISTRICT'S URBAN DIVERSITY: CASE STUDY OF RACHADAMNOEN KLONG AVENUE, BANGKOK

Tanakorn UDOMSAP
Graduate Student
Urban Environmental Planning and Development,
Faculty of Architecture and Planning,
Thammasat University
Klongluag, Pathumthani, Thailand 12120
Tel: +66-2986-9605
Fax:+66-2986-9687
Email: del_pieroro@hotmail.com

Pawinee IAMTRAKUL
Assistant Professor
Urban Environmental Planning and Development,
Faculty of Architecture and Planning,
Thammasat University
Klongluag, Pathumthani, Thailand 12120\
Tel: +66-2986-9605
Fax:+66-2986-9687
Email: apawinee@hotmail.com

ABSTRACT:

Diversity of activities on Rachadamnoen Klang Avenue has demonstrated the difference between space usage and time. As a result, some areas cannot be maximized in term of its utilization for activities all day long. The understanding of the associate factors that influence on the diversity of activities on various time and space allocation are required as a necessary input in planning process to design for maximum efficiency of space usage. Thus, this research aims to determine needs and their association factors which influence the activity performances and to propose a development guideline for Rachadamnoen Klang Avenue. The research methodology includes both qualitative and quantitative analysis to reflect the actual behavior and the tourists and local people needs for improvement of the study area. The geographical information system (GIS) was employed to graphically demonstrate the differences of site characteristics for the integration of both qualitative and quantitative approach. The illustration of the multidimensional of the sites' distinctive and all requirements for upgrading the site characteristics could then be recommended during the designing of improvement plan. The finding result based on this study revealed that the area improvement can ensure the distribution of benefits of space utilizations by proposing the linkage of the activities and spaces in both sides of Rachadamnoen Klang Avenue. This benefit could bring the economic enhancement to the local people and tourism. Finally, more activities could be created and input into the area to attract more tourists and developments and enhance the quality of life by increasing more accessibility and green space on the basis of rehabilitation of district's urban diversity.

KEYWORDS: Accessibility, Urban Diversity, Activity

1. INTRODUCTION

Currently, the rapid growth of urban area in Bangkok, capital city of Thailand, causes the problem of inefficient land usages. Some areas in Bangkok have not been effecctively covered by Bangkok's comprehensive plan which has resulted to the imbalance changing of environments and impacting on t he locality business as usual, namely, urban activities, land use, utilities and facilities which could yield the amenities to the society. However, it has been distorted by the unplanned management. Rachadamnoen Klang Avenue, the famous road with long history in the old capital island, is now facing with the previously problems. Along the road presently, it was comprised with various activities and cultures of the allocation of center of tourism destination. The diversity of nationalities, both from foreign tourists and people living in the area, generate various culture and exchange cultures, then uncountable cultures has existed in this area. These varieties of cultures are the main factors which causes the uncontrolled quality of urban environments in both sides of the study area as depicted in Figure 1.

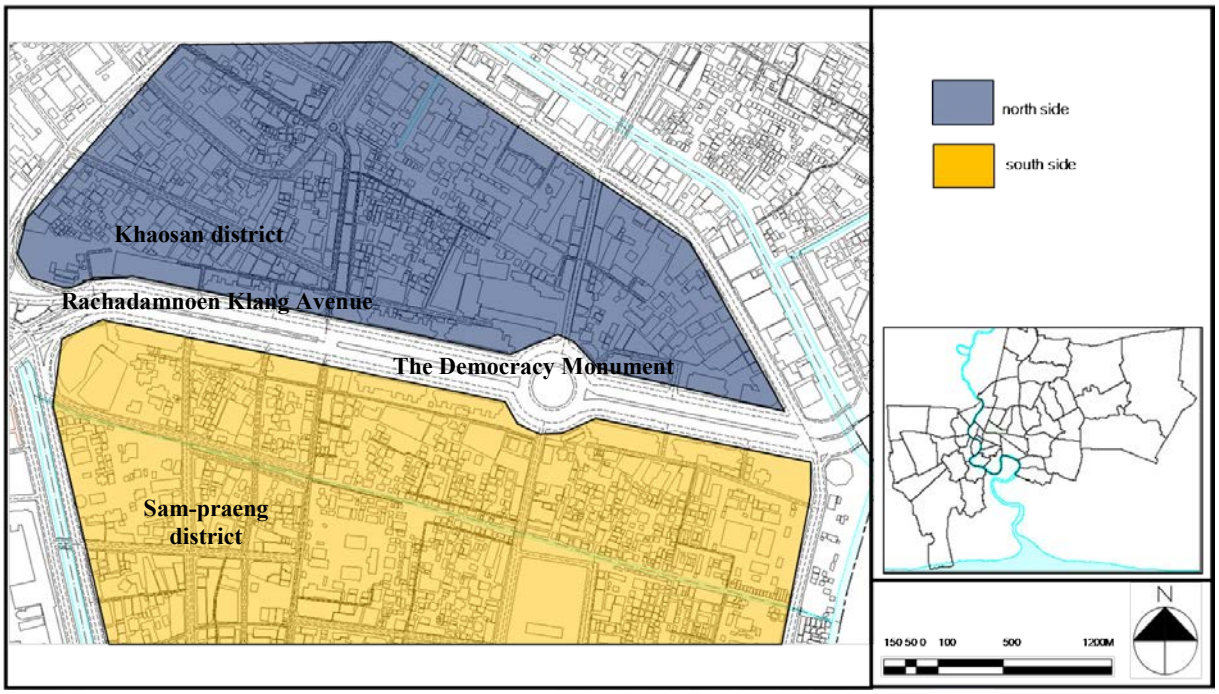


Figure 1 Rachadamnoen Klang Avenue Area

Khao-san sub-district is located to the north side of Rachadamnoen Klang Avenue was well-known as an attractive point to tourist groups and people. This district contains many kind of business area such as trading, tourism services and offices. During daytime, this district is highlighted at trading and shopping and working offices which represented as main activities. On the other hand, in the nighttime, this district is highlighted to tourist service and entertainment places to attract foreigners and also Thai people to enjoy night activities, those activities could generate incomes to local people. In contrary to southern side of Rachadamnoen Klang Avenue, although these areas are the allocation of the plenty of historical sites and governmental offices, but now this area is degenerate in income, tourism and environment. Moreover, many historical building are adapted to be used as residential units which serve for local people which can be shown in Table 1

Table 1 Identity of the north side and south of Rachadamnoen Klang Avenue

Area's Characteristic	North side	South side
Land use	commercial	residential
Ownership	Private sector	King' s property
Community	3	4
Occupation	Government affair/labor	Commerce/labor
Tourism attractive	Shop/ restaurant/pub/guest house	Shop/historic communities
Use of area in daytime	Commerce/tourism	Commerce/communities meeting
Use of area in nighttime	restaurant/pub	residential

Due to the existing condition of different activity types for both daytime and nighttime, the diversity of ownership and attractivenesss of different areas create the problem of inequality of the distribution of income and economic in the areas. Thus, the space improvement should be considered in term of designing physical aspects to shape behavior of people and enhance their quality of life of the community in both sides of Rachadamnoen Klang Avenue.

2. REVIEW LITERATURE

2.1 Accessibility Concept

There are many activities in urban area, especially historical quarter or city core contains many kind of activities such as trading, workings, services, productions etc. The diversity in urban area can be described in terms of the principle of space and the principle of time. For example, many people works on central area in daytime, need to relax at recreation places in evening, and go back to their residential units for sleep. Thus, daytime and night time would always effect on people choice or decide about type of activities that person prefer to do (Fellman J. and D. Getis. J, 1972). Factors that can be used for consideration in time and space are 1) pattern of accessibility 2) distance from origin to destination 3) types of activities and 4) duration of activities. Furthermore, the consideration of the residential environment also plays an important role on space utilization for diversity of usage. The inhabitant could be formed as communities in urban area which could be categorized by three components; 1) geographic area 2) social interaction and 3) common ties.

Among these factors, transportation plays an important role to increase social interaction between two or more communities to create and generate urban diversity. Jeans Jacob (1961) recommended that transportation could be designed to serve for increase urban safety and encourage urban area to generate diversity which can be explained as follows;

Road network system – Roads, streets and pavements can be used as one indicator to measure the quality of city since livable roads or pavements always attract people. The design guideline to make street or pavement more attractive can be use kiosk or retail shop or generate activities in that area. Building roads or pavements should be designed in difference patterns. Moreover, it should define territory between private and public and avoid design that may cause blind-spot.

Diversity – In urban area or urban core area, land use planning should be encouraged to mix-used area. Such as office, retail shop, pollution-free productive sectors, factory, etc. And it should concern historical buildings more than modern buildings which effect to local people. Modern buildings come from investors and spectacular or new comers. And it will result on

the the relationship between local people tol be decreased and also decrease the diversity in that area. Moreover, increasing density and intensity also generate urban diversity. The environment for pedestrian approach should be considered as easily and basically of accessibility between point-to-points. However, this approach has limitation of distance approximately 1 kilometer. Mainly, pavement improvement are required to safe, comfort and aesthetic for pedestrian and distance between origin to attractions is not over 200 meters (Rubenstein, 1978).

2.2 Analytical tool for accessibility analysis

Potential Surface Analysis (PSA) is one of the spatial analysis techniques which aims to analyze the suitability of area to development. This technique could be adopted to measure suitability area in grid analysis which use index and factors, then prioritize the set of analyze factors by weight score or penalty score. Consequently, the overlay technique can be used to analyze all of factors to measure level of suitability. This technique can range the score in each grid and can be compared in statistic terms, which clearly to understand. And it can be adjusted value or weight score to re-analyze in case of making alternatives in different situation. PSA can be calculated by using weight and multiply to each factor, and calculate all of each factors score to evaluate the suitability of development in site. Its equation can be shown below.

$$S = W_1X_1+W_2X_2+W_3X_3+\ldots W_nX_n \qquad (1)$$

Where S is Summation of suitability score in area
W_n is Weight of factor n
X_n is Criteria Score of factor n

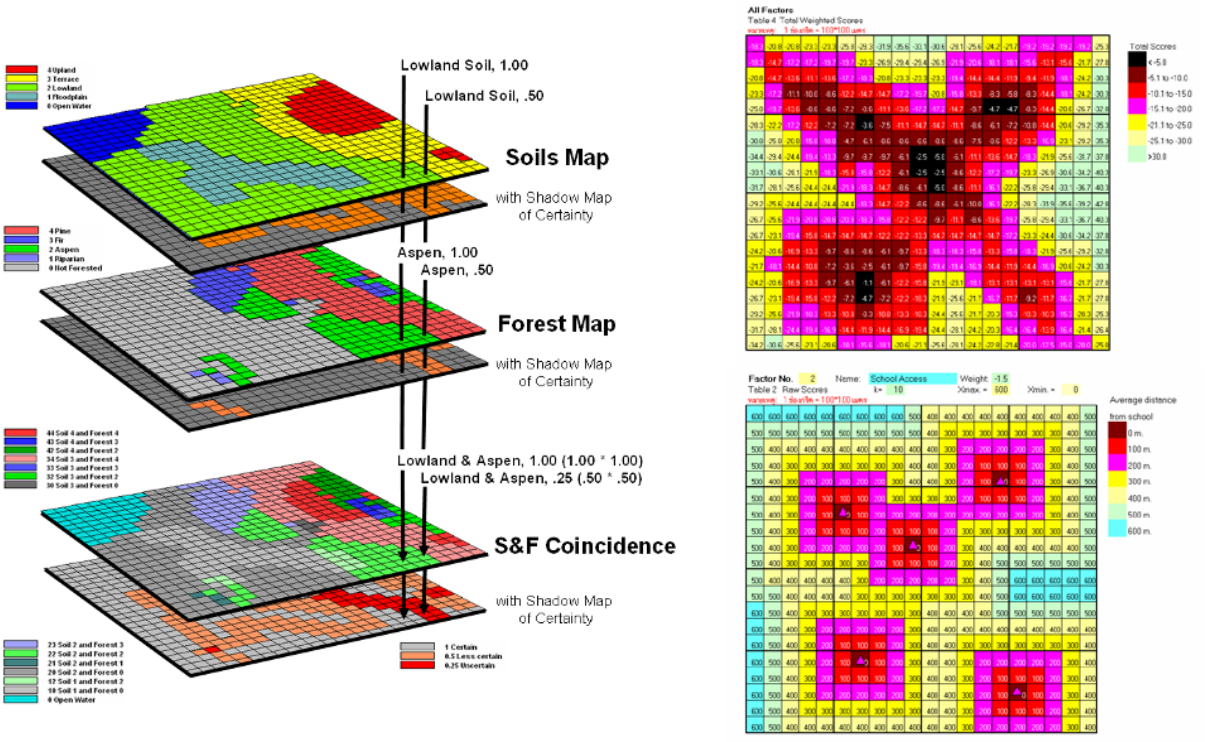


Figure 2 Potential Surface Analysis (PSA)
(Source: Geometrics Internet Service to Millennium Education, 2009)

3. STUDY AREA

This study area is located on both sides of Rachadamnoen Klang Avenue, which is located in historical area in Phra Nakorn district in Bangkok. It is connected to Talad Yod sub-district and Bann Phanthom sub-district, Phranakorn district in the north, Baan Bart sub-district and Wat Sommanat sub-district in the east. Its location also connect to San Jaopoasua sub-district, Sao Chingcha sub-district and Sumrahnraj sub-district in Phranakorn district in the south, connect to Phra Borommaha-rachawang sub-district, Phranakorn district in the west.

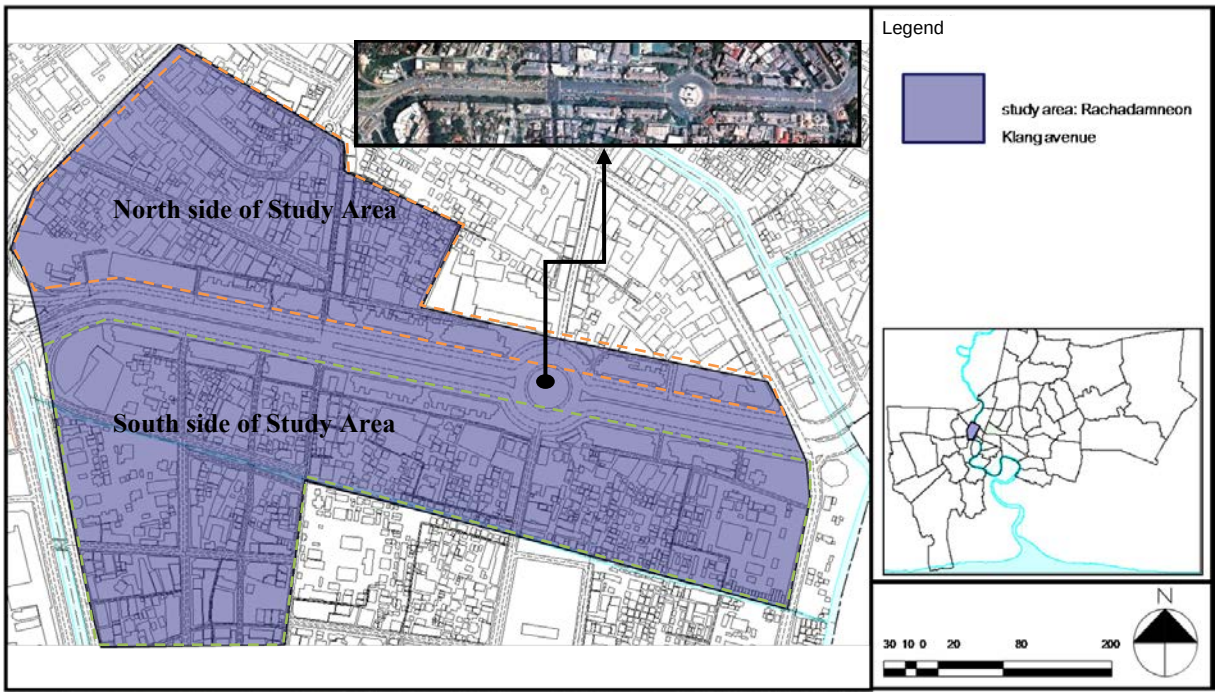


Figure 3 Study area (Rachadamnoen Klang Avenue)

There are three types of attractive places such as schools, temples and institutional office. These attractive locations play as historical vital places in central area of Bangkok. This study area is allocated nearby public parks, religions places, secondary schools, institutional places. Location and type of attraction places nearby the study area can be shown in Figure 4. In terms of urban morphology, road pattern in this study area and nearby district is in form of grid pattern, which consist of different size of road which vary between two lanes road to 12 lanes. The major road such as Rachadamnoen Klang Avenue and Boromrachachonnanee Road, which construct of 12 lane road and distribute within the inner area such as Asadang Road, Rahmbuttri Road, Larn Luang Road as a local roads. Moreover, there are arrays which align in grid pattern and road network in study area and nearby district can be demonstrated in Figure 5.

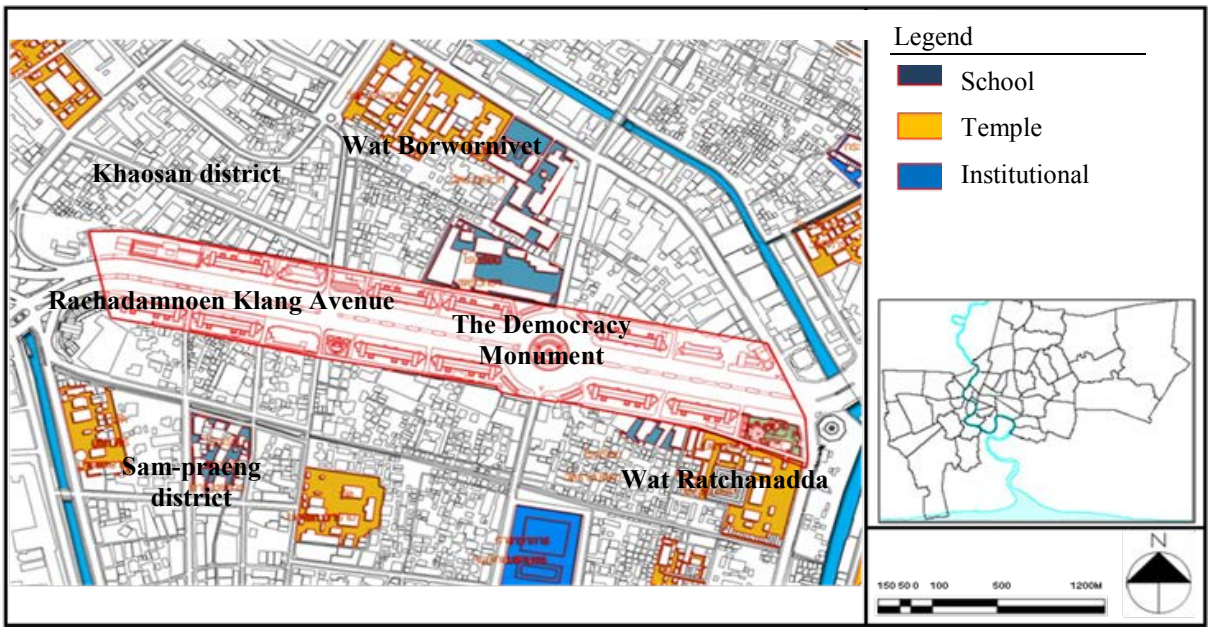


Figure 4 Attractive places nearby the study area

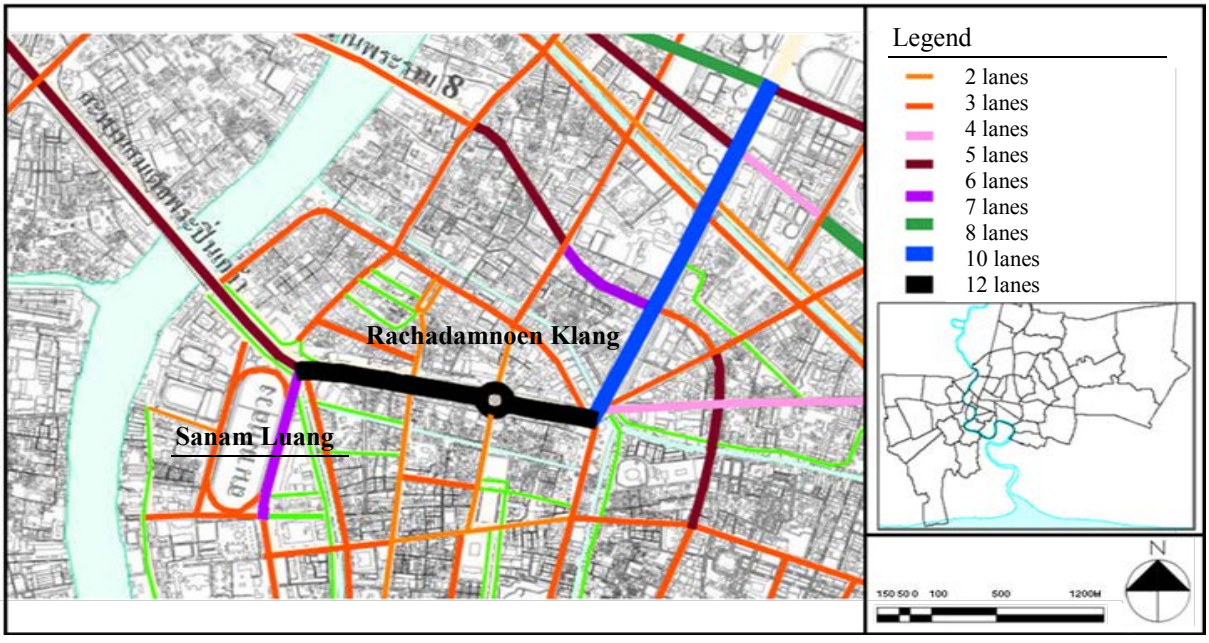


Figure 5 Road network in study area

About the residential area, there are 8 main communities located nearby Rachadamnoen Klang Avenue which consist of Thanon Khaosan community, Trok Borwornrangsri community, Tuk Din Mosque community, Lang Thanon Rachadumnoen Klang community, Trokslip-Tukdin community, Lang Wat Ratchanadda community, and Sam Prang community. The location on e ach community can be shown in Figure 6. A s a historical quarter which contains many attractive points, this study area is provided for many activities and allow for both day and night activities. In daytime, these areas are filled with activities

both tourism places such as Khaosan road, gallery, temples and trading activities such as markets. However, in the nighttime, this area, especially in Khaosan sub-district is highlighted for tourism and services such food and restaurants, flea market. The differences between daytime activities and nighttime activities can be illustrated in Figure 7. According to observation in study area, there are 3 groups of users that are tourists, students and shopkeeper. Tourists groups, especially foreigners always commute by walking around Khaosan sub-district. Also for students group, they mostly walk along Thanon Dinso due to the proximity location of schools such as Striwittaya School and Wat Borwornniwej School. Shopkeepers and lottery sellers perform their trading activity along Rachadamnoen Klang Avenue (in south side). The circulation area for each group can be depicted in Figure 8.

