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ZONAL IMPACT ASSESSMENT BASED ON ZONAL COMMUNITY PREFERENCES: AN ALTERNATIVE OF LAND DEVELOPMENT CONTROL IN DEVELOPING COUNTRIES

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ABSTRACT: Many planners have recently utilized the Development Impact Assessment to control land developments in their cities. The traditional impact assessment framework focuses on the site specific level, and mostly concerns only limited types of development impacts. In fact, the city growths are the results of simultaneous developments and their adverse impacts are diverse, such as economic losses and environmental degradations. These become the limitations of impact assessment to manage the actual urbanizations. We have developed a framework of Zonal Impact Assessment (ZIA) to overcome those limitations. Our framework mainly evaluates the generated impacts in each zone rather than an isolated project. The ZIA can analyze the impacts of simultaneous developments in many zones, and many kinds of impacts can be considered. Furthermore, the survey results of public participation