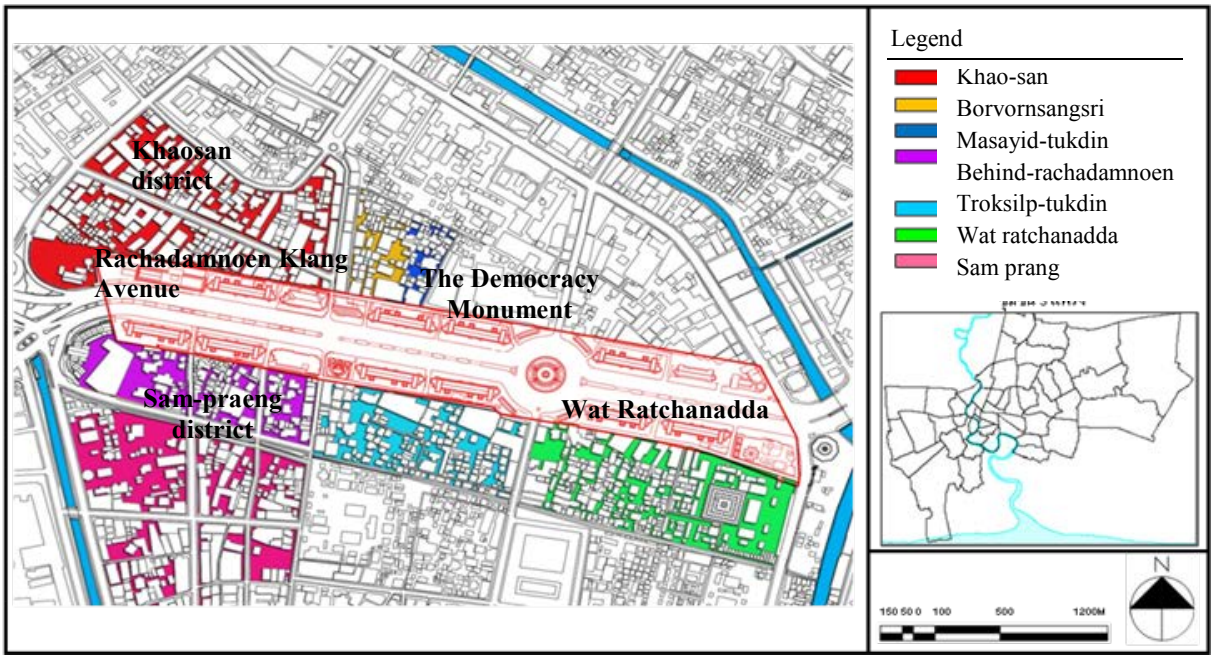
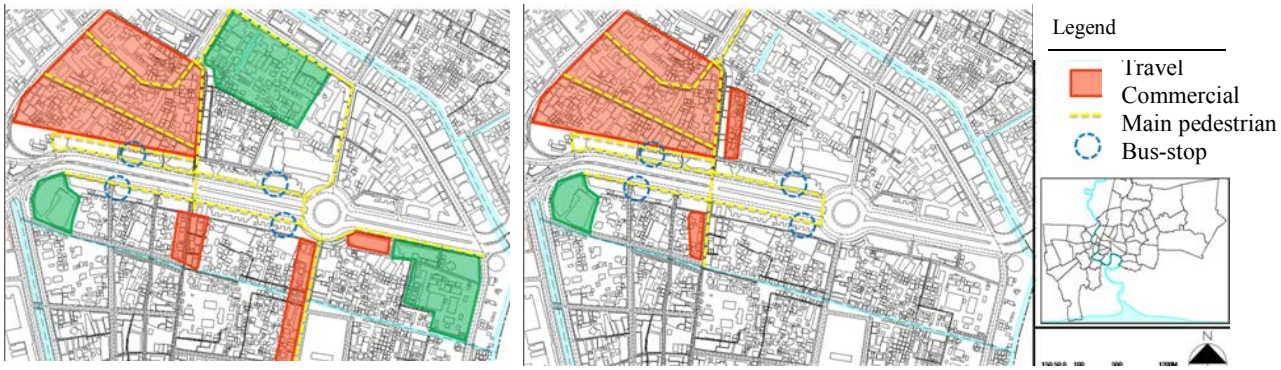


Figure 6 Communities in study area



Daytime **Nighttime**

Figure 7 Activities between daytime and nighttime in study area

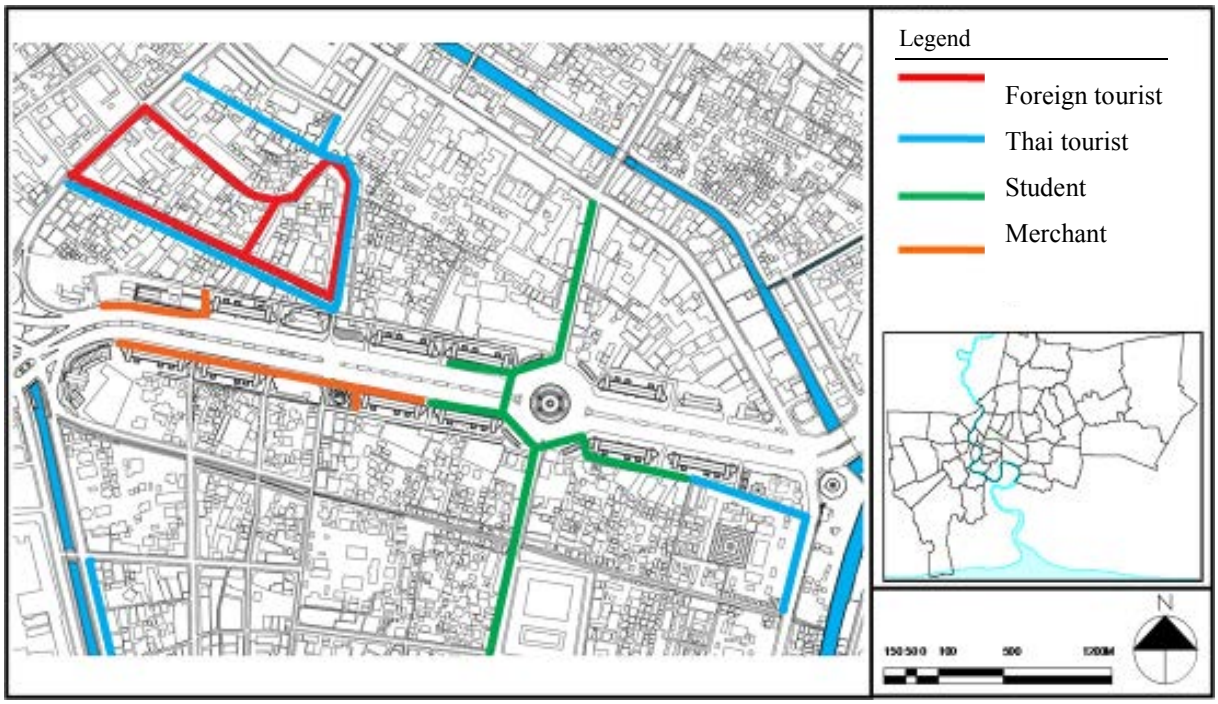


Figure 8 Circulation of commuters from outside the study area

4. METHODOLOGY

This study utilized both questionnaire survey and spatial analysis to analyze the current situation together with their perception and needs of area improvement. Questionnaire survey was collected of 30 samples which can be separated into three groups, which consist of 1) samples who live in the northern part of Rachadamnoen Klang Avenue 2) samples who live in the southern part of Rachadamnoen Klang Avenue and 3) samples who lives outside the study area. This is to describe the perception of development guideline on the basic descriptive statistics and cross tabulation.

In spatial analysis, this study used Model Builder™ in ArcView GIS to analyze the potential surface analysis (PSA) and categorize the area which suite for develop and further improvement. According to spatial analysis, this study use potential surface analysis (PSA) with the application Model Builder™ in ArcView GIS. This is similar to overlay technique which can analyze on the basis of weight overlay approach. Three major factors were use to analyze spatial characteristics and can be shown in Table 2

Table 2 Spatial analysis weight score

Factors	Score 4	3	2	1
1. Physical factors (60%)				
• Major road accessibility 25%	Less than100 M.	100-200 M.	201-300 M.	More than 300 M.
• Local roads/arrays accessibility 15%	Less than 50 M.	50-100 M.	101-150 M.	More than 150 M.
• Location of subway station 20%	Less than 200M.	200-400 M.	401-600 M.	More than 600 M.
2. Community settlement factor (15%)	Less than100 M.	100-200 M.	201-300 M.	More than 300 M.
3. Activity factors (25%)				
• Distance from Khao San road 5%	Less than100 M.	100-200 M.	201-300 M.	More than 300 M.
• Distance from Wat Rachanaddaram 10%	Less than100 M.	100-200 M.	201-300 M.	More than 300 M.
• Distance from the government lottery office 10%	Less than100 M.	100-200 M.	201-300 M.	More than 300 M.

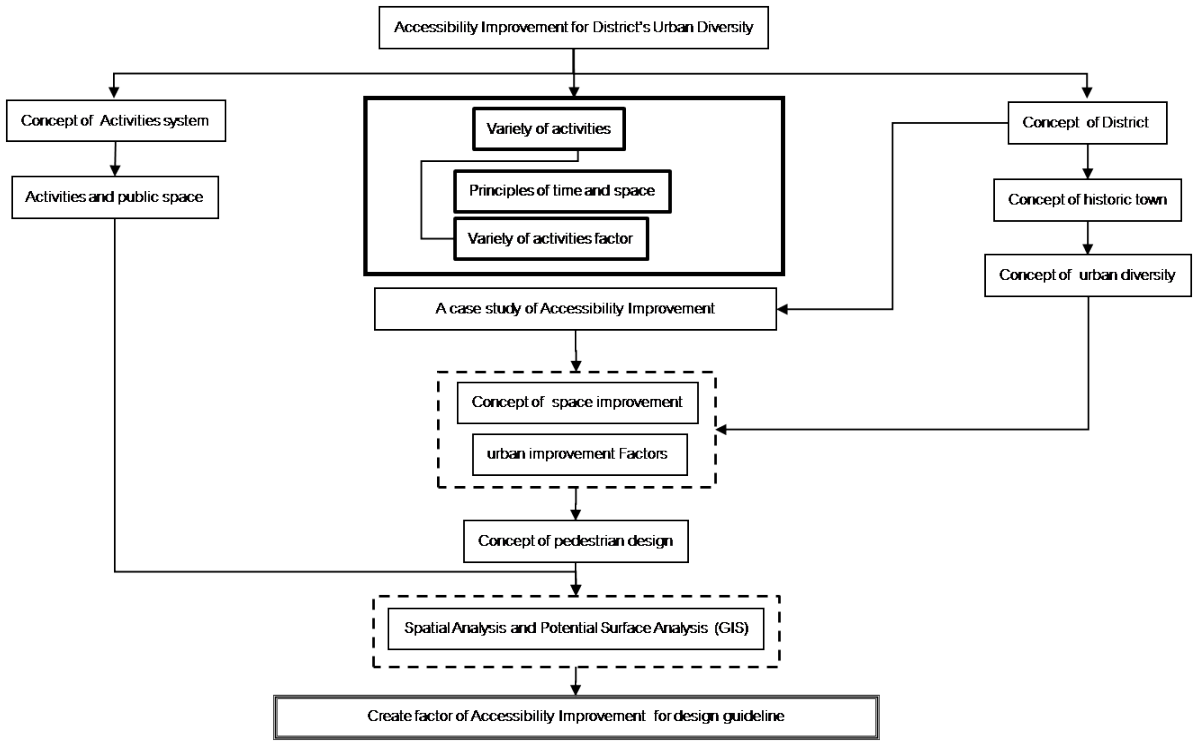


Figure 9 Conceptual framework of the study

This study is focused on accessibility improvement by using both primary data source such as observation and questionnaire survey for understanding of demand, perceptions of local people. The secondary data sources such as documentary research and spatial analysis were also utilized for analyze the suitability area for improvement. Then all necessary data was input to the design process of establish guideline for accessibility improvement in Rachadumnoen Klang Avenue. The conceptual of this study can be shown in Figure 10.

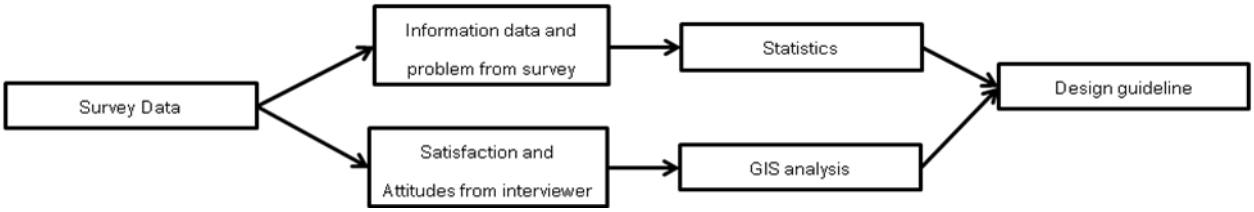


Figure 10 Method of study

The analysis of study for accessibility improvement design guideline is separated into three parts: 1) analysis of information data and existing problems based on the approach of site investigation 2) analysis of satisfaction and attitude from interviewer survey and 3) spatial analysis and potential surface analysis (PSA). Base on t he combination of analysis among three parts of design guideline, the study diagram can be shown in Figure 11.

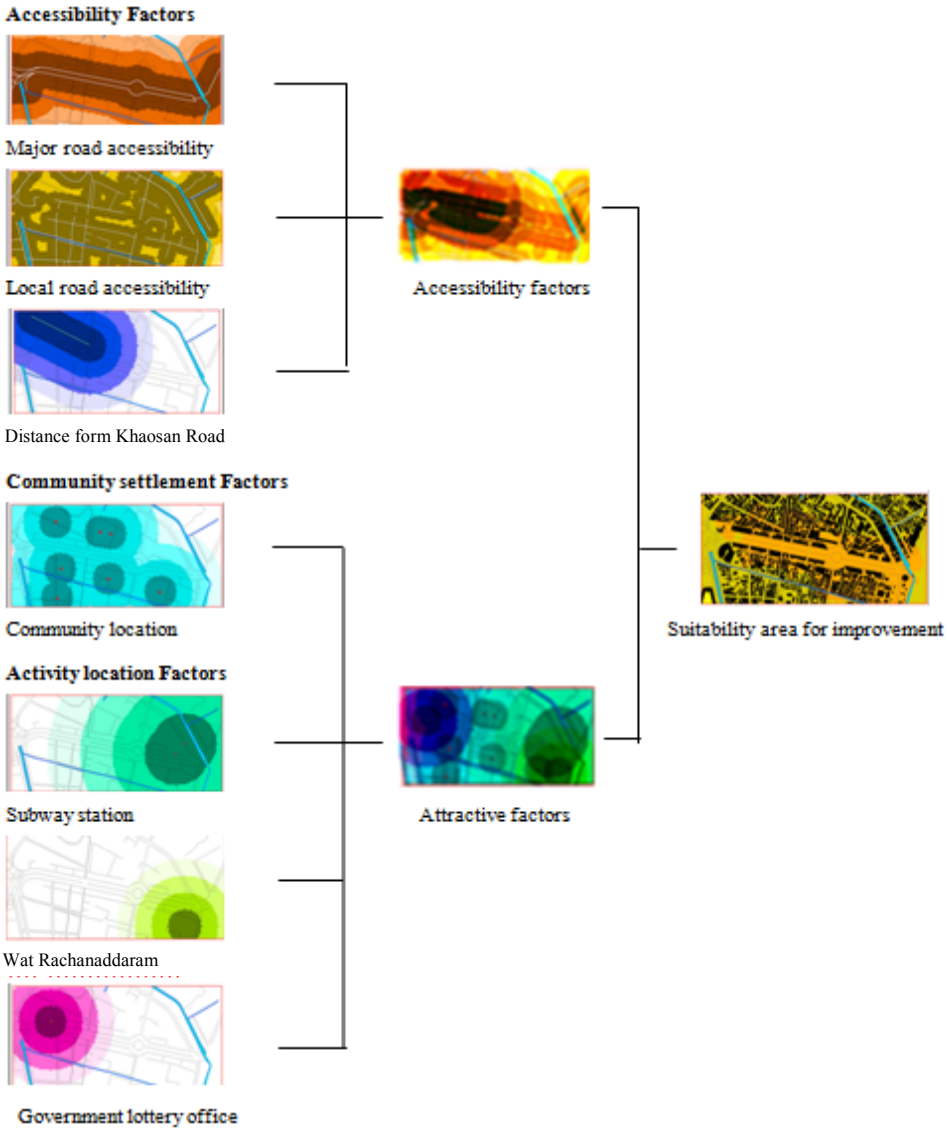


Figure 11 Conceptual of Spatial Analysis

5. RESULT OF ANALYSIS

5.1 Spatial Analysis

According to spatial analysis by using overlay technique incorporating with using major road accessibility factor, local road accessibility factors, distances from attraction points to analyze the suitability for improvement, the result was shown that the suitability area for improvement is the area which locate nearby Rachamnoen Klang road, Thanon Khaosan community, Trok Borwornrangsri community, Lang Thanon Rachadumnoen Klang-community, Tuk Din Mosque community, Trokslip-Tukdin community and Lang Wat Ratchanadda community in high level (score 3 of 3). Another area such as Sam Preng community is suitable to improve in moderate level (score 1 of 3). The result of spatial analysis is graphically demonstrated in Figure 12.

Figure 12 Suitability level of improvement in study area

5.2 Questionnaires survey

According to questionnaire survey, this section can be described into two parts, descriptive statistic and cross tabulation. In descriptive statistic, it aims to analyze perception of respondents in field of adaption in study area between northern side and southern side of Rachadamnoen Klang Avenue that suite for development or improvement. In descriptive statistic section, according to result of respondents to improvement approach, it demonstrated that most respondents would like to improve both sides of Rachadamnoen Klang Avenue to attract more business and tourism activity by using both green corridor approach and shopping street. This is due to most respondents would not prefer to improve for vehicle access. The result of descriptive can be shown in Table 3.

Table 3 Descriptive statistics in respondents' perception of improvement

Questions	Mean	SD
Do you need to improve the area which located on the northern part of Rachadamnoen Klang Avenue for encourage local economic and tourism?	1.10	0.305
If development project had occurred on the area located on the northern part of Rachadamnoen Klang Avenue, it should be improve to shopping street?	3.80	1.157
If development project had occurred on the area located on the northern part of behind Rachadamnoen Klang Avenue, it should be improve to green corridor?	3.37	1.351
If development project had occurred on the area located on the northern part of behind Rachadamnoen Klang Avenue, it should be improve to vehicle approach?	2.13	0.860
Do you need to improve the area which located on the southern part of Rachadamnoen Klang Avenue for encourage local economic and tourism?	1.13	0.346
If development project had occurred on the area located on the southern part of Rachadamnoen Klang Avenue, it should be improve to shopping street?	3.77	1.104
If development project had occurred on the area located on the southern part of behind Rachadamnoen Klang Avenue, it should be improve to green corridor?	3.97	1.066
If development project had occurred on the area located on the southern part of behind Rachadamnoen Klang Avenue, it should be improve to vehicle approach?	2.03	0.809

After analyze the relationship between factors by using cross tabulation, the result was shown that most respondents would like to improve their residential area both northern part of Rachadamnoen Klang Avenue and southern part of Rachadamnoen Klang Avenue. In case of improvement approach, respondents prefer the improvement approach in the north part of Rachadamnoen Klang Avenue by using shopping street approach and green corridor. Respondents would like to improve the area which located in south part of Rachadamnoen Klang Avenue by using green corridor, and both two sites are not prefer vehicle approach for improvement. The result of cross tabulation can be shown in Table 4. According to the result of cross tabulation analysis between respondents settlements and shopping street improvement approach, the result from Table 5 demonstrated that both respondents who live in between northern part of Rachadamnoen Klang Avenue and southern part of Rachadamnoen Klang Avenue are strongly agree to improve by shopping street approach.

Furthermore, when consider about respondents settlements and green corridor improvement approach, the result from Table 6 illustrated that both respondents who live in between northern part of Rachadamnoen Klang Avenue and southern part of Rachadamnoen Klang Avenue are strongly agreed to green corridor improvement approach.

Table 4 Cross tabulation between respondents settlement and improvement approach

Group	Do you need to improve the area for encourage local economic and tourism?					
	Northern part			Southern part		
	Yes	No	Total	Yes	No	Total
Residents who lives on the northern part of Rachadamnoen Klang Avenue	9	1	10	9	1	10
Residents who lives on the southern part of Rachadamnoen Klang Avenue	9	1	10	9	1	10
Residents who live outside study area	9	1	10	8	2	10
Total	27	3	30	26	4	30

Table 5 Cross tabulation between respondent's settlement and perception of shopping street improvement approach

Group	If development project had occurred on the area, it should be improve to shopping street?							
	North				South			
	Low	Moderate	high	Highest	Low	Moderate	High	Highest
Residents who lives on the northern part of Rachadamnoen Klang Avenue	1	1	3	5	3	0	4	3
Residents who lives on the southern part of Rachadamnoen Klang Avenue	3	1	3	3	2	1	4	3
Residents who live outside study area	2	3	2	3	1	3	3	3
Total	6	5	8	11	6	4	11	9

Table 6 Cross tabulation between respondent's settlement and perception of green corridor improvement approach

Group	If development project had occurred on the area, it should be improve to green corridor?									
	North part					South part				
	Lowest	Low	Moderate	High	Highest	Lowest	Low	Moderate	High	Highest
Residents who lives on the northern part of Rachadamnoen Klang Avenue	1	1	0	4	4	0	1	1	4	4
Residents who lives on the southern part of Rachadamnoen Klang Avenue	1	3	1	4	1	0	1	2	3	4
Residents who live outside study area	1	3	2	2	2	0	2	2	2	4
Total	3	7	3	10	6	0	4	5	9	12

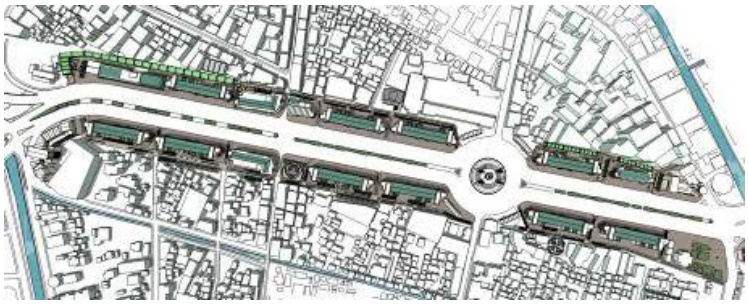
According to cross tabulation between respondents settlements and vehicle approach improvement, the result from Table 7 explained that both respondents who live in between northern part of Rachadamnoen Klang Avenue and southern part of Rachadamnoen Klang Avenue are tend to disagree to improve by vehicle approach.

Table 7 Cross tabulation between respondents settlement and perception of green corridor improvement approach

Group	If development project had occurred, it should be improve to vehicle approach?							
	North part				South part			
	Lowest	Low	Moderate	High	Lowest	Low	Moderate	High
Residents who lives on the northern part of Rachadamnoen Klang Avenue	3	5	2	0	4	3	3	0
Residents who lives on the southern part of Rachadamnoen Klang Avenue	2	5	2	1	2	4	4	0
Residents who live outside study area	2	4	3	1	3	4	3	0
Total	7	14	7	2	9	11	10	0

6. CONCLUSION AND SUGGESTION

Based on r esult of analysis, most of respondents prefer to improve accessibility by shopping street approach and green corridor approach in both side of Rachadamnoen Klang Avenue. This study suggested that not only urban design can improve accessibility by install ornaments such as benches, fountains and street lights for attracts people to come to this area, but installing or building arcades and allows merchants to trade also improve attractive into the study area. In some places, the allocation of install arcade and pavement improvement can be an instrument to discuss the access of vehicle and raise pedestrian friendly into study area. Guidelines for improvement can be designed and demonstrated in Figure 13 and Table 8, respectively.



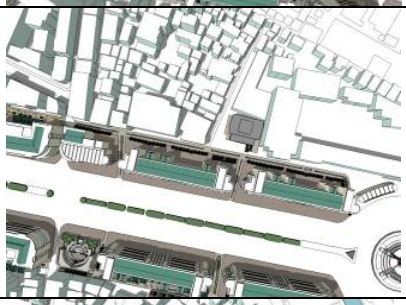
Overview of Area Improvement

Green area near Wat Ratchanadda

Figure 13 Improvement suggestions in study area

In case of adoptive measurements to improve accessibility, it can recommend for site management such as time or duration of access to some area or improve connectivity between bus stop and subway station to major destination such as Khaosan road, gallery and temples. Also, the recommendation can direct to encourage pedestrians to go to attraction places by walking instead of motorizations. Moreover, building or provide spaces for retail shops, kiosks could encourage local people to come and create social activities such as local festival can be an option to raise attractive of study area in term of local income to local people nearby communities.

Table 8 Accessibility improvement guidelines in study area

	Area of improvement	Before	After
Southside of Khaosan road			
Democracy Monument			
Wat Ratchanadda			
Northside of Sam Prang			

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COORDINATION, SUPPLY CHAIN OPTIMIZATION AND FACILITY LOCATION SELECTION PROBLEM

Mohammed Forhad UDDIN
Doctoral Student
Department of Civil and Environmental Engineering
Nagaoka University of Technology
Kamitomiokamachi, 1603-1.
Tel: +81–258–47–6635
Fax: +81–258–47–9650
Email: forhad@stn.nagaokaaut.ac.jp

Kazushi SANO
Associate Professor
Department of Civil and Environmental Engineering
Nagaoka University of Technology
Kamitomiokamachi, 1603-1.
Tel: +81–258–47–9616
Fax: +81–258–47–9650
Email: sano@nagaokaut.ac.jp

ABSTRAT:

The present work deals with an enterprise consisting of vendor-buyer and facility location selection problem. The coordinated mechanism among the members of supply chain has been proposed to achieve the optimal solution and the optimal location for the warehouse. Further, a price-sensitive linear demand function with single vendor-buyer and multiple products-consumers model has been formulated. In this work, Buyer's Mixed Integer Problem (MIP) model, Vendor's Integer Problem (IP) model and Coordinated MIP model have been formulated. Numerical examples presented in this research, which include the sensitivity of the key parameters to illustrate the models. Branch and bound algorithm has been applied to solve the models. Results show that by coordination, (1) the individual profit as well as joint profit could be increased, (2) consumers purchasing price could be decreased and (3) products allocations for different cases are not differ much and the location set for the warehouses is become confined.

Key Words: Warehouse location problem, coordination between vendor and buyer, mixed integer program.

1. INTRODUCTION

The coordination among the members of supply chain is one of the vital issues to overcome the new challenges of the comprehensive enterprise. If there is no coordination exists between the members in a supply chain, vendor and buyer will act independently to maximize their own profit and reduce cost which does not guarantee the optimal state of the whole system That is why to ensure the optimal system and to satisfy customer demands in today's competitive markets, significant information needs to be shared along the supply chain. And a high level of coordination between vendor's and buyer's decision making is also required. The idea of optimizing the joint total cost in a single-vendor and a single-buyer model was first introduced by Goyal (1976). Viswanathan and Wang (2003) described the effectiveness of quantity discounts and volume discounts as a coordination mechanism in distribution channels with price sensitive demand. They concluded that the effectiveness of volume discounts as a coordination mechanism is higher when the sensitivity of demand to price changes higher and the effectiveness of quantity discounts

is higher with lower price demand. In addition, Qin et al. (2007) have considered volume discounts and franchise fees as coordination mechanism in a system of supply chain with single supplier and single buyer with price sensitive demand.

At the same time, Jokar and Sajadieh (2009) have described a vendor–buyer integrated production inventory model considering Joint Economic Lot Sizing (JELS) policy with price sensitive demand of the customer. In the meantime, Sajadieh and Jokar (2009) described a JELS model consisting one vendor and one buyer where the shipment; ordering and pricing policy are all optimized. Finally, they investigated the effectiveness of customer price sensitive demand.

Another stream of literate that deals with locational decision-making has led to a strong interest in location analysis and modeling within the operations research and management science community. Undoubtedly, humans have been analyzing the effectiveness of locational decisions since they inhabited their first cave. The term "facility" here is used in its broadest sense. That is, it is meant to include entities such as air and maritime ports, factories, warehouses, retail outlets, schools, hospitals, day-care centers, bus stops, subway stations, electronic switching centers, computer concentrators and terminals, rain gages, emergency warning sirens, and satellites, to name but a few that have been analyzed in the research literature.

Classical plant location problems have been discussing over the years, as initiating with the work of Weber (1909), however, the workable models are constituted only in the 1960s with the arrival of automatic computation capabilities implied by Laporte and Revelle (1996). Holmberg (1999) proposed a solution method for uncapacitated facility location problems where the transportation costs are nonlinear and convex. He developed a branch and bound method based on dual ascent and adjustment procedure and compared to application of a modified Benders decomposition method. Arya, N. et al. (2004) used in facility location problems. It is stated the locality gap of a local search procedure for a minimization problem as the maximum ratio of a locally optimum solution (obtained using this procedure) to the global optimum.

Consequently, Ko (2005) described an integrated decision model to determine the location of distribution faculties. He proposed the hierarchy process and analyzed the survey data based on the location selection criteria and demonstrated the practical applicability of the research findings. Eroglu and Keskintürk (2005) investigated a model for locating an economic facility to determine how many warehouse to set up, where to locate those warehouses. They proposed a genetic algorithm for the warehouse location problem and cities of Turkey are considered where the warehouses construct for minimizing the distribution costs. Sheng et al. (2006) have investigated a transportation model with discontinuous piecewise linear cost function and proposed a genetic algorithm based on the matrix encoding which more efficient than previous algorithm. Uddin and Sano (2010) described a linear fraction model that maximizes the return on investment and find the location for the facility. They also discussed an MIP based approach to solve linear fractional programming problem. A standard approach to warehouse location is to start with the centre of gravity of demand, and to model various options at or near the centre. The centre of gravity method is technically unsound

Despite the large amount of research extending different dimension of facility location problem, they are not boundless and technically sound. Locating facilities and allocating demand to these facilities is a huge problem. There is a trade-off between the cost of construction and operating of the facility and the cost of transportation. Low facility costs and high transportation costs implies the decentralization concept. Lead times, customer service and response depend on the warehouses. Therefore, the location of the warehouse is also important as facility location. One part of the Warehouse Management Systems contains also warehouse location. One aim is to minimize the travel or shipment distance as location selection.

On the other hand, Coordination mechanism is beneficial. Min (2001) determined that Supply chain coordination provides risk reduction, access to resources and competitive advantage. In addition, Cristiaanse and Kumar (2000) argue that Supply chain coordination dictates the cost improvement and value that can be gained. Jorgensen and Zaccour (2003) also express that Uncoordinated decision-making creates inefficiency with the channel members' profits significantly lower for each channel member independently and collectively than what could be achieved with coordination.

That is why, considering the benefits of the coordination mechanism and the existing limitations of the facility location problem, we are interested to apply the coordination theory as an alternate approach to solve facility location problem. In this work, combining the facility location problems with the coordination between the members of enterprise, MIP and IP based models have been formulated. Since coordination could guarantee the optional state of the whole system, coordinated model could achieve the best location for the warehouses. A linear price sensitive demand function for multi-product and multi-customer has been considered to formulate the constraints. The sensitivity on the buyer's selling prices has also been discussed. Transportation cost, ordering (or setup) cost, inventory holding cost and production cost have been also considered. Finally, a conclusion has drawn in favor of the coordination mechanism that could be applied to solve the facility location problem as well as to maximize the benefits of the members. This proposed model could to achieve the optimal solution and applicable to find the best location for the plant that lead a more profitable system.

The reminder of this paper is organized as follows. In Section 2, notation, assumption and mathematical models are formulated as MIP. In Section 3, a numerical example with solution approach is considered. In Section 4, the results of these models and sensitivity or the parameters are discussed. Finally, Section 5, contains some conclusions and scopes of future research

2. NOTATION, ASSUMPTION AND MODEL FORMULATION

It is considered an enterprise consists of single vendor and single buyer with a set of locations candidate for feasible warehouse. The vendor manufactures products and delivers to buyer's warehouses and then buyer delivers the products to the customer located at different geographical areas as described in figure 1. The solid arrows define the commodity flow whereas the dotted arrow shows the information flow.

Parameters:
Let
I: set of products
J: set of customers
L: set of location for the warehouses
s_i: buyer's purchasing price of i^{th} product ($/unit)
w_{li}: the maximum capacity for i^{th} product at warehouse l (unit)
f_v: vendor's set up cost ($)
h_i: vendor's holding cost of i^{th} product ($/unit)
t_{li}: unit transportation cost of i^{th} product from vendor to warehouse at l ($/unit)
p: production rate
fw_l: buyer's set up cost of l^{th} warehouse ($)
tt_{lj}: transportation unit cost from warehouse l to customer j ($/unit)
hh_{li}: holding cost at buyers warehouse l for product i ($/unit)

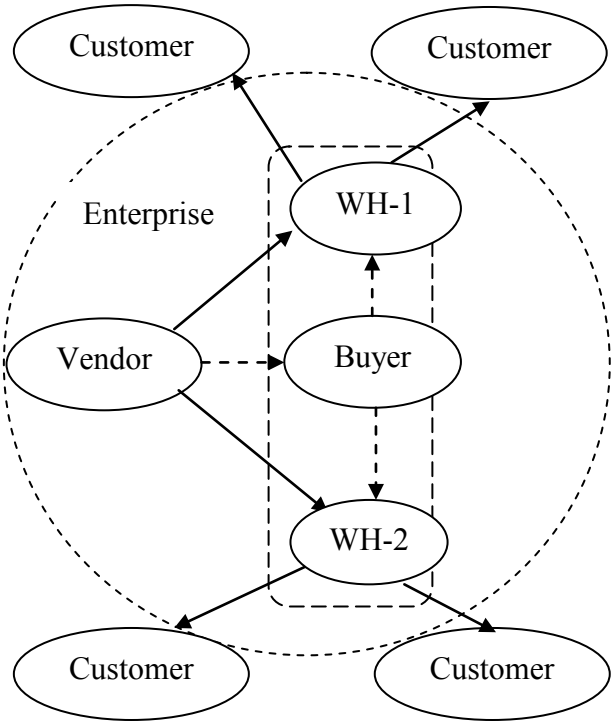

Figure 1 Framework of the model

M: any large scalar
$b = (b_i)$: a constant vector, i in products set
$A = (a_{ij})$: a matrix of appropriate dimensions, (i,j) are in products set
Decision Variables:
c_i: buyer's selling price of i^{th} product ($/unit)

$$x_l = \begin{cases} 1, \text{ if warehouse l is open,} \\ 0, \text{ otherwise} \end{cases}$$

n_i : number of shipment of i^{th} product (unit)
Q_{li}: ordered quantity of i^{th} product for warehouse l (unit)
z_{lji}: amount of i^{th} product shipped from warehouse l to customer j (unit)
d_{ji}: the demand of i^{th} product to j^{th} customer (unit)
w'_{li}: the optimal capacity f or i^{th} product at location l
Linear demand function:

Let us consider the linear demand system of the form $d(p) = b - Ap$, where d and p are the demand and price vectors respectively, b is a

constant vector and A is a matrix of appropriate dimensions. By the law of demand, the demand d_i decreases in its own price p_i. Suppose that a vendor produces m product for n customers, then linear demand could be define as:

$d : R_+^m \to R^m$, where, $R_+^m = \{p \in R^m : p \geq 0\}$. Since d is linear, it can be restated as :

$$d(p) = b - Ap, \text{ where, } \quad b = \begin{pmatrix} b_1 \\ \vdots \\ b_m \end{pmatrix} \quad \text{and}$$

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \\ a_{m1} & \cdots & a_{mm} \end{pmatrix}$$

The diagonal entries a_{ii} of A are the decrement in demand for product i when the price p_i increases by one unit, and the (i,j) entries a_{ij}, $i \neq j$ of A represent the change in the demand for product i as the prices p_j change.

Assumption**:**

1**.** Since demands d are non ne gation, hence, $b \geq Ap$

2. The model deals with a single vendor-buyer for a single product

3. Vendor finite production rate is greater than the demand rate.

4. The inventory holding cost at the buyer is greater than that at the vendor.

5. Storage is not allowed.

2.1 Buyer's Model

MIP1: Maximize,

$$P_B(c_i, Q_{li}, x_l, z_{lji}) = \sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j)(c_i - s_i)$$
$$- \sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j)\sum_{l=1}^{L}(fw_l x_l / Q_{li})$$
$$- \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m}(Q_{li}hh_{li}/2 + tt_{lj} * d_{ji})$$

Subject to

$$b_i \geq \sum_{j=1}^{m} a_{ij}c_j \ , \forall i \in \textit{product set} \qquad (1)$$

$$\sum_{j=1}^{n} d_{ji} = (b_i - \sum_{t=1}^{m} a_{it}c_t) \ , \forall i \qquad (2)$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m} z_{lji} = \sum_{i} d_{ji} \quad , \forall j \qquad (3)$$

$$\sum_{l=1}^{L} z_{lji} = d_{ji} \quad , \forall i, j \qquad (4)$$

$$\sum_{l=1}^{L}\sum_{j=1}^{n} z_{lji} = \sum_{j=1}^{n} d_{ji} \quad , \forall i \qquad (5)$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m} z_{lji} \leq Mx_l \quad , \forall l \qquad (6)$$

$$\sum_{l=1}^{L} Q_{li} = (b_i - \sum_{t=1}^{m} a_{it}c_t) \ , \forall i \qquad (7)$$

$$\sum_{l=}^{L}\sum_{i=1}^{m} Q_{li} = \sum_{i=1}^{m}(b_i - \sum_{i=1}^{m} a_{ij}c_j) \qquad (8)$$

$$\sum_{l=1}^{L} w'_{li} \geq (b_i - \sum_{t=1}^{m} a_{it}c_t) \ , \forall i \qquad (9)$$

$$\sum_{l=1}^{L} w'_{li} * x^l \leq \sum_{l}^{L} w_{li} \ , \forall i \qquad (10)$$

$$s_i, w_{li}, w'_{li}, fw_l, d_{ji}, tt_{lj}, hh_{li}, c_i, z_{lji}, Q_{li} \geq 0,$$
$$x_l \textit{ is binary} \qquad (11)$$

The first term of the objective function MIP1 is the total revenue obtained by multiplying the difference of Buyer's selling price and purchasing cost of each product by the demand of that product, the second term is the fixed opening cost (including land acquisition costs, order processing costs, facility construction costs) and the last term is sum of the holding cost and the transportation cost. The constraints (1) make sure that the linear demands are non negative. The constraints (2) represent the demand of each product. The constraints (3) ensure that the shipment amount satisfy the demand of each customer. The constraints (4) ensure that the total amount of specific product being stored for a p articular customer at all warehouses is equal to the demand of the product from that customer. The constraints (5) provide that the total amount of a particular product being stored at all warehouses for all customers is equal to the total demand of that product. The constraints (6) describe that a warehouse is located if and only if there is a demand. The constraints (7) show that the demand of each product is equal to the order quantity of that product. The constraints (8) provide the relation between total ordered quantities of the products and total demand of the products at all locations. The constraints (9) make sure that the capacity of each product is greater than the demand of that product. The constraints (10) stipulate that required capacities cannot exceed the existing capacities for each product. Finally, the constraints (11) guarantee the non-negativity.

2.2 Vendor's Model

IP2: Maximize,

$$P_V(n_i) = \sum_{j=1}^{n}\sum_{i=1}^{m} d_{ji}s_i - \sum_{l=1}^{L}\sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j) f_v *$$

$$n_i Q / Q_{li} - \sum_{l=1}^{L}\sum_{i=1}^{m}(h_i * Q_{li} / 2(n_i(1 - \sum_{i=1}^{m}(b_i -$$

$$\sum_{j=1}^{m} a_{ij}c_j) / p - 1 + 2\sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j) / p + t_{li}d_{ji})$$

Subject to

$$n_i(n_i - 1) <= \sum_{j=1}^{m} 2(b_i - a_{ij}c_j) p f_v / \sum_{l=1}^{L}(h_i Q_{li}{}^2$$

$$*(p - b_i + a_{ij}c_j)) <= n_i(n_i + 1), \forall i \qquad (12)$$

$$\sum_{j=1}^{n} d_{ji} = \sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j), \forall i \qquad (13)$$

$$s_i, w_{li}, f_v, d_{ji}, t_{li}, h_i \geq 0 \qquad (14)$$

The first term of the objective function IP2 is Vendor's total revenue that is obtained by the multiplication of the selling price and demand. The remaining terms are the opening, holding and transportation cost respectively. The constraints (12) stipulate the optimality condition of the number of shipment of each product. The Constraints (13) represent the demand of each product by the customer. T he final constraints (14) guarantee the non-negativity.

2.3 Coordinated Model

If both vendor and buyer agree on c oordination between themselves, then the coordinated model could be formulated as an MIP problem.
MIP3: Maximize,

$$P_{AC}(c_i, Q_{li}, n_i, x_l, z_{lji}) = \sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j)c_i -$$

$$\sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j)\sum_{l=1}^{L}((fw_l x_l + n_i f_v)/Q_{li}n_i) -$$

$$\sum_{l=!}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m}(Q_{li}hh_{li}/2 + tt_{lj}z_{lji}) - \sum_{l=1}^{L}\sum_{i=1}^{m}(h_i * Q_{li}/$$

$$2(n_i(1 - \sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j)/p) - 1$$

$$+ 2\sum_{i=1}^{m}(b_i - \sum_{j=1}^{m} a_{ij}c_j)/p) + t_{li} * Q_{li})$$

Subject to

$$b_i \geq \sum_{j=1}^{m} a_{ij}c_j \ , \forall i \in \textit{product set} \qquad (15)$$

$$\sum_{j=1}^{n} d_{ji} = (b_i - \sum_{t=1}^{m} a_{it}c_t) \ , \forall i \qquad (16)$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m} z_{lji} = \sum_{i} d_{ji} \quad , \forall j \qquad (17)$$

$$\sum_{l=1}^{L} z_{lji} = d_{ji} \quad , \forall i, j \qquad (18)$$

$$\sum_{l=1}^{L}\sum_{j=1}^{n} z_{lji} = \sum_{j=1}^{n} d_{ji} \quad , \forall i \qquad (19)$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m} z_{lji} \leq Mx_l \quad , \forall l \qquad (20)$$

$$\sum_{l=1}^{L} Q_{li} = (b_i - \sum_{t=1}^{m} a_{it}c_t) \ , \forall i \qquad (21)$$

$$\sum_{l=}^{L}\sum_{i=1}^{m} Q_{li} = \sum_{i=1}^{m}(b_i - \sum_{i=1}^{m} a_{ij}c_j) \qquad (22)$$

$$\sum_{l=1}^{L} w'_{li} \geq (b_i - \sum_{t=1}^{m} a_{it}c_t) \ , \forall i \qquad (23)$$

$$\sum_{l=1}^{L} w'_{li} * x^l \leq \sum_{l}^{L} w_{li} \ , \forall i \qquad (24)$$

$$Q_{li} * x_l \leq w'_{li} \ , \forall l, i \qquad (25)$$

$$n_i = \sqrt{\frac{\sum_{l=1}^{L} f_v(p(hh_{li} - h_i) + 2h_i(b_i - \sum_{j=1}^{m} a_{ij}c_j)}{\sum_{l=1}^{L} h_i fw_l(p - b_i + \sum_{j=1}^{m} a_{ij}c_j)}} \qquad (26)$$

$$s_i, w'_{li}, f_v, t_{li}, h_i, s_i, w_{li}, fw_l, d_{ji}, Q_{li}, tt_{lj},$$
$$hh_{li}, c_i, z_{lji} \geq 0, \quad x_l \textit{ is binary} \qquad (27)$$

Where, the objective function MIP3 maximizes the joint profit is the combination of their individual objective functions. The constraints (15)-(27) are the combination of the constraints of vendor's and buyer's models.

3. NUMERICAL EXAMPLE AND SOLUTION APPROACH

In this section, we illustrate our models by presenting example, including the optimal solutions. Let the supply chain scenario be as: Suppose that a vendor-X which manufactures the 3 products in batches at a finite yearly rate 3200 with a selling prices 100, 105 and 100, a nd delivers in equal-sized transfer lots to the buyer-Y having a set containing 5 f easible locations for warehouses with fixed opening cost (4500, 3500, 4000, 3000, 2500) and maximum capacities are (300, 200, 300),(120, 800, 200), (150, 200, 170), (100, 100, 100) and (500, 200, 500).

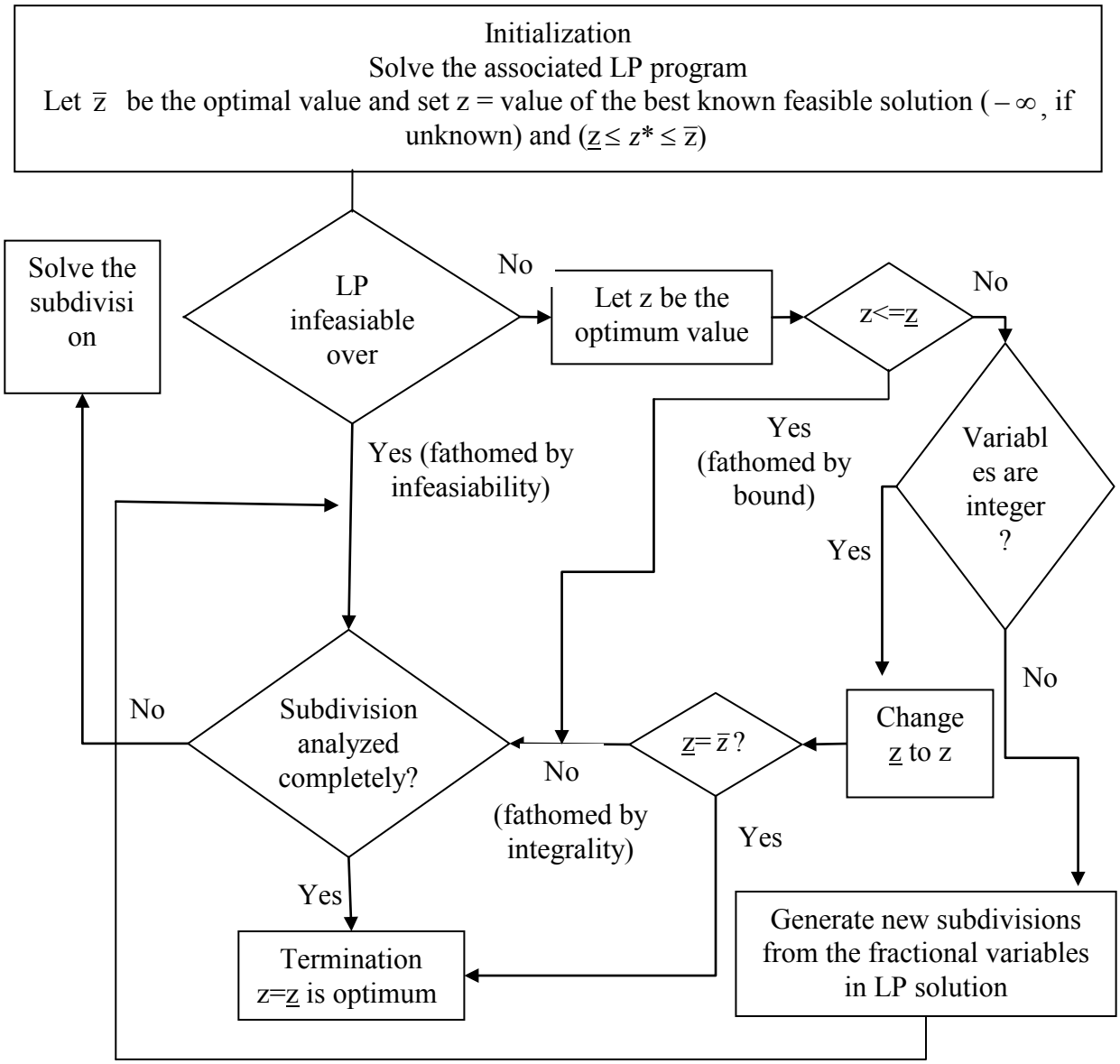

Figure 2 Flow chart for MIP based Branch and Bound algorithm

Buyer-Y satisfies his two customers with a price-sensitive demand having constant vector b a nd appropriate matrix

$$\begin{pmatrix} 2 & -3 & 2 \\ 1 & 4 & -1 \\ -1 & 2 & 1 \end{pmatrix}$$

In order to obtain the sensitivity of linear demand function, it is considered three set of constant vectors of b such as (1030 1080 980), (1050 1100 1000) and (1070 1120 1020).

Further, each warehouse has a yearly holding cost (1.0, 1.2, 1.2), (1.3, 1.2, 1.3), (1.3, 1.4, 1.2), (1.5, 1.4, 1.4), (1.2, 1.3, 1.2) and the transportation cost for two customer are (1.5, 1.6, 1.6, 1.0, 1.5) and (1.7, 1.4, 1.5, 1.2, 1.5). Finally, vendor's transportation cost for three products are (0.5, 0.6, 0.6, 0.5, 0.5), (0.7, 0.4, 0.5, 0.4, 0.5) and (0.6, 0.5, 0.5, 0.45, 0.5).The aim of this work is to provide a consistent logistics support to the buyer-Y as well as to find the best feasible locations for the warehouses among the given set of locations which optimize the supply chain network.

The formulated buyer's MIP1 model and coordinated MIP3 model have been solved by the method of branch and bound algorithm employing AMPL with Bonmin and Couenne.On the other hand, the vendor's IP2 has been solved also by the method of branch and bound algorithm using Cplex. A program has been written according to the flow chart illustrated in figure 2 for AMPL. The program consists of two main parts; the main module containing the actual program and the data file containing data for the various parameters. The program was executed on a Pentium IV machine with a 1.73 G Hz processor and 2.0 GB RAM.

4. RESULT ANALYSIS

Significant finding regarding the numerical example of the proposed model is described in table-1. Table-1 also provides the comparative analysis for the model before and after coordination. The percentage of change of profit after coordination is obtained by $PI(\%) = (P_{AC} - P_{BC}) * 100 / P_{BC}$, where, P_{BC} and P_{AC} are the profit Before Coordination (BC) and After Coordination (AC) between vendor and buyer respectively. The individual benefit of vendor and buyer is calculated from the formula of described by (Sajadieh and Jokar, (2009); Goyal, (1976)), that is:

$P_V(\text{AC}) = \frac{P_V(BC)}{P_{BC}} \times P_{AC}$, and

$P_B(\text{AC}) = \frac{P_B(BC)}{P_{BC}} \times P_{AC}$, where, P_V and P_B stand for profit of vendor and buyer.

Table1 The Values of Different Parameters Before Coordination

Before Coordination(BC)				
Cases	Prices	P_V	P_B	P_{BC}
1	290.74 163.20 390.63	104172	8904	113076
2	294.53 165.29 397.73	107252	20869	128121
3	298.25 167.38 404.74	110052	16378	126430

Table 2. The Values of Different Parameters After Coordination

After Coordination(AC)				
Prices	P_V	P_B	P_{AC}	PI (%)
273.92				9.54
131.26	114115	9754	123869	
122.66				
279.08				9.0
137.07	116901	22747	139648	
136.21				
284.24				22.9
142.87	135291	20135	155426	3
149.76				

The figures 3, 4 and 5 show the distribution of different products for different customers before coordination for the three cases:

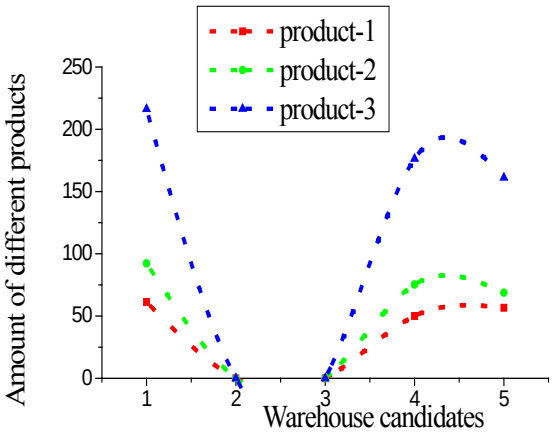

Figure 3. Optimum Allocation for Case-1 (BC)

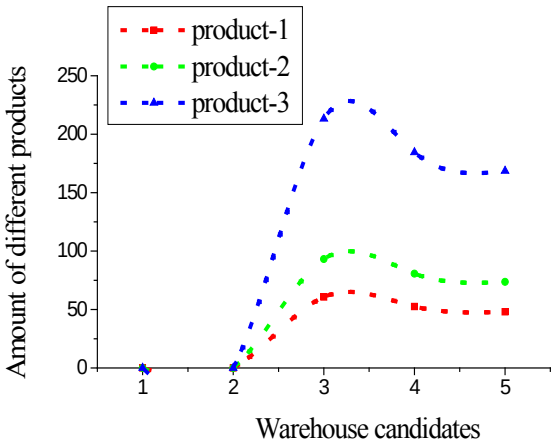

Figure 4. Optimum Allocation for Case-2 (BC)

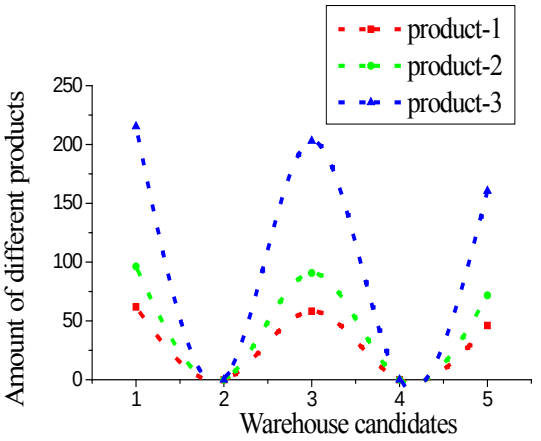

Figure 5. Optimum Allocation for Case-3 (BC)

The figure 6 shows the distribution of different products for different customers after coordination for all the cases.

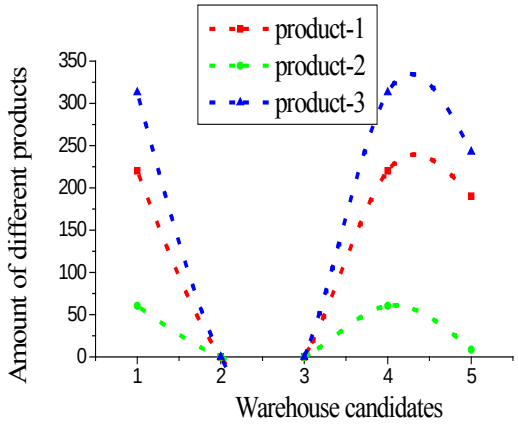

Figure 6. Optimum Allocation for Case-1,2 & 3 (AC)

Therefore, from the figure-3, 4 and 5, it is concluded that if both buyer and vendor have no coordination, the binary values (1 0 0 1 1), (0 0 1 1 1) and (1 0 1 0 1) represent the feasible location sets for the warehouses. On the contrary, after coordination, for the three cases, the binary values (1 0 0 1 1) represent the feasible location set for the warehouses. Moreover, the optimal distributions of the three products for two customers are also remained identical which is depicted in figure 6. However, before coordination the optimal number of shipments for the three cases are (67 80 43), (66 77 42) and (66 76 42). Whereas, after coordination the optimal numbers of shipment in all cases become (5, 4, 6). In fact, from the above figure-3, 4, 5 and 6, it is summarized that if both buyer and vendor have no c oordination, then buyer's selling prices can manipulate the optimal solution though after coordination the effectiveness of buyer's selling prices could be reduced.

The figure7, 8 and 9 show the price and reduction of price of product-1, 2 and 3 respectively after coordination for different cases. On the other hand, the graph 10 demonstrates the effect of sensitivity of buyer's selling price on total profit and profit enhancement before and after coordination

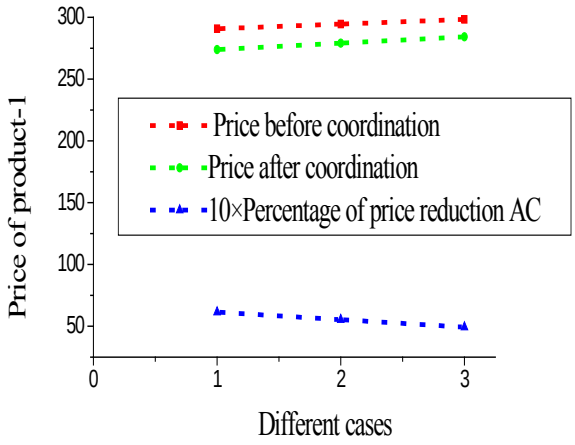

Figure 7. Price reduction of product-1

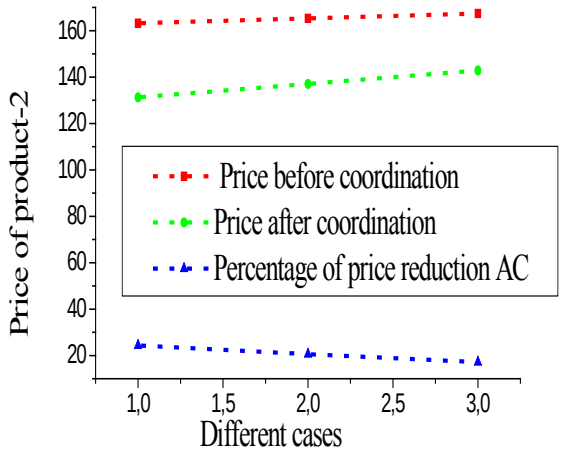

Figure 8. Price reduction of product-2

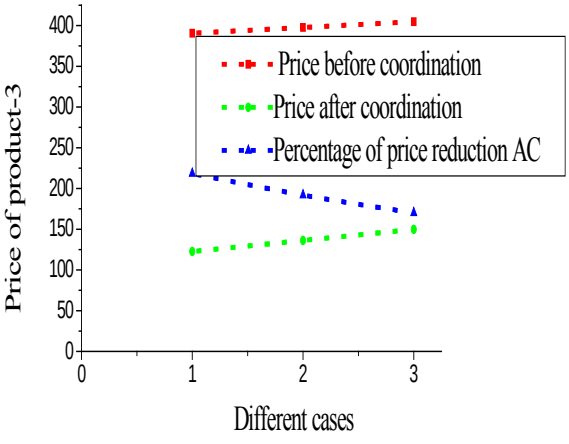

Figure 9. Price reduction of product-3

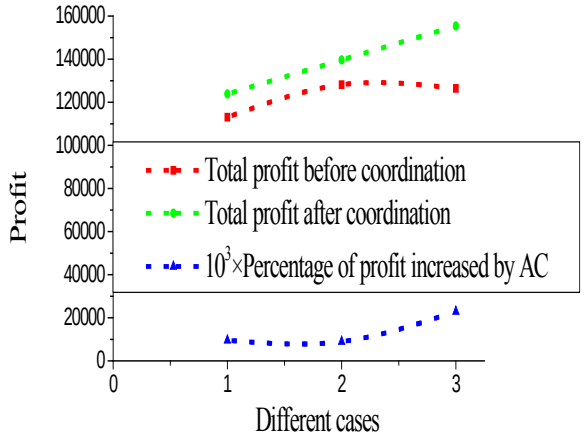

Figure 10. Profit increament

Indeed, figure-7, 8 & 9 show that all the cases, the prices of different products after coordination is smaller than the prices of before coordination. Consequently, at least 5% of the consumer purchasing price as well as buyer's selling price could be reduced by coordination. In addition, figure-10 shows that the profit after coordination always remains higher than before coordination. The most of the cases the percentage of profit increment is mounting, in particular, for this example, it lies between 9% and 23%. Consequently, after coordination the profit of buyer and vendor could be increased as well as the purchasing price of consumer could also be reduced which is the significance advantages of the coordinated supply chain.

5. CONCLUSION AND FUTURE RESEARCH

In this research, a two echelon-supply chain network of single vendor-buyer has been investigated. This study has combined the coordination mechanism among the members of supply chain and warehouse location problem so that the model could achieve the optimum solution as well as select the best feasible locations for the warehouses. Using a multiproduct and multi-customer linear price-sensitive linear demand function, the nonlinear MIP and IP based models have been formulated. Numerical example has also been presented, which aim to demonstrate the models. The individual profits as well as combined profit with consumer's optimal purchasing price, vendor's selling, optimal shipments and optimal order quantity have been obtained. Through the sensitivity analysis, the effect of main parameters on the selling price, holding cost transportation cost, optimal location for warehouse and the profit function have also been investigated.

Some of the significance findings of this research are: Firstly, it is observed that after coordination the individual profits could be increased without any extra investment. In the same way, coordination among the member of an enterprise could reduce the consumer purchasing price as well as buyer selling price. Besides this, it is observed that after coordination the consumer allocation of different products from different warehouses is remained identical though it changes before coordination. Further, before coordination the model is achieved different set of locations but after coordination the model achieved the same set of locations for buyer's warehouse though the price sensitive demand is changing. Above all, it could be concluded that coordination among the members of an enterprise will be more beneficial in the current competitive environments.

This work has some limitations concerning the real application. In future work, after collecting real data, I will apply this model to acquire optimal decision in the real case. Multi vendor-buyer policy with sensitivity of different inventory policies for coordinated supply chain is also planned. Further, analysis of the lead-time effects and batches of different sizes are also proposed.

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CONCEPT PLAN OF TRANSPOT INFRASTRUCTURE FOR MID SIZED CITY IN INDIA

Rinku SHRIVASTAVA
Doctoral Student
Department of Architecture
Birla Institute of Technology Mesra,
Ranchi, Jharkhand -835 215,India
Phone: + 91 9546703721
Email: rinku76sh@yahoo.com

Sanjeev SINHA*
Associate Professor
Department of Civil Engineering
National Institute of Technology Patna
Patna – 800 005, India
Phone: +91 612 2341613
Fax: + 91 612 2670631
Email: sanjeev_bangkok@yahoo.com
* Corresponding Author

Manjari CHAKRABORTY
Professor and Head
Department of Architecture
Birla Institute of Technology Mesra
Ranchi, Jharkhand -835 215, India,
Email: dr_manjari@bitmesra.ac.in

ABSTRACT:

Large scale data collection has been carried out in order to come up with a concept plan for transport infrastructure for mid- sized city in India which have so far not been attended to. The proposed plan advocates the establishment of counter magnetic towns to attract the migrating population towards it and to prevent it from going to the existing city areas. The plan also incorporates proposal for setting up a new ring road parallel to arterials in Patna. Much emphasis was given to public transport planning which includes the existing bus and mini bus service and also identifies the routes and operation of mass rapid transit (MRT) /bus rapid transit (BRT). The plans for non-motorized vehicles and pedestrians were also included. The establishment of truck and bus terminals at various locations and integration of intermediate public transport (IPT) with public transport system have been proposed in the plan.

KEYWORDS: Concept plan, Trip distribution, Public transport

1. INTRODUCTION

Rapid population growth accompanied with large scale rural-urban migration has lead to rapid urbanization in developing countries including India. Though the demand for urban transportation infrastructure has increased, the existing transport infrastructures in urban areas of most of the developing countries have so far been inadequate to meet the demand. Urban areas of developing world are characterized by mixed traffic, slow speed, congestion and high rate of accidents. The existing public transport is inadequate, ill conceived and is of poor quality.

In spite of the existing poor transportation scenario in India, in general, not many efforts have been made to come up with comprehensive transportation plans. Even though some piecemeal and isolated instances have been found, they are mostly concentrated in the metropolitan cities. Mid- sized cities of India, having population more than one million but less than the metropolitan cities, have been by and large devoid of any such plans.

The present study is the part of the effort aiming to come up with a comprehensive transportation plan for the historic city of Patna, a mid-sized city in India. The main objective of the paper is to propose concept plan for development of transport infrastructure for a mid-sized city. It is an amalgamation of ideas which is taken into consideration for evolving any comprehensive transport infrastructure development plan. Though, based on work carried on a single midsized city of Patna in India, the work can be used for transport planning of any midsized city of developing world. The paper highlights the lack of planning effort for transport planning for mid sized cities in developing world in the first section. The existing situation of transportation for the city is described in the second section. The concept plan is proposed in the third section followed by section on conclusions and recommendations.

Large scale data collection has been done by the Transportation Engineering Section of NIT Patna, India and a doctoral researcher of BIT Mesra, India to assess and analyse the present situation and propose a comprehensive plan for transportation for Patna. Salient features of the plan are described in this article:

Study Area

Patna is the capital city of Eastern state of Bihar in India. The historic city of Patna has acquired a strong position in regional trade and commerce. Situated on the southern bank of the river Ganges, it had a population of 1.69 million according to the census of 2001 which is expected to increase to 2.80 million by the year 2021(Master Plan, 2006). The present study was carried out in the municipal limits of Patna Municipal Corporation along with the adjoing areas jointly referred as Patna Urban Agglomeration Area (PUAA). The vehicular growth in the city has registered 67 fold increase in the number of vehicles in the last two decades and the same trend continues even at present. About 60 percent area has residential land use and about 7.61 percent is given towards transport infrastructure. The city has followed organic pattern of development and has maximum population density along the banks of the Ganges. The population density reduces as we move southwards. Similar trend has been observed in the density of roads which range from 0.35 to 0.5 km/ hectare having the least towards South- West and South-East.

2. EXISTING SITUATION

2.1 Road Infrastructure

The existing circulation pattern of Patna is linear. This is due to the geographical location of Patna which has the Ganges in the North and the river Punpun in the South. This has led to a linear (East-West) orientation of the road network which is shown in the Figure 1. The right of way of major roads shows that more than 70% of the roads are less than 7.5 m. The Bailey Road, Ashok Rajpath, New Bypass Road, Old Bypass and road connecting Patna Junction to Gandhi Maidan were observed as important arterials in PUAA.

2.2 Public Transport

Public transport in Patna mainly consists of buses, mini buses, auto-rickshaws, and cycle rickshaws. All motorized forms of public transport constitute about 12% of the total motorized form of traffic in the city. In addition to the motorized public transport, there exist 35000 registered cycle rickshaws. Another estimate puts the count of cycle rickshaws between 1.2 t o 2 hundr ed thousand (Source: Master Plan 2006).

2.3 Survey

Cordon line survey and screenline surveys were done at 14 1ocations in the city. These surveys give the idea about the classified vehicular and passenger traffic. The locations of outer cordon points are shown in the Figure 2. O/D Survey was also conducted at the outer cordon points. In order to have the idea about he socio economic conditions of the households and the societies every 50th household for non- slum households and every 100th household for slum households. The home interviews gave the idea about the size of the household, occupation, income, travel expenditure, modal shares, trip purpose and trip lengths.

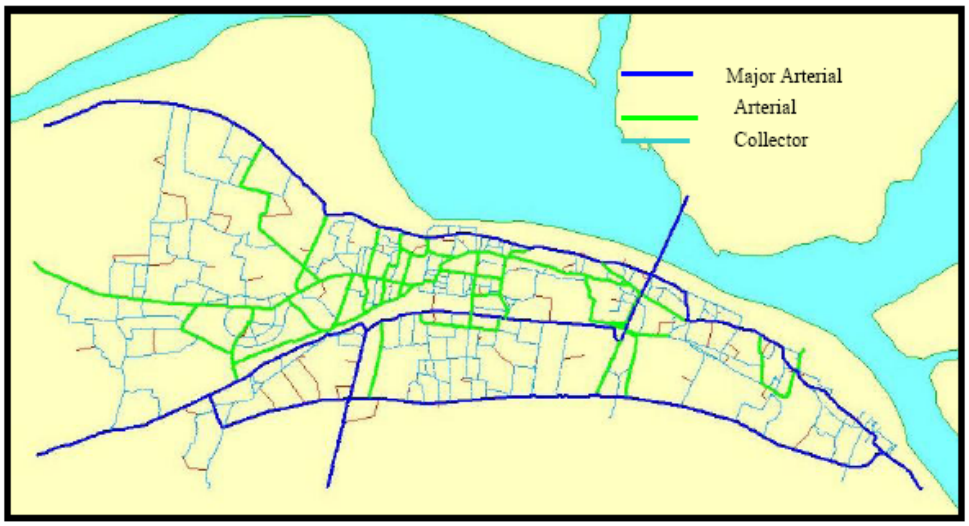

Figure1 Map showing the major arterials, arterials and collector roads in PUAA.

2.4 Modeling

Trip generation and trip distribution modeling was carried out for the year 2021 for the zones given in Figure 3. The data for trip generation modeling is given in Table 1 and multiple linear regression model was developed for trip generation which is given by equation 1. The model took into account dependent variable as work trips and independent variables as

Population = Variable 1 (X_1)
Number of household = Variable 2 (X_2)
Number of household having 4/2 wheelers = Variable 3 (X_3)
Number of work trips = Y

$$Y = 0.9659\ X_1 + 4.5504\ X_2 + 93.1243\ X_3 + 8469.4504 \quad (1)$$

Similarly the trip distribution modeling was also carried out using Gravity model. A computer program was developed to calibrate the model and the resulting trip distribution is given in the Table 3. The lack of choice available for the transportation modes for the road users in Patna prompted us to desist from attempting mode choice modeling. The trip generation and trip distribution models give idea about the trip numbers, nature and distribution and thus have become the basis of development of the concept plan of the city. The salient features of the concept plan are given in the following section.

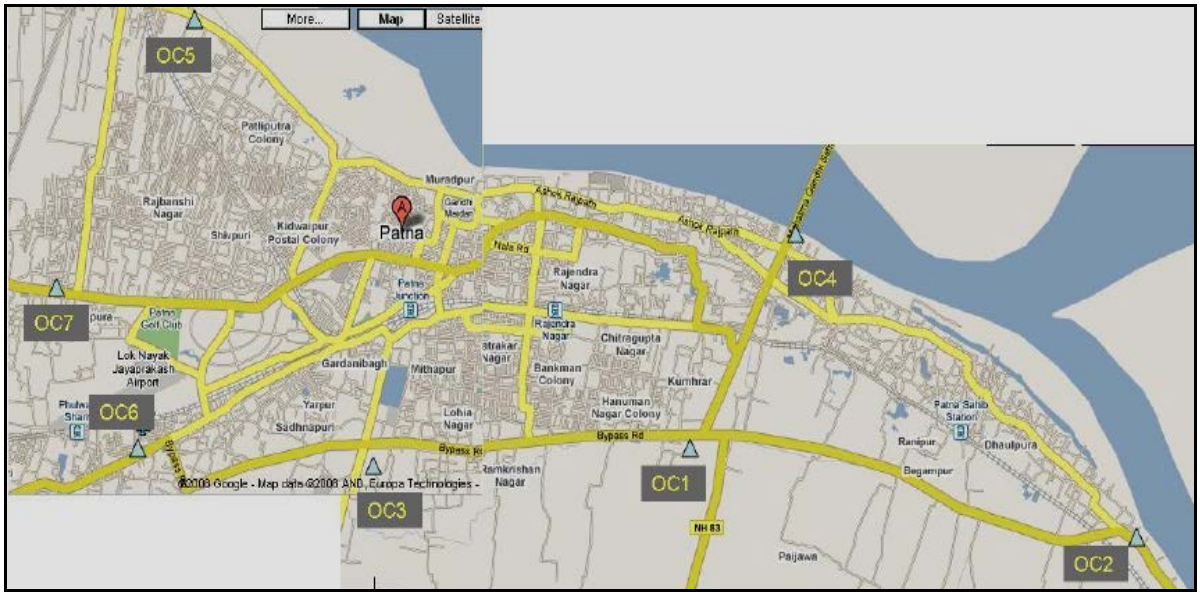

Figure 2 Locations of Outer Cordon Points (*Source: Google Maps)*

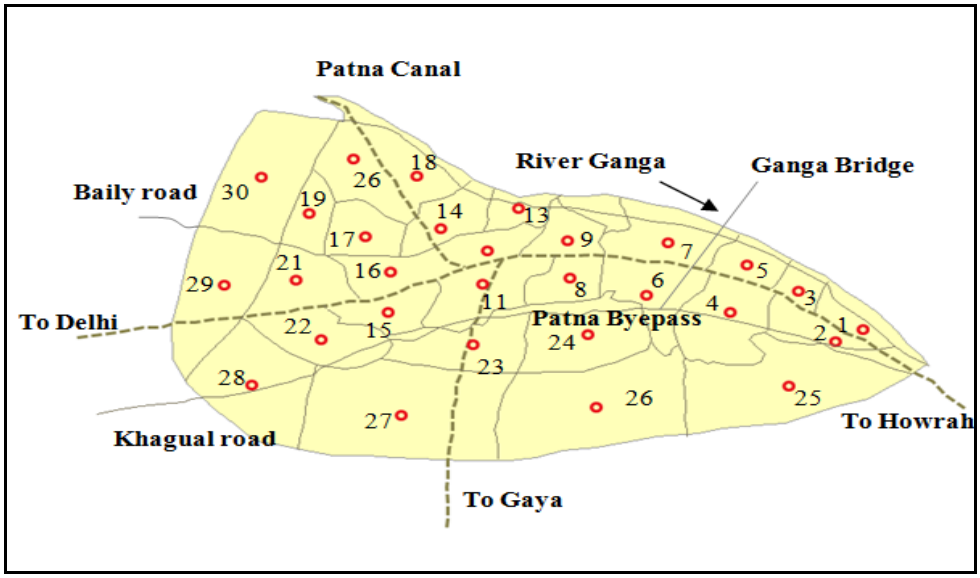

Figure 3 Map showing 30 zones of Patna in 2021

Table 1 Distribution of Population, Household, Total Trips and Proposed Density in each zone for the year 2021

Zone	Area of zone in acre	Proposed Density	Population	Percent of households having 4/2 wheelers	No. of Households	Work Trips	Total Trips
1.	663.6	90.0	106906	29.6	17817	21380	53360
2.	1163.6	100.0	208284	32.5	34713	39574	108999
3.	360.0	150.0	96660	43	16110	19332	63000
4.	2832.0	120.0	608314	55	101386	152078	405578
5.	509.4	100.0	91183	61.2	15198	16717	57748
6.	2030.9	95.0	345353	81.6	57559	69069	207232
7.	1153.6	100.0	206494	86	34416	44741	148117
8.	519.2	95.0	88290	62	14715	15450	53706
9.	582.0	106.2	110635	59.1	18439	12906	36874
10.	290.4	171.8	89303	67.8	14884	17861	59533
11.	1009.6	120.0	216862	89.6	36144	43372	140957
12.	1021.2	75.0	137096	86.5	22850	25134	79970
13.	617.6	95.0	99495	83.2	16583	18240	51405
14.	763.8	90.0	123048	74.9	20508	18457	43066
15.	1033.4	95.0	175730	66.3	29288	380733	465666
16.	1222.0	105.0	229675	68.1	38279	45935	933254
17.	934.8	90.0	150597	42.0	26000	22588	47688
18.	158.0	65.0	18383	32.3	3064	2755	8881
19.	806.48	65.0	122705	29.1	20450	22905	53991
20.	1153.58	85.0	175517	34.1	29253	32762	77222
21.	3126.60	85.0	475719	41.6	79286	88800	275914

Zone	Area of zone in acre	Proposed Density	Population	Percent of households having 4/2 wheelers	No. of Households	Work Trips	Total Trips
22.	3940.9	85.0	599610	42.1	99935	111925	347769
23.	2338.4	85.0	355793	58.9	59299	66413	206353
24.	2125.8	85.0	323443	56.2	53907	60373	187590
25.	1896.3	75.0	254581	16.8	42430	47521	147655
26.	2920.78	80.0	418257	17.1	69709	78073	242581
27.	3384.91	85.0	515015	21.1	85836	961355	1163926
28.	3323.26	75.0	446149	22.6	74358	83278	258759
29.	3751.22	85.0	570749	24.5	95125	106540	331031
30.	3233.66	75.0	434119	23.1	72353	81033	251782

3. PROPOSED CONCEPT PLAN

3.1 Identification of counter-magnetic towns

To improve the quality of life of the people of Patna there is a n eed to check the spurt of population in the city which has been mostly attributed to large scale rural-urban migration. This can be done by developing what can be taken as counter-magnetic towns. Counter magnetic towns are those which can be developed as alternative centers of growth and attract migrations to them in place of cities under consideration. It can be taken as principal component to reduce migration and population explosion in the cities. These towns nearby Patna can be used to attract the migrating population by providing better and affordable facilities for business, other economic activities, socio-cultural activities, entertainment and education. Towns like Bihta in the South-West, Bakhtiyarpur in East, Hajipur in North across Ganges can be selected accordingly (Figure 5). Steps should be taken up to encourage establishment of infrastructural and institutional facilities for these towns

3.2 Proposal of a new Ring Road

A new ring road parallel to Ashok Rajpath connecting Danapur to Fathua with interchange points at Gandhi Setu, Boring Road and Gandhi Maidan is proposed. The total number of vehicles entering and exiting Patna in 24 hours from the seven outer cordon points is 172797 of which around 10% is during the morning peak hour. Out of the seven outer cordon points, four outer cordon points have more than 24% of vehicles having external – external origin and destination points. At present these trips use the same road network as internal trips. Thus, diverting the external – external trips would ease the load on t he existing road network. The ring road would be used by all external-external trips that has one O-D point at Danapur and second O-D point at Gandhi-Setu or Fatua or NH-30.Similarly the ring road would be used by all the external-external trips with one O-D point at Gandhi-Setu and second O-D points at Fathua.

3.3 Proposal on Current Flyovers

The Master Plan has proposed flyovers at 13 locations as shown in Figure 4. Flyover number 1, 5 and 10 in the following figure are over the railway tracks, others are located over major intersections and crossings. These flyovers shall be aligned in such a manner that they are able to fulfill the requirements of transport network and NMV facilities as the focus should be on m oving people rather than moving vehicles.

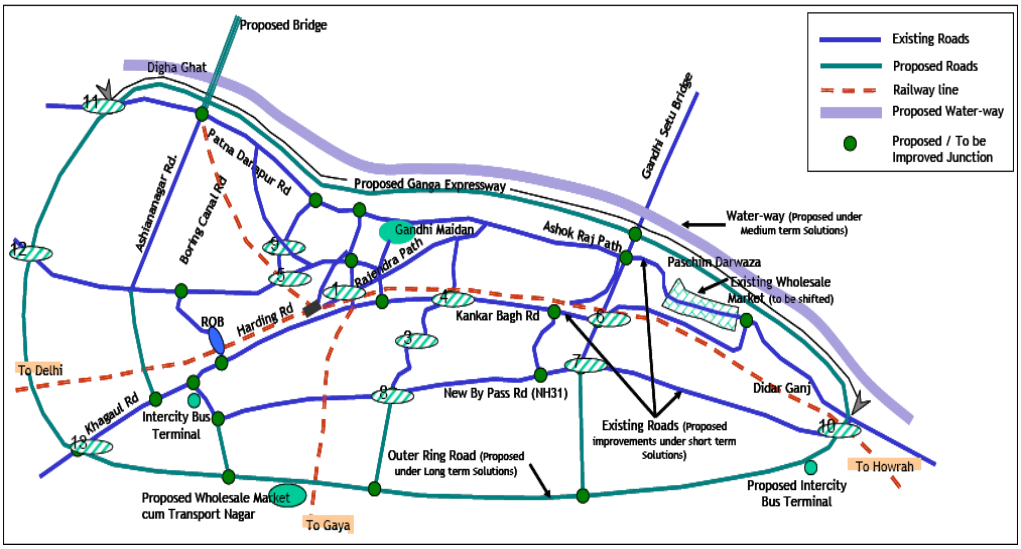

Figure 4 Proposed Ring Road and Flyovers **(***Source: Master Plan of Patna)*

3.4 Public Transport Planning

At present there is an existing city bus service, which is operational in 12 routes of the Patna Urban Agglomeration Area. This service is provided by a contract between the local government and private bus operators. These services are however not well organized in terms of scheduling and reliability. And the present bus service is insufficient to cater the demand. It has been mentioned earlier that there are four major corridors in the city namely, Ashok Rajpath, Bailey Road, Old Bypass and New Bypass and it has been observed that most of the trips on these roads are short distance trips. These short trip length corridors should be developed as an efficient bus system. In the above mentioned corridors, Bailey road (Bhattacharya road to Saguna More, 8.71 km) has the ROW greater than 30 meters at 8.71 km. In those stretches segregated bus lanes should be provided. The segregated bus lanes at Bailey road are further justified if one sees the growth of the city along the Western side and along the Southern side. The New Bypass is also recommended for Bus Rapid Transit. The master plan of Patna shows that the city is growing towards south and a ribbon development is proposed along the New Bypass Road. The western part of the city has a residential landuse and the southern a commercial land use, thus the New Bypass attracts trips from western to southern part of the city. Moreover, the proposed ROW of the New Bypass is 60 metres and a length of 20 km makes it sufficient good for Bus Rapid Transit. At Ashok Rajpath and Old bypass where the maximum ROW is 27.43 meter an improved bus service with adequate fleet size running at regular frequency, well designed bus stops, improved pedestrian facilities and NMV planning are recommended**.**

Table 2 Trip distribution for the year 202

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	0	1553	3165	19	1918	122	536	2815	4925	2634	607	1735	5714	1617	40	556	880	14666	831	2362	552	569	346	215	1143	474	51	671	109	40
2	6001	0	6467	43	3849	252	1043	6669	9660	5171	1204	3400	11093	3141	79	1075	1697	28341	1595	4577	1060	1087	715	439	2988	983	101	1293	209	75
3	1179	623	0	31	4159	159	733	3275	5833	3185	794	1920	5907	1756	42	583	924	15793	865	2476	565	573	372	246	961	507	52	686	110	40
4	5187	2979	22009	0	32021	2171	7466	35431	58294	29531	6610	18481	59926	16087	630	5423	8226	130372	7568	21636	5076	5231	3635	2877	8587	5713	499	5991	973	350
5	561	291	3270	35	0	204	1058	3685	6637	3750	692	2027	6896	1815	41	577	907	15834	835	2458	545	550	366	257	664	483	50	630	105	40
6	1450	773	5050	97	8266	0	5502	30265	45404	21582	4472	12601	39285	9804	221	3151	4775	82007	4233	12130	2813	2904	2318	2381	2234	3176	279	3185	522	188
7	944	475	3463	50	6356	818	0	16046	30681	19150	2486	7653	27480	6271	136	1907	3025	54954	2693	7989	1732	1705	1222	885	1202	1482	154	1920	321	122
8	245	128	767	11	1097	223	796	0	23481	6764	1915	5529	17648	3439	72	1032	1532	26011	1259	3673	824	852	759	644	356	688	80	890	146	53
9	202	102	642	9	929	157	715	11040	0	10735	1403	5265	21007	3428	60	893	1378	25588	1140	3514	724	705	542	326	273	443	61	762	126	49
10	272	138	885	11	1325	188	1127	8025	27088	0	1350	4839	23574	3769	67	1017	1615	32616	1371	4376	852	819	555	323	943	496	69	879	156	62
11	519	266	1824	21	2020	323	1209	18783	29262	11162	0	29860	41935	16042	343	5039	6265	92413	4718	13295	3201	3400	3757	1019	745	1512	310	3169	524	182
12	303	154	899	12	1207	186	759	11055	22390	8155	6090	0	41137	13848	177	2856	4034	66674	2895	8970	1846	1797	1373	497	418	751	145	1728	304	116
13	247	124	686	10	1018	144	676	7699	22147	9850	2120	10198	0	7827	100	1605	2619	56400	2504	5491	1193	1106	750	328	323	505	87	1148	209	87
14	192	96	559	7	735	98	423	4676	9913	4319	2224	9415	21466	0	148	3130	4963	88821	3012	10334	1739	1430	808	259	259	430	99	1385	266	111
15	3620	1828	10199	132	12702	1661	6874	73888	13074	57715	35614	89932	204119	110433	0	95633	83539	769196	616382	136868	56092	72831	24691	5079	5121	9500	3971	47277	7460	2480
16	438	219	1235	16	1554	210	855	9324	17167	7748	4642	12901	29258	20793	850	0	19380	128418	10216	22850	7407	5877	2314	581	596	1061	329	4812	903	300
17	205	102	576	7	720	94	400	4080	7807	3625	1702	5371	14067	9720	219	5714	0	87508	8066	19235	3654	2303	863	246	274	448	126	2177	495	193
18	41	20	118	2	151	19	87	833	2017	880	302	1067	3642	2091	24	455	1052	0	776	3935	369	279	131	46	53	81	18	287	61	32
19	188	93	526	7	646	81	347	3269	6296	3002	1249	3759	13114	5742	157	2936	7864	62963	0	19771	4861	2299	674	203	249	393	111	2386	705	327
20	293	147	824	10	1041	127	564	5221	10624	5243	1927	6376	15744	10804	192	3596	19268	174693	10824	0	3706	2430	928	310	380	575	142	2605	645	440
21	731	363	2011	25	2466	315	1304	12512	23376	10903	4954	14004	36505	19404	838	12443	20826	174685	28413	39560	0	15630	3006	835	981	1638	560	14384	4185	771
22	969	485	2657	34	3245	424	1674	16861	29674	13663	6860	17778	44135	20800	1418	12870	17107	172476	17520	33822	20376	0	4848	1170	1360	2430	1202	27870	3010	609
23	772	413	2225	30	2789	436	1549	19377	29433	11958	9784	17527	38626	15107	621	6540	8277	104501	6625	16671	4852	11577	0	1577	1153	2796	829	5721	837	255
24	999	528	3072	51	4081	934	2335	34212	36925	14501	5524	13209	35132	10137	265	3415	4899	76040	4172	11572	2922	3143	3283	0	1614	5087	339	3386	527	180
25	2140	1448	4831	61	4247	354	1280	7640	12458	6397	1631	4482	13973	4086	108	1417	2205	35622	2954	5730	1387	1479	969	652	0	1587	142	1734	273	96
26	1316	706	3775	60	4577	746	2339	21880	29999	13298	4905	11935	32381	10062	235	2998	4566	72310	5162	16310	7910	15405	2667	637	2255	0	221	3558	534	203
27	10734	6312	29073	437	37276	5493	21278	126560	447638	187166	40391	143994	901511	207646	4391	45067	86018	1189600	117476	537327	156148	68272	15917	13489	15499	38276	0	58734	4944	1852
28	736	397	1911	26	2429	317	1372	8458	23977	11732	2790	10518	56256	15925	398	3719	9675	114298	15828	65296	5649	3579	1017	682	3115	2189	835	0	420	156
29	867	472	2328	31	2975	382	1671	11002	28984	15076	3708	14788	64901	21848	662	5794	20886	207044	33676	51577	6039	4072	1171	739	2636	5753	184	14982	0	196
30	674	359	1875	24	2972	314	1293	11542	22965	11569	4532	14295	45627	20014	474	12260	18654	199146	8163	15802	3026	1918	1217	728	1891	3689	2005	33967	5311	0

3.4.1 Mini bus service:

Mini bus services shall be reinforced on the existing routes and new routes such as Patna Sahib to Danapur via Ashok Raj Path, along the New Bye-Pass, along Bailey Road, along cross roads connecting New Bye-Pass with Kankarbagh Road and Ashok Raj Path shall also be started. The quality, headway, scheduling of the bus service should be such that it can become attractive to all sections of the society. Some air conditioned bus service can also be started along the above routes. School bus services should be such that it provides access upto the collector streets and accordingly bus stoppages for the school children may be established. The roads along the corridors shall be widened and shall have removal of all encroachments. These buses shall be running on compressed natural gas (CNG) and thus will be less polluting. For arterial roads exclusive bus lanes shall be provided for rapid movement of these buses

3.4.2 Identification of corridors for MRT/BRT:

The inherent benefits of public transportation like occupation of less space per person, movement of larger number of person at the same time, high fuel efficiency make it more attractive in comparison to personalized vehicles. Mass rapid transits (MRT) popularly known as Metro trains in India can be the best alternative as it uses electric traction which is the cheapest and non- polluting. MRT can be developed along three corridors which are coinciding with the three arterial roads namely Ashok Raj Path, Kankabagh Road (along the railway track) and New Bye-Pass Road. The corridor along Ashok Raj Path can follow the bank of river Ganges and extend up to Bakhtiyarpur in East and Hajipur in the North. A new railway bridge across the Ganges is proposed for the purpose. There shall be convergence of all the three corridors near Patna Sahib. The corridors shall be merging at some intermediate locations namely Gandhi Maidan, Boring Road, Ashiana Nagar and Saguna More. These convergences will provide interchanges of the passengers from the three corridors. Bus Rapid Transit (BRT) can be taken as an alternative to the proposed MRT. The corridors have been showed in the Figure 6

3.4.3 Truck and bus terminal:

The existing truck terminal facilities at Transport Nagar shall be improved and encouragement shall be given for the establishment of other truck terminals at Bihta, Hajipur, Fathua- Bakhtiyarpur and at other places outside the city. Bus terminal facilities at Mithapur shall be improved and it shall be connected to the MRT corridors and other routes of public transportation. The frequency, scheduling, headway and comfort provided by bus services should be such to give maximum benefits to the passengers.

3.4.4 Integration of Intermediate Public Transport with Public Transport

The integration of IPT with PT with is very important especially in the case of Patna because there are at present 12 functional routes of PT and 7 routes of IPT. All the IPT routes overlap with the PT routes. Also, with proper planning IPT acts as a feeder service to the Public Transport planned. Therefore the role of IPT with respect to PT need to be further investigated. The routes of IPT should be rationalized in order to make it complimentary with the PT. At infrastructural level, parking places, boarding and alighting points needs to be designed.

3.4.5 Enforcement of security:

The public transportation system can only be attractive for users coming from all sections of the society only if apart from the quality of facilities the mode is able to give a s afe and secured travel. This can only be provided through rapid monitoring and policing of Patna in general and modes of public transportation in particular. The encroachments on the pavements shall be removed and the on streets hawkers can be lured away by providing them better alternatives.

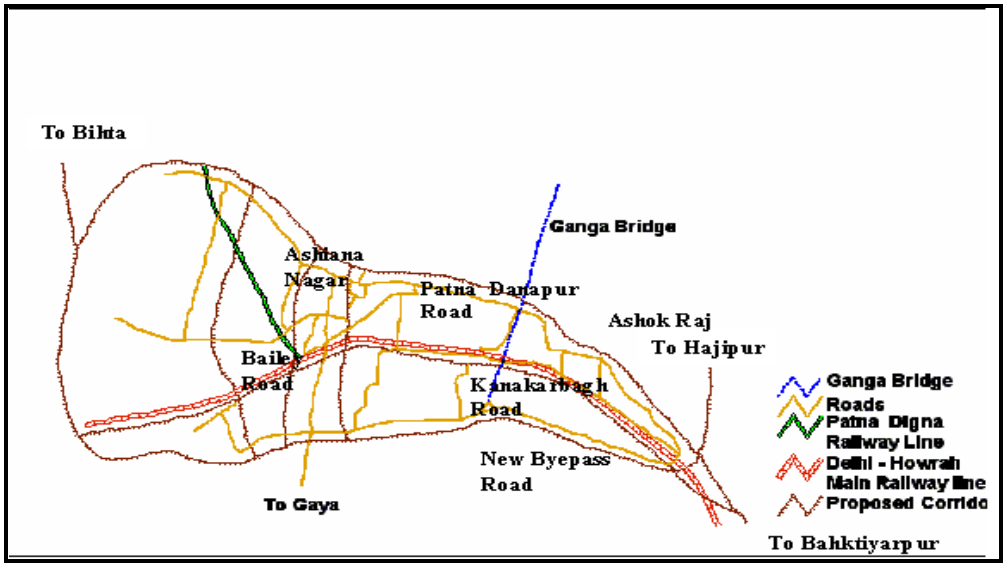

Figure 5 Proposed corridors for MRT in Patna

3.5 Improved Pedestrian and NMV facilities

For a good public transport system feeder services are very important. In the case of Patna, pedestrians and NMV's would become most important feeder services to bus. This is because one of the features of road network is that 1 km of the influence zone of the major arterials and arterials covers the entire city. This means maximum 10 minute of walk trip (assuming walking speed = 6 km /hr) or a 5 minute of bicycle trip is required to access the nearest arterial road. Exclusive pedestrian precincts shall be declared along heavily congested areas of East and Central Patna. The narrow but over crowded lanes/ streets having perennial congestion problems shall not allow any other vehicle apart from bicycles. In order to implement this, parking facilities shall be provided for the vehicles which are not allowed in the pedestrian precincts. Multi storied parking can be a solution for the problem. This will also encourage people to walk which is beneficial for the health of people. The NMV inclusive planning should ensure the safety of bicycle commuters. In order to achieve the guiding principles are.

- Provision of segregated NMV track on arterials where speed of motorized vehicle is more than 30 km /hr and Right of Way is greater than 30 meters.
- Traffic calming techniques on t he arterials where the speed of motorized vehicles is more than 30 km /hr. In such roads painted bicycle track of width 1.5 m eter should be provided.

3.6 Expansion and improvements of roads:

The roads shall be improved and expanded to fulfill the increased demand of traffic. The quality of the roads surface, geometry, road furniture, sign signals etc. should be improved. The widening of the carriageway shall also be done. When the percentage of slow moving vehicle is high there is a need to provide frontage road for the slow moving vehicle to ply. Flyovers and road over bridges shall be provided over bottlenecks. Intersections having intermediate level of vehicular traffic, roundabouts shall be designed. For heavier traffic, grade separated intersections with interchanges shall be provided.

3.7 Improvement of walking and cycling facilities:

All the roads should be provided with pedestrian sidewalks and crosswalks. These should be clean and devoid of any encroachments. The cycle tracks shall also be developed along all important routes and special care shall be taken up near the intersection. Pedestrian foot over bridges or sub ways shall be built up near major commercial establishments, major intersections and educational institutions.

3.8 Parking facilities and charges:

In order to discourage trips by personalized vehicles high parking fees shall be charged on the vehicles parked in congested commercial areas like Exhibition Road, Frazer Road, Dak Bunglow Road, Ashok Raj Path, Boring Road, Boring Canal Road etc. In these areas multi storied parking shall be established to cater for the heavy demand of parking facilities. Commercial establishments and residential complexes shall be encouraged to have at least two floors dedicated to the parking facilities.

3.9 Proposal for Future Land Use and Transport Interaction

It has been established that land-use and transportation are closely related (Michell and Rapkin, 1954; Buchanan 1963). In other words land-use whether commercial, industrial, residential or recreational, influence transportation and are also itself influenced by transportation infrastructure. Keeping in mind this fact, planning for any new townships, localities, industries, commercial centers etc. should incorporate a comprehensive plan for transportation infrastructure as well. Residential locations shall be planned in such a way that people are nearest to their place of work and the students are nearest to their educational institutions. Colonies should be based on s elf-contained neighbourhood principle in order that the travel for the dwellers is minimized. Step shall also be taken up to stagger the working hour to avoid peak hour movement. The Master plan shows a major corridor of administrative and institutional land use along the Gaya railway line; and another corridor of commercial development is proposed parallel to the existing new bypass road. Both these major developments are to the south of the existing city limits. However, the natural growth of Patna city has been observed towards the west. The existing growth pattern to the west and the adjacent municipalities in the west, Danapur and Khagaul, are predicted to cater to the residential/ housing requirements of future. Although the housing is proposed to the south, no major commercial or institutional land use is proposed to the west. This uneven pattern can be seen as one of the reasons for such long trip lengths. This also indicates the need for comparable developments to the west.

3.10 Dislocation of the existing airport

The existing Jai Prakash Narayan International Airport is deficient in the length of the runway. Moreover, the location of the airport is within the city. The landing and takeoff of planes causes huge noise pollution of the area. Further, being in a city there is a possibility of the planes getting bird- hit. With the increase in the number of passengers and flight operations there is a need for the airport expansion. As there is no area left for the expansion of the airport it should be re- located near Bihta.

3.11 Development of jetty facility

Inland jetty facility shall be developed for passengers and freight handling near Mahendru Ghat and Gai Ghat respectively. This is needed as Patna lies on the national water way connecting Haldia to Allahabad.

4. CONCLUSIONS AND RECOMMENDATIONS

The comprehensive plans for transport infrastructure have not been attempted for the midsized cities. Lately, the Master Plan of the city has been prepared which suggests for the construction of ring road, roads, flyovers and operation of buses as modes of public transportation. However, there are certain distinguishable features in the proposed plan which makes it unique and enhances its contribution. Planning of transport infrastructure has not been attempted taking into account the land use. The proposed plan takes this into account and counter magnetic towns are also identified on this basis. Public transport development based on MRT/BRT has also been incorporated. The plans for NMV and pedestrian have also been proposed.

The proposed concept plan has been prepared on the basis of large scale data collection. It advocates for the establishment of counter magnetic towns to attract the migrating population towards it and to prevent it from going to the existing city areas. The plan also incorporates proposal for setting up a new ring road parallel to Ashok Raj Path connecting Danapur to Fathua with interchange points. Public transport planning including existing bus service, mini bus service, identification of mass rapid transit (MRT) /bus rapid transit (BRT), establishment of truck and bus terminals at various locations and integration of intermediate public transport (IPT) with public transport system have been proposed in the plan. Improved facilities for pedestrians and non motorized vehicles (NMV), expansion and improvement of road, parking facilities have also been suggested in the proposed plan. It is recommended to carry out more data collection for transport modeling and subsequently for coming up with a comprehensive transportation plan for the mid-sized city of Patna in India.

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The Application of Accident Clock for the Identification of Hazardous Locations :A Case Study of Nakhon Ratchasima Province

Phattarasuda WITCHAYAPHONG
Graduate Student
School of Transportation Engineering
Suranaree University of Technology
111 University Avenue, Muang District
Nakhon Ratchasima 30000 Thailand
Fax: +66(0)4-422-4239
E-mail: p.witchayaphong@gmail.com

Vatanavongs RATANAVARAHA
Associate Professor
School of Transportation Engineering
Suranaree University of Technology
111 University Avenue, Muang District
Nakhon Ratchasima 30000 Thailand
Fax: +66(0)4-422-4239
E-mail: vatanavongs@yahoo.com

Chisanu AMPRAYN
Assistance Dean in Student Affairs
Faculty of Engineering
Sripatum University
Chatuchak, Bangkok 10900 Thailand
FAX +66(0)2-579-1111 ext 2147
E-mail: chisanu.am@spu.ac.th

ABSTRACT:

This research aims to identify and analyze hazardous road locations on a main road in the area of Muang District, Nakhon Rachasima Province, together with the application of accident clock in safety planning and accident prevention for relevant stakeholders. Researchers have reviewed various methods for the identification of hazardous locations, and then selected 'Rate Quality Control' technique to identify hazardous locations based on accident rates considered appropriate for the data. In this research, a system approaching to identify hazardous locations on roadways in the pattern of ASP.NET website was developed. The research applies Microsoft Visual Studio 2010 C# Express as a tool to develop such system integrating with Microsoft SQL Server 2005 Express – an information database pattern for data storage which is considerably more convenient, faster and easier to record, to analyze and to store data. Thus, the locations of accident risks are visualized through the electronic chart based on Google map to facilitate a quick and reliable analysis coinciding with data display of accident clock for better understanding such locations in real conditions. As well, the outcomes would help to identify factors affecting hazardous conditions in the focussed areas in order to reduce the number of accidents and to continuously improve road safety.

Key Words: Accident Clock, Hazardous Locations, Nakhon Ratchasima

1. BACKGROUNDS

As it is currently known that, in each year, traffic accidents have certainly become one of the major causes of serious injuries and the massive loss of lives and properties. Hence, the reduction of accidents and casualties on roads has been included in Thailand National Agenda. Accordingly, the government announced year 2010 as 'the year of public safety' with the slogan 'Transportation Security, Thai Society Happy'. Albeit, during the previous months, traffic accident statistics are still quite high, especially in high seasons which have seen as higher injury and fatality. It associates with the data of Central Information Technology Center. Royal Thai Police found that the number of accidents among years 2000-2004 increased from 79,737 to 124,530 cases. After that the trend has been declining. In the year 2009, the rates have been increasing up to 84,806 cases. According to the year 2000 and 2009, such accident rates at 11,988 and 11,048 fatalities were reported, respectively [Royal Thai Police, 2010]. Each accident incurred not only personal injuries or even deaths, but also extensive property damages, slow traffic, and restricted flow. In addition, it may cause even greater damage of immeasurable value to society such as image of tourism city, image of travel safety, etc.

In addition, the accident situation of Thailand is extremely addressed by World Health Organization [WHO, 2010] that only 10 percent of accident data were used for studying and reporting in order to develop practical preventive measures. So, it is a major challenge for Thai society to design 'how to increase data usage for a problem analysis and improve a highly efficient level of data management bearing on sustainably solving the critical damage'. Based on this issue, the most important thing is to transform 'available data' into 'information' for obvious illustration; for example, 'calculating mortality rate compared to the number of population' or 'conducting the data set of risk locations, and then representing cause-and-effect relationship to analyze and to continuously improve learning'. After information synthesis, it becomes to be integrated into an actual practice toward the sustainable achievement of accident reduction targets.

Through synthesizing 'data' into 'information' with the aim of traffic accident prevention and reduction, the identification of hazardous road location is one of important activity required for incessantly carrying out by using road accident statistics, traffic volumes, road lengths to calculate 'Actual Accident Rate' for a particular roadway location compared with 'Critical Accident Rate' to consider hazardous areas. Therefore, this research survey develops a system assisted for identifying hazardous locations on main road in the area of Muang District, Nakhon Rachasima Province with the pattern of ASP.NET website by applying Microsoft Visual Studio 2010 C# Express as a tool for a system development and storing data in an information database pattern with Microsoft SQL Server 2005 Express – providing a convenient, fast and easy way to record, to analyze and to store data. Moreover, the illustration of locations of accident risks through the electronic chart based on Google map can facilitate a quick and reliable analysis. Corresponding with data display of accident clock, it largely enables understanding hazardous locations in real conditions. Also, the outcomes can contribute to find potential factors that affect hazardous conditions in the concerned areas, expected to benefit for solving traffic problems, reducing the number of fatalities, injuries, disabilities and properties of all related stakeholders. Furthermore, the research can be useful for road safety planning such as determining work zone traffic control, arranging more patrolling police officers particularly in the hazardous areas, setting systematic roadside inspection, and allocating budgets for road improvements. It could be indicated that the overall results dedicate the reduction of enormous nation's loss and provide efficient safety to road users.

2. OBJECTIVES

The research of the Application of Accident Clock for the Identification of Hazardous Locations has three objectives as follows:

- To identify and analyze hazardous locations of road traffic accidents
- To develop and apply 'Accident Clock' in safety planning and solving accident problems for authorities in charge of work related traffic accidents
- To provide a system in the website pattern for learning

3. RESEARCH METHODOLOGY

- Review of related literatures and previous studies
- Survey on the selected study area - National Highway No.304, and then plan for data collection
- Collect data required for identifying hazardous locations
- Conduct technology trials for developing ASP.Net website by applying Microsoft Visual Studio 2010 C # Express as a tool for system development and store the data in an information database pattern with Microsoft SQL Server 2005 Express
- Calculate the hazardous locations
- Provide conclusions and suggestions

4. DATA COLLECTION

The selected study area for this research is National Highway No.304, Nakhon Ratchasima Province being performed in the multi-lane highway constructed with asphalt concrete road surface. The start of the study is from KM109 – KM132 covering total of 24 km. Data gathered for analyzing hazardous locations include,

- Accident statistics on National Highway No.304 during year 2008, 2009 and 2010
- Average Annual Daily Traffic (ADDT) on the area of National Highway No.304 during year 2008, 2009 and 2010
- Physical road characteristics on National Highway No.304

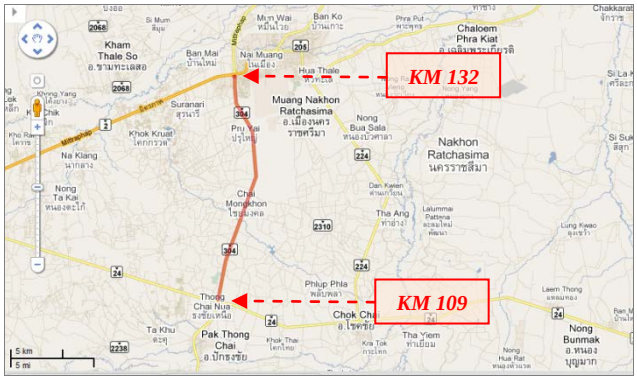

Figure 1 The study area - National Highway No.304, Nakhon Ratchasima KM109 – KM132

5. DEFINITION OF HAZARDOUS LOCATIONS

Hazardous Road Locations refer to the parts of road network where accidents always happen and/or the accident risks are present and expected to be improved. Since accidents have occurred many times in the same location and they have shown the similar characteristics, it is possible that one cause might be derived from road defection and environment. [Office of Transport and Traffic Policy and Planning (OTP)., 2005]

6. ANALYSIS OF HAZARDOUS LOCATIONS

The calculation technique to identify hazardous locations comprises the following steps:

6.1 Input data of road network and then divide it into segments at the length of 0.1, 0.3, 0.5 o r 1 km by using 'Fixed technique' as illustrated in Figure 2 [S. Utainarumol et al., 2000 and Krungboonklong et al., 2007]

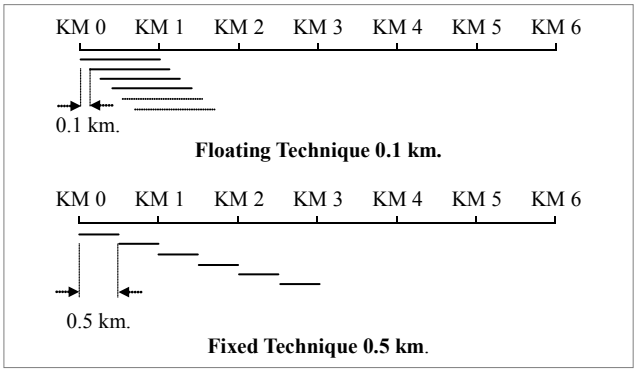

Figure 2 Two types of road segmentation: 'Floating Technique' and 'Fixed Technique'

After the accident database was completed, the hazardous roadway locations were identified based on the following methods [Zegeer 1982]:

6.2 Calculate hazardous roadway locations, for which researchers select 'Rate Quality Control Method' in which hazardous locations are identified by calculating 'Accident Rate' proposed in Equation (1)

$$R = A*1{,}000{,}000/(365*T*V*L) \quad (1)$$

Where,

R = Accident Rate for road segment (expressed as accidents per million vehicle-km),
A = Total accidents occurred during the analysis period (3 years),
T = Study period (3 years),
V = Average Annual Daily Traffic (AADT) during the analysis period, and
L = Road segment length (0.1, 0.3, 0.5, 0.7 and 1 km).

In the next step, 'Accident Rate' from Equation (1) is used for determining 'Average Accident Rate' (R_a), which is an average value of the total number of accident rates of all segments. The result provides the data for calculating critical accident rate (R_c) as shown in Equation (2). It is based on t he assumptions that the crashes are approximated by the Poisson distribution. If the actual accident rate for any particular locations is greater than the critical accident rate, such location is considered 'Hazardous'. [Vatanavong et al., 2007]

$$R_c = R_a + K(R_a/E)^{0.5} + 1/(2E) \quad (2)$$

Where,

R_c = Critical Accident Rate (accidents per million vehicles or accidents per million vehicle-km),
R_a = Average Accident Rate for all road segment of similar characteristics or on similar road type (accidents per million vehicles or million vehicle-km),
K = Probability factor determined by the level of statistical significance desired for R_c i.e., at 95% confidence level: $K = 1.61$, and
E = Millions vehicle-km of vehicles traversing road segment during the analysis period = $(365*T*V*L)/1{,}000{,}000$.

After calculating the critical accident rate (R_c), 'Dangerous Factor' (DF) is determined by Equation (3)

$$DF = R/R_c \quad (3)$$

Particular roadway segment that presents the largest value of DF is considered as the most hazardous location.

7. DEVELOPMENT OF DATABASE SYSTEM

Microsoft SQL Server 2005 E xpress is applied for a s ystem development to store database system and to validate and directly upgrade from program, as well it is convenient to create the relationship between databases as shown in Figure 3.

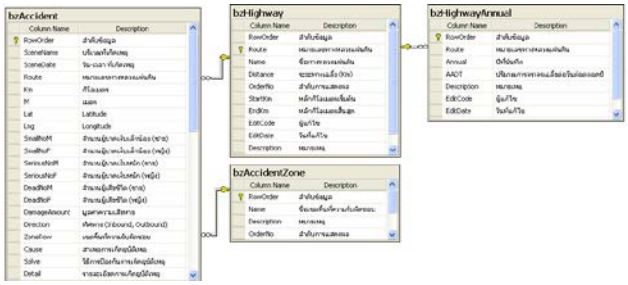

Figure 3 Diagram of database storage

Based on Figure 3, it is clearly seen that system development comprises the application of four tables that include (1) Table of accident record (bzAccident); (2) Table of the list of accident zones (bzAccidentZone); (3) Table of the list of National Highway (bzHighway); and (4) Table of Average Annual Daily Traffic (AADT) (bzHighwayAnnual)

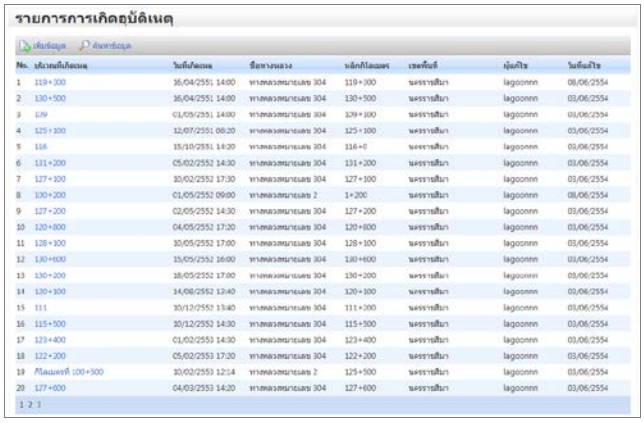

Figure 4 Accident data storage

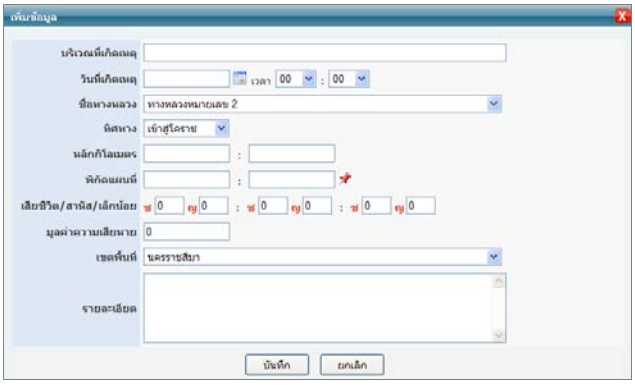

Figure 5 Accident record

Figure 6 The storage of the list of accident zones

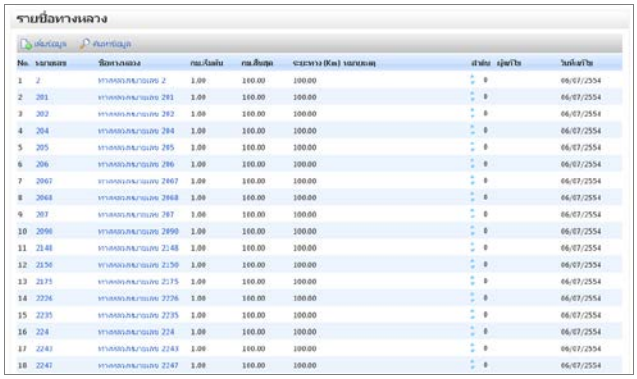

Figure 7 The storage of the list of National Highway

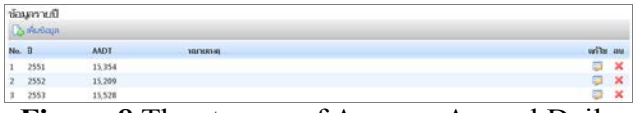

Figure 8 The storage of Average Annual Daily Traffic (AADT)

8. THE ANALYSIS RESULTS

According to a system designed by technology used for developing ASP.Net website through a tool of Microsoft Visual Studio 2010 C # Express, users can determine the data that requires the identification of hazardous locations such as selecting of hazardous location techniques, specifying highway kilometer (KM) and dividing the segment length of roadway under study.

8.1 Analysis of Hazardous Locations from a System

Based on observed accident data, hazardous locations can be addressed by 'Accident frequency Method' through counting the number of accidents on divided highway segment illustrated by the graph of the relationship between the accident frequency and highway segment for each kilometer as shown in Figure9.

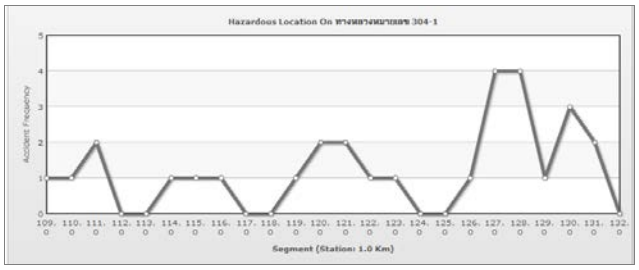

Figure 9 Graph of Accident Frequency of Highway segment for each kilometer

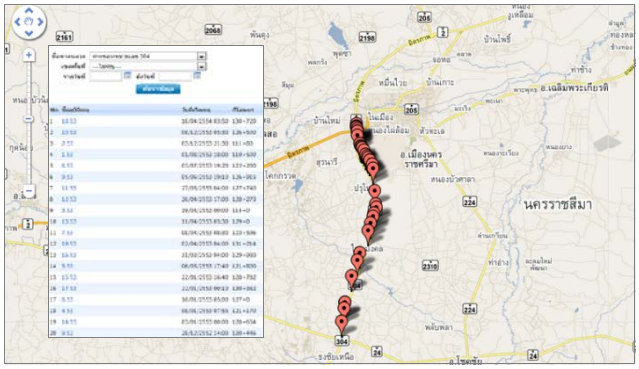

Figure 10 Accident Map by using 'Accident Frequency Method'

A system analyzes hazardous locations on National Highway No.304 based on the data of the number of accidents and average annual daily traffic corresponding Equations (1), (2) and (3) provide the results of 'Rate Quality Control' method from dividing the segment length of highway at 1 km as shown in Figure11.

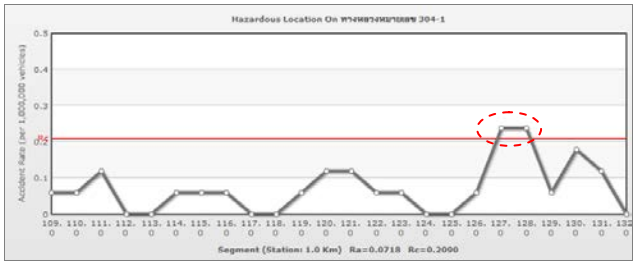

Figure 11 The relationship between segment and accident rate (per 1,000,000 vehicles) for each kilometer

Figure11 shows the curves of the critical accident rate and the accident rate of each segment. The comparison of both graphs noticeably describes that location of KM 127+000 – 127+999 and KM 128+000 – 128+999 are considered 'hazardous' since the observed accident rate of both segments are greater than the critical accident rate (R: 0.2378 ≥ R_c: 0.2090). Regarding the findings, the average accident rate represents equal to 0.0743 (R_a = 0.0718). And also, sequence of accident rates of all segments is carried out in consistently with hazardous ranking as shown in Figure 12.

Km-Station	Frequency of Accident	Accident Rate	DF	Ranking
127+000 – 127+999	4	0.2378	1.14	1
128+000 – 128+999	4	0.2378	1.14	1
130+000 – 130+999	3	0.1783	0.85	2
111+000 – 111+999	2	0.1189	0.57	3
120+000 – 120+999	2	0.1189	0.57	3
121+000 – 121+999	2	0.1189	0.57	3
131+000 – 131+999	2	0.1189	0.57	3
109+000 – 109+999	1	0.0594	0.28	4
110+000 – 110+999	1	0.0594	0.28	4
114+000 – 114+999	1	0.0594	0.28	4
115+000 – 115+999	1	0.0594	0.28	4
116+000 – 116+999	1	0.0594	0.28	4
119+000 – 119+999	1	0.0594	0.28	4
122+000 – 122+999	1	0.0594	0.28	4
123+000 – 123+999	1	0.0594	0.28	4
126+000 – 126+999	1	0.0594	0.28	4
129+000 – 129+999	1	0.0594	0.28	4

Figure 12 Illustration of table of accident rates of each highway segment (as of segment length at 1 km)

8.2 Map Illustration and Accident Clock

Accident clock is a tool assisted for the illustration of the accident severity level at any time of particular hazardous locations. This circle hierarchy involves listing each crash occurring at a site under one of four severity classes: Fatal crash, serious crash, slight crash and property damage only.

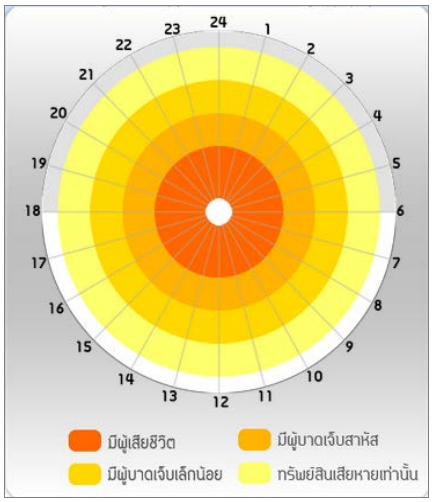

Figure 13 Accident Clock

It is standard practice for these crashes to be classified by injury severity as fatal, serious or slight, as follows: [DFID 2003]

- A fatal crash is one in which one or more persons are killed as a result of the accident, provided death occurs within 30 days (Vienna Convention 1968).
- A serious crash is one in which there are no deaths, but one or more persons are seriously injured. A serious injury is defined in the UK as either one for which a person is detained in hospital as an 'in patient', or if any one of the following injuries are sustained whether or not he or she is detained in hospital: fractures, concussion, internal injuries, crushing, severe cuts and lacerations, or severe general shock requiring medical treatment. In the UK this category includes deaths occurring after 30 days.
- A slight crash is one in which there are no deaths or serious injuries, but a person is slightly injured. This will be an injury of a minor character such as a cut, sprain or bruise.
- A damage only crash is one in which no one is injured, but damage to vehicles and or property is sustained.

In terms of the analysis of hazardous locations through a system, besides the illustration of the results through a map of hazardous location on highway segments, the display visualizes in to a color spectrum according to accident rates as shown in Figure 14. In case, users need the information of overall accidents occurred in particular highway segments, they can click on the color line, and then system will display the required information in the pattern of 'Accident Clock'. The total number of accidents will be showed in the clock.

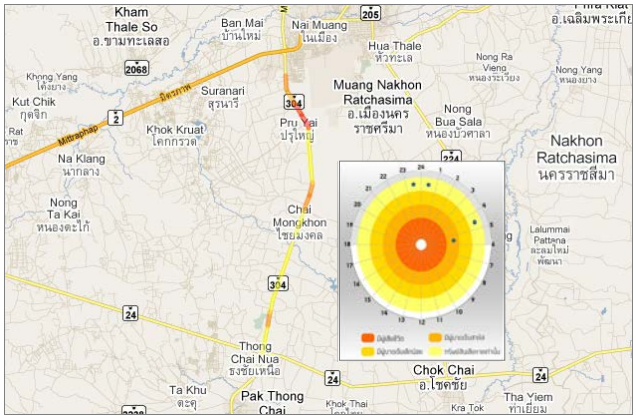

Figure 14 Map and Accident Clock on National Highway No. 304 at KM 127+000 – 127+999

The system can display the details of particular accident with the information of accident characteristics as shown in Figure 15.

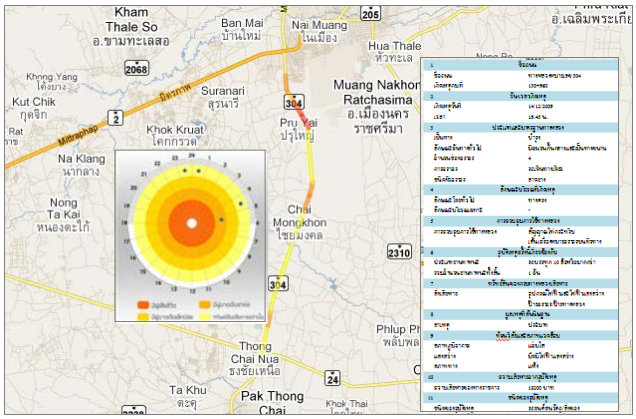

Figure 15 Information of accident characteristics on National Highway No. 304 at KM 127+000 – 127+999

9. BENEFITS

The application of 'Accident Clock' for the identification of hazardous locations would benefit other users as follows:

9.1 Benefits for Related Authorities

- Increasing and developing a capability of public sector staff that are responsible and involved in the prevention of road traffic accidents, as prepared data is even ready enabling for an analysis of the real problems**.**
- Identifying hazardous locations on main road in the area of Muang District, Nakhon Ratchasima Province in order to provide guidelines for related departments to improve road safety on such area, and to alleviate the severity of traffic accidents because of getting the exact locations of accidents and being preparedness, leading to increase safety.
- Allowing police officers and security agencies to set roadside inspection at specific time when knowing that at hazardous locations, what time usually shows the accident frequency.
- Getting benefits for road safety planning of related authorities**.**
- Providing a guideline for developing database system of traffic accidents in other provinces.
- Supporting public sectors to determine strategic plans for the real problem areas that would lead to reserve national resources and to accurately allocate budgets for efficiently solving road accidents. This will be feasible if budgets will be given to the appropriate areas that need the most improvement.

9.2 Benefits for Public

- Recognizing the people of hazardous locations on main road in the area of Nakhon Rachsima Province where accidents usually occur. It consequently raises the consciousness of people to prepare the prevention and to increase the awareness of risks in that particular roadway, resulting in reducing the risks of traffic accidents on such roadway.
- Perceiving the causes of traffic accidents on particular roadway can result in changing people's misbehaviors to use the road addressed as public property.
- Meanwhile people recognize the particular hazardous locations on main road in the area of Nakhon Rachsima Province; they can choose the new route to avoid encountering expected hazardous road at that time.
- Providing knowledge to students in terms of the application of information system in tracing the position of hazardous road locations and subsequently in understanding the causes of accident hazards being more likely to happen from road usage.

10. CONCLUSIONS

By applying Rate Quality Control method for the identification of hazardous locations on National Highway No. 304, the research found that two locations, as of 1 km segment length are considered to be significantly greatest hazardous including highway KM 127+000 – 127+999 and KM 128+000 – 128+999. Dangerous Factor (DF) of both locations is equal to 1.14, representing the maximum value. Furthermore, considering 'Accident Clock' of such segments, the study found 4 crashes at a particular highway KM 127+000 – 127+999, by which accidents occur during 11 pm to 6 am, at the locations being studied. According to such number, only 1 was found serious injury and other three were property damages. For highway KM 128+000 – 128+999, the findings found the similar number of accidents as previous one, by which accidents occur during 4 pm to 1 am; however, 2 crashes were reported as serious injury and the other two were property damages that can be illustrated in Figure 16.

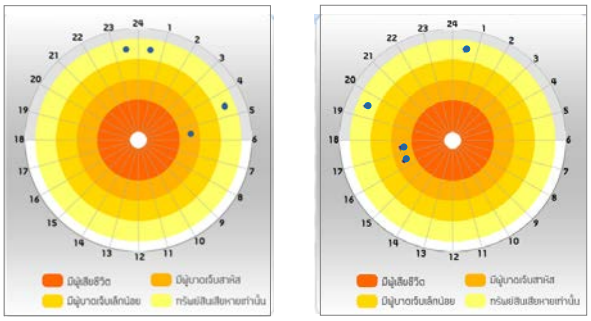

Figure 16 Accident Clock on National Highway No.304 at KM127+000 – 127+999 and KM128+000 – 128+999

The development of a decision-making tool for identifying hazardous location on road network can be used to display the potential exposure locations on main road in the area of Muang District, Nakhon Rachasima Province. The system would actually benefit to alleviate accident problems. Developing system with ASP.NET website applies Microsoft Visual Studio 2010 C# Express as a development tool for storing data in the pattern of information database system through Microsoft SQL Server 2005 Express, which is convenient, fast, and easy to record, analyze and store data. As well, system users can retrieve and direct access accident data through website. Moreover, the system development is exerted to provide guidelines for related authorities to improve safety on such hazardous locations and to reduce the severity of traffic accident because of getting the exact locations of accidents and being preparedness, leading to increase of safety.

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FUEL CONSUMPTION MANAGEMENT IN THE TRANSPORTATION SECTOR IN IRAN

Aliasghar MEHDIZADEH DASTJERDI
MSc Student of Science for Sustainable Development
Linköping University
SE-581 83 LINKÖPING ,
Sweden
Fax: +46-13-1494-03
E-mail: alime149@student.liu.se

Bahar NAMAKI ARAGHI
PhD Student of Transportation Engineering
Development and Planning Department
Aalborg University
Fibigerstræde11, 9220 Aalborg East,
Denmark
Fax: +45-99-4084-29
E-mail: isc-sec@eng.hokudai.ac.jp

ABSTRACT:

Energy consumption in the transportation sector in Iran is significantly higher than global norms and standards which caused some issues including wasting national resources, deteriorating air quality, GHG emissions etc. The major purpose of this paper is to introduce practical policies, strategies and technologies to reduce liquid fuel consumption known as a dominant source of energy in transport sector in Iran. Since, the road subsector has the major share in consuming liquid fuel amongst others, more attention is given to the methods for reducing consumption in this subsector. The relating policies and actions were classified by optimization measures according to four separate categories as follows; "Optimization of Supply of Transportation Services", "Optimization of Transport Demand", "Optimization of Energy Consumption" and "Optimization of Car Manufacturing".

Key Words: liquid fuel consumption, optimization, sustainable accessibility, Transportation Sector

1. INTRODUCTION

The transportation sector is one of the main energy consumers amongst other sectors and liquid fuels which are predominantly derived from fossil fuels are the dominant source. Transportation share of the total energy use in the world is approximately 20% and in this regard, liquid fuels accounts for more than 50% of total fuel source being consumed by the subsets of the transportation sector including air, marine, rail and road to transport people and goods. It is anticipated that, with regard to current trends in transportation energy demand, total liquid fuels consumption in this sector will rise to 61% in the year 2035 (EIA, 2010). On the one hand, high dependency of the transportation sector on fossil fuels as non-renewable source of energy and on the other hand, Green House Gases (GHG) as well as air pollution stemming from combustion of fossil fuels would necessitate the application of energy conservation strategies and policies as to control fuel consumption in this sector. Obviously, effectual solutions can only be provided in the context of the state of each country regarding energy consumption in the transportation sector. In other words, dominant incentives for inefficient energy consumption patterns might not be similar in different parts of the world.

In this paper, Iran as a developing country suffering from this issue is taken into consideration and some practical methods are proposed for reduction of energy consumption in the transportation sector.

2. The state of energy consumption in the transportation sector in Iran

Iran is one of the members of OPEC (Oil Producing and Exporting Countries) enjoying large oil and gas reservoirs. Owing to abundance of energy resources and its low price, energy consumption in this country is extremely higher than global norms and standards. A high proportion of the nation's annual energy is swallowed by the transportation sector. For instance in 2005, around 52% of liquid fuels were distributed to this sector to supply domestic demands. Furthermore, total energy consumption in the transportation sector in Iran was 264.95 Million Barrels of Oil Equivalent (MBOE) in the year 2006 which saw an upward trend at 6.05% next year. Gasoline and gas oil are the main source of energy in the transportation sector to transfer passengers and goods where, their shares have been 49.5% and 42% of total energy consumed in this sector until 2006 respectively (Mazraati, 2007).

According to BP Statistical Review of World Energy as cited by Sharify (2009), t he annual growth rate of the gasoline consumption on global scale from 1996 to 2006 was 1.75%, while this rate was above 8.35% i n Iran throughout that period. This obviously indicates that level of energy consumption in Iran has been extremely higher than all other countries and regions in the world mentioned in Table1. It is clear that the transportation sector in Iran plays a vital role in determining trend and pace of growing demand for gasoline consumption.

Table1 Gasoline regional consumption (Thousands of barrels daily) and annual consumption growth rate in Iran and other regions and countries (Sharify, 2009).

Regions	Year		Growth rate
	1996	2006	
North America	9389	11106	1.69
USA	8167	9571	1.60
S. & Cent. America	1433	1497	0.44
Europe	4223	3632	-1.50
Former Soviet Union	892	999	1.14
Middle East	789	1252	4.73
Africa	552	648	1.61
Asia	4686	6986	4.07
China	1140	1968	5.61
Japan	1576	1816	1.430
OECD	15968	17720	1.05
Non-OECD	5996	8399	3.43
Iran	207	462	8.35
World	21964	26120	1.75

Energy in Iran is heavily subsidized. The proportion of the transportation sector as the second largest consumer of energy subsidy in this country until 2006 has been 21% of total share. From 1996 to 2005, growth in amount of energy subsidy in the transportation sector accounts for about 250% which more specifically, rose from $3.59 bi llion to $12.43 billion (Mazraati, 2007). According to a report being released by IRPETRO (Iranian petro energy news network) as cited by Sarabi and Moosavi (2010) e nergy consumption in Iran doubles every 10 years, whereas this period for the world in average is about 50 years. Likewise, the level of fuel consumption in Iran is about 4-5 times more than its level in the world. This is mainly related to the road transportation, where the average automobile consumption is 11 liters per day per vehicle. The relevant statistics have revealed that road transportation ranks first in consumption of energy compared to air, marine and rail transportation. The ratio of energy consumed by this subset of transportation was about 86% unt il 2006 (Sarabi & Moosavi, 2010). This is clearly indicating that in order to achieve an effectual solution for reducing energy consumption in transport sector in Iran, more attention should be devoted to the road subsector.

3. Consequences and causes of over consuming energy in the transportation sector in Iran

In Iran, the transportation sector is the main source of air pollution in urban areas. Air quality problems in megacities such as Tehran (i.e. the capital city of Iran), Isfahan, Shiraz, Tabriz etc. has been exacerbated to the extent that it is known as a serious threat for public health and one of the main causes of death in megacities (e.g. by fatal heart attack) (Abbaspour & Soltaninejad, 2004). For instance, only in a period of one month between October 23 to November 23 in the year 2010, air pollution directly or indirectly caused the deaths of 3,600 citizens in Tehran (The population of the Tehran Metropolitan Area is about 12 million) (Nadim et al, 2009). From 1996 to 2006 the transportation sector accounted substantial portions of the total emissions in Iran. The relating data has been illustrated in Figure1 (Sarabi & Moosavi, 2010). According to a five year period study in Tehran, it was shown that there is a direct link between levels of CO and the number of admissions to hospitals because of cardiac angina. Therefore, since the transportation sector has the major share in CO emissions in Iran, its role in endangering public health is inevitable (Nadim et al, 2009). When it comes to Tehran, 70% of air pollution emissions related to mobile sources including private vehicles, light duty trucks, heavy duty trucks, buses, motorcycles and aircrafts. This clearly shows that vehicular emissions play a critical role in deteriorating air quality in this megacity (Abbaspour & Soltaninejad, 2004).

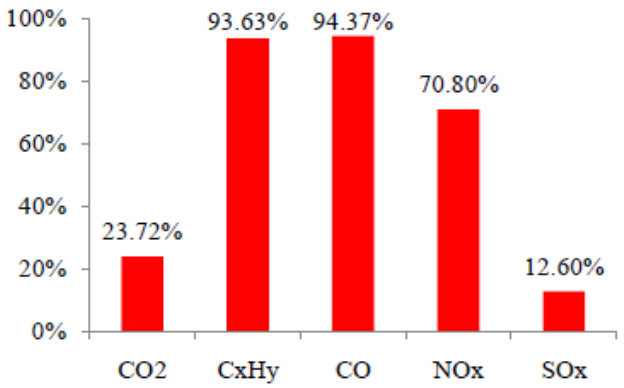

Figure1 the portions of transportation sector in the total emissions of air polluting agents in Iran From 1996 to 2006 (Sarabi & Moosavi, 2010)

Considering the above-mentioned features, over consumption of fossil fuel in road transport and its consequences i.e. high vehicular air pollution is an acute problem. In order to deal with this issue primarily, the main contributors need to be identified and correspondingly, methods and technologies applied for reduction of energy consumption should be introduced. In this regard, these contributors are summarized as follows (Rasouli, 2009);

1. The fleet's low fuel efficiency due to long operating lifetime.
2. High energy subsidies in the transportation sector which are mainly allocated to gasoline and gas oil as main fuel sources of the road subsector.
3. Out-dated technologies in Iran's automotive industry as the main supplier of vehicles in domestic market.
4. Inattention to electronic government and its required infrastructure (i.e. broadband internet) as a digital interaction tool to reduce unnecessary urban travelling for citizens.
5. Paying less attention to development of Intelligent Transportation Systems (ITS) in order to decrease travel time and correspondingly reduce fuel consumption in the transportation sector.
6. Poor public transportation services in urban, suburban and rural networks with regard to the development of the required substructures (i.e. bus, monorail, subway, railroad etc.) as well as the quality of services which leads passengers to use private vehicles remarkably.

7. Unsuitable land use and unplanned development particularly in city centers which cause heavy traffic in urban areas.

According to a study conducted by Abbaspour and Soltaninejad in 2004 it has been revealed that the "*Cost of air pollution reduction*" in Tehran as direct cost is about $1.9 million, whereas owing to the negative effects of this amount of pollution, the sum of "*Cost of gasoline over use and petrol evaporation*", "*Cost of life saving*", "*Cost of extra hygiene*", "*Cost of car wash*" and "*Cost of human Illness*" are around $424 million which is imposed indirectly on government and citizens. Thus, in addition to environment protection and health care perspectives, economic considerations also justify applying new strategies and policies regarding fuel consumption management in road transport in Iran.

4. Fuel consumption management; strategies, policies and technologies

In order to reduce energy consumption in road transport in Iran, the reversal of the traditional managerial approach is needed and different new strategies and policies have to be considered concurrently. Furthermore, responsible organizations including standard and environment institutions and ministries such as ministries of transportation, industry, interiors and petroleum should collaborate jointly to make this problem more tractable. These relating policies and actions were classified by optimization measures according to four separate categories as follows; "*Optimization of Supply of Transportation Services", "Optimization of Transport Demand", "Optimization of Energy Consumption" and "Optimization of Car Manufacture"*.

4.1. Optimization of Supply of Transportation Services

Supply of transportation services refers to providing required infrastructure to transit passengers and cargos in transport networks (i.e. urban, suburban and rural), in order to meet existing or upcoming travel demand as well as increase or maintain the speed of movement in networks.

Comprehensive public transportation services which integrate different transport modes including bus, monorail, subway etc. play a vital role in increasing transit ridership levels. In other words, it would attract more people to use public transports instead of personal vehicles. As for Tehran, the public transportation system is comprised of buses, subway, taxies and minibuses which have not been developed in accordance with transport demand growth in the recent decades mainly due to dramatic population growth in this megacity. In this regard, inappropriate public transportation services (i.e. old public transit fleets, incompleteness of the network of lines and so on) is known as one of the main contributors of high tendency toward private vehicles and correspondingly, high gasoline consumption. As a result, it led the quality of life to fall in terms of some criteria such as citizen's security, health, costs etc (Joodi et al, 2012). In recent years, development of a public transportation system as a sustainable approach came to the fore considerably in Iran. For instance, an increasing share of rail transportation in passenger and goods transit through extending and upgrading rail networks has been mentioned. In this regard, it is anticipated that the ratio of rail transport in passenger transit would increase from 7.1% in 2007 to 30% in 2011. Furthermore, rate of carry of cargo by this mode of transport would reach to 18% in 2011 while this rate was just 4% in the year 2007. Besides, an upward trend in the proportion of other public modes including taxis, vans, buses, mini buses, midi buses due to increasing quality and quantity of services, plays a significant role in reduction of fuel consumption for one person per day from 1.01 liters in 2007 to 0.7 liter in 2011. In that, it contributes to more using public transit in suburban and interurban trips (Sarabi & Moosavi, 2010).

Development of transportation infrastructures such as tunnels, highway and freeway could lead to enhanced mobility and reduced travel time in transport networks for vehicles and ultimately, contribute to energy saving in this sector. In fact, maintaining capacity of transport networks came up to traffic flow would reduce congestion and delay associated with motor vehicle travel. When it comes to relation between traffic congestion and fuel consumption, owing to consecutive vehicle's acceleration and deceleration in congested traffic, additional fuel would be definitely consumed. However, this value depends on severity of speed changes, the type of road and its speed limitations, the quality and feature of individual vehicles (Greenwood & Bennett, 1995). In order to increase accessibility and maintain mobility in Iran, 14417 km of freeway, highway and main road have been built just throughout three years (from 2007 to 2010) specifying 161% increase in this period (Sarabi & Moosavi, 2010). As for Tehran, for instance, construction of tunnel has been considered as a solution to ease traffic jams in urban corridors in recent years. A tunnel called *Resalat* has been built in order to enhance traffic mobility and fluidity in the west-east highways of Tehran. Construction of *Towhid* tunnel in north-south highways of Tehran is another civil project contributing to annual saving of 26 million liters of gasoline (Tehran Times International Daily, 2010).

It should be emphasized that construction of new roads, tunnels, bridges etc. would not necessarily lead to maintain mobility of traffic flow. Increasing capacity of road networks might attract more drivers to use them and correspondingly, the number of private vehicles could increase on those corridors gradually. Ultimately, travel demand would surpass supply once more and under this circumstance, traffic congestion is inevitable and as a consequence, fuel consumption would increase accordingly.

4.2. Optimization of Transport Demand

Transportation Demand Management (TDM) is a general term encompassing different strategies and policies in relation to travel demand reduction in order to utilize transportation resources efficiently. More specifically, TDM aims at reducing unnecessary daily trips as well decreasing travel distance particularly for private vehicles in transport networks. In some cases, it is known as an alternative approach instead of road and parking facility expansion for the sake of meeting travelers' needs. Since, private vehicles have a major share in carrying passengers and goods in megacities in Iran, adopting different TDM strategies plays an important role in reducing fuel consumption in the transportation sector.

Electronic government or E-government is defined as delivering public sector information and services to people through employment of the internet which provides interaction between government and citizens over the web-based technologies. It is obvious that, developing robust E-government system would reduce travel demand for citizens to acquire needed services or information which otherwise have to arrive at corresponding organizations. When it comes to Iran, less attention has been given to E-government owing to some barriers including "Social and cultural obstacles", "lack of IT skills", "Legal obstacles" and "Security obstacles" (Fallahi, 2007).

Integrating land use and transport is one the most important strategies to manage the demand for travel in urban areas through minimizing the number and length of individual trips which travellers require to make. The integration of transport and land use planning is widely recognized as essential to the achievement of sustainable development and has shifted the thought from sustainable mobility towards sustainable accessibility in transportation planning. In the sustainable mobility perspective, providing ability for vehicles to move freely through, for

instance, the construction of new motorways is the center of attention whereas, facilitating movement of passengers and cargos with a minimum of daily travel via increasing access to activities is the main goal in sustainable accessibility. In nutshell, integrating land use and transport strategy would help to "reduce growth in the number and length of private car journeys" and "make walking, cycling and public transport use more attractive" (Refshauge & Scully, 2001). I n order to achieve these objectives, some principals should be considered in context of developing sustainable accessibility. These principals are outlined as follows (Refshauge & Scully, 2001);

a. Concentrate and mix uses in centers: concentrating popular activities (i.e. business, shopping, public facilities and other compatible land uses) in centers would decrease the number and length of necessary daily car trips which are taken to meet a range of purposes. Furthermore, the proximity of activities to each other would make walking and public transport options more attractive for passengers. Developing main public transport nodes such as rail stations, taxi and bus terminals within a satisfactory walking distance to popular activities plays a critical role in making centers more accessible.

b. Align centers within corridors: activities in major and neighbourhood centres should be arranged so that they are located along key public transport corridors (including subway and monorail links, transit ways and bus lanes).

c. Link public transit with land use strategies: new public transport infrastructure and services should be developed in accordance with land use strategies. As an example, optimum location and alignment of transit ways would consider the layout of residential and commercial areas, densities, and other relevant factors in order to maximize the load of the passengers to and from the central destinations.

d. Connect streets: Provision of efficient access to public transport for cyclists and pedestrians with consideration of safety and walking distance, can be achieved by interconnected street networks. A long with that, providing frequent bus services will be more efficient in these types of networks due to the dispersion of the travellers along this transit way.

e. Improve pedestrian and cycle access: providing pedestrian facilities in urban area plays a critical role in creating a safe environment for pedestrians. Walkable urban areas enjoy footpaths networks, curb ramps, signal timing, good lighting, gradients, weather protection and shade etc. In addition to improving safety, security and mobility, these facilities provide great priority to access for pedestrians. When it comes to cyclists, construction of bicycle lanes is an approach to increase their accessibility to different locations in urban areas and correspondingly, make it more attractive for users.

f. Manage parking supply: limitation of parking spaces in crowded urban areas is an incentive for travellers to shift in travel from the private car to public transport, walking or cycling. Control of parking supply is known as an effectual method in management of travel demand in urban area.

g. Improve road management: as an example of a managerial approach giving higher priority to public transport services through exclusive bus lane can be mentioned. These lanes mainly reduce the public transport travel time, and improve the accessibility to main regional destinations etc.

As for Tehran, establishment of bus rapid transit (BRT) has been considered to increase travel demand by public transport. Developing BRT in Tehran aimed at improving quality of public services for customers through increasing accessibility, reducing travel and waiting time, easing approachability, improving safety etc. According to a study conducted by Mahmoudi et al. (2010) it was shown that construction of BRT has had a direct effect in providing customer

satisfaction. In other words, it has made bus transport more attractive for passengers.

4.3. Optimization of Energy Consumption

Nowadays, application of technologies which help to minimize travel time in road transportation plays an important role in fuel consumption management. Since road transport in Iran depends extremely on liquid fuels, following this approach would reduce fossil fuel consumption in this subsector.

Development of Intelligent Transportation Systems (ITS) is deemed as a managerial approach in traffic science. In addition to its benefits for improving safety and solving congestion issues, mobilizing transportation infrastructure by intelligent technologies could save fuel consumption in this sector. For instance, an intelligent traffic control system such as Video Image Processing (VIP) monitors traffic flow in order to prevent drivers from exceeding the speed limits on motorways. It would contribute not only to improving safety for road users through avoiding dangerous manoeuvres but also, reducing fuel consumption (Shaheen & Lipman, 2007). It is obvious that driving at a steady speed in accordance with the speed limit have a direct effect on decreasing fuel consumption. Besides, there are some intelligent technologies which save travel time and correspondingly, fuel consumption through removing unnecessary stops and eliminating deceleration/acceleration time for traffic flow. In this regard, the Electronic Toll Collection (ETC) system can be mentioned as an example. As a case study, ETC equipments were installed in toll stations on two crowded freeways of Iran i.e. Tehran-Karaj and Tehran-Qom. This technology substituted for traditional tollbooths where drivers have to pay toll directly by cash or ticket. Annual fuel savings owing to employing the ETC method in Tehran-Karaj and Tehran-Qom routes are estimated 5,155,200 and 2,014,824 liters respectively (Saffarzadeh & Arjroody, 2006).

The low price of energy in Iran due to heavy government subsidies is identified as one of the important contributing factors in high fuel consumption in the transportation sector (Rasouli, 2009). Iran ranked first in allocating energy subsidies in 2008 amounting to $101 billion (International Energy Agency, 2010). A considerable amount of fuel subsidies is injected into road transport annually and accordingly, swallowed by millions of vehicles. Adopting policies relating to reducing government subsidies in this sector would lead to optimizing fuel consumption particularly gasoline and gas oil as the main energy sources. Rationing of gasoline consumption has been carried out in Iran since 2007 as the first step to fulfil energy subsidy reform. Accordingly, two different prices are fixed for each liter of gasoline based on the level of usage. The lower price is allocated for a limited level of usage, whereas the higher price is determined for the cases where that level of usage has exceeded. However, there are some considerations for public services such as taxis, vans etc. regarding their fuel ration. The fuel supply is controlled via the intelligent cards allocated to each vehicle. The fuel ration is about to decrease gradually so that gasoline will be supplied without government subsidy. It should be considered that current Iran's gasoline rationing system is running by the abovementioned mechanism in order to control inflation effect of growth in the gasoline price as far as possible (Sharify, 2009). Implementing this gasoline rationing system in Iran has resulted in 21,000,000 liters saving in gasoline consumption per month (Sarabi & Moosavi, 2010).

Owing to increasing rate of gasoline consumption growth in Iran, alternative fuels have been deemed to control consumption of gasoline in the transportation sector in recent years. With respect to the fact that a great amount of natural gas resources exist in Iran accounting for 14.5% of the world's gas reserves, Compressed Natural Gas (CNG) is an appropriate and clean alternative fuel (i.e. unlike gasoline, combustion of CNG does not increase greenhouse gases emissions). Additionally, its low price, existing widespread pipeline networks to transfer CNG and need for simple technologies in terms of its development are known as strengths. These advantages justify increasing share of this fuel in road transportation in Iran which would be achieved through extension of CNG stations and vehicles running on CN G. Following sustainable development goals for using more clean fuels and increasing the exports of liquid oil products are some opportunities which would be prepared via developing application of CNG in the transportation sector; although, this will not be without any weaknesses. In this regard, high expenditures of development and maintenance of CNG stations and car cylinders, need for foreign technologies and imports, low mileage, high weight and volume of CNG cylinders can be considered as some of the negative points facing the expansion of CNG in Iran (Jafari & Baratimalayeri, 2008).

4.4. Optimization of car manufacturing

The auto manufacturing industry is the second largest industry of Iran after the oil and gas industry which supplies a major ratio of domestic demands including light-duty and heavy vehicles. Due to the government monopoly on the automotive industry, high taxes are imposed on imported vehicles and accordingly their prices are too high. As it has been mentioned above, Light-duty vehicles consume large amounts of gasoline in Iran which according to the Technology Needs Assessment Report released in 2008 out -dated technology in Iran's automotive industry was introduced as a contributing factor in addition to high age of vehicles and inappropriate maintenance. In this regard, priorities regarding taking enhancement measures in the car manufacturing industry have been put forward to reduce fuel consumption. These proposed measures are "*Motor efficiency improvement*", "*Weight Reductions*", "*Appearance*" and "*Power transmission system improvements*".

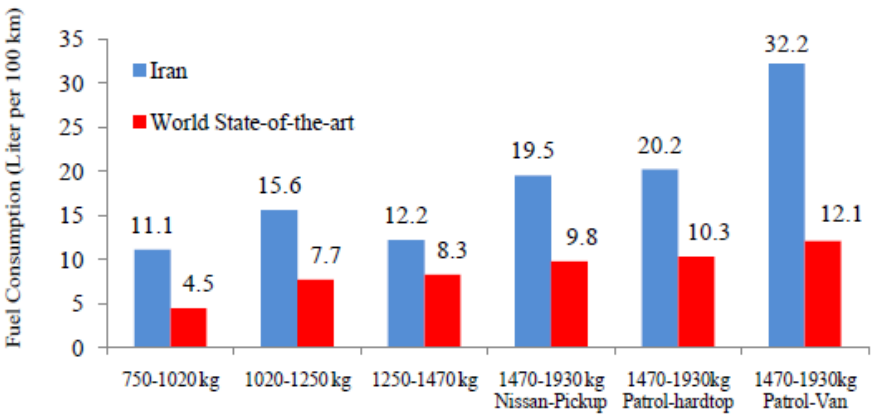

Figure 2 Average fuel consumption for some weighting classes of Iran's domestic-produced vehicles, in comparison with the world's state-of-the-art vehicles (Jafari & Baratimalayeri, 2008)

With regard to high potential of CNG as an alternative fuel in Iran, producing dual-fuel consuming cars i.e. CNG and gasoline should be focused more. This action incorporated both new vehicles and those are used. Initially, implementation of this plan was limited to urban bus services and taxis in that, people did not welcome purchasing vehicles running on CN G. Scarcity of CNG stations and wasting time in long queues to fill up vehicles exacerbated public reluctance. Following the implementation of the gasoline rationing system in Iran, the number of dual fuel vehicles has increased considerably to the extent that just throughout three years, they increased by 33 times when it comes to manufactured vehicles and by 3 t imes as for converted vehicles (Sarabi & Moosavi, 2010). Besides, at the 3rd International Conference on CNG held in Tehran the 18th September 2010 *Mohammad Royanian*, the Head of the Fuel and Transportation Management Headquarter, stated that the number of CNG stations have increased 30-fold over the last three years and is about to reach 400 CNG stations by March 2011. H e also mentioned that the growing tendency towards CNG consumption has had direct effects on 20 to 25% daily gasoline consumption reduction (SHANA, 2010).

5. Conclusion

A higher level of energy consumption in Iran compared to the corresponding global norms emphasized the desire for identifying methods for changing this trend. The importance of the transportation sector as the second dominant energy consumer is inevitable. Hence, altering the dominant pattern regarding passenger and freight transit plays a vital role; paradigm shift from private to public transport. Increasing the share of public transport in terms of rapid buses, rail, subway, LRT and monorail to carry passengers and cargoes can be considered an effectual solution for fulfilling this objective. Besides, declining the numbers of gasoline car, gas oil minibus and gas oil bus technologies in transferring passengers would facilitate the achievement of optimum transportation pattern in Iran. This clearly indicates the importance of CNG as an alternative fuel in the road subsector. As for freight transportation, the proportion of gasoline pick-up and gas oil light trucks needs to be decreased and instead, more attention should be devoted to heavy trucks. It is anticipated that by following this pattern, consumption of gasoline and gas oil in the transportation sector could decline 24% a nd 17% by 2029 (Sadeghi & Hosseini, 2008).

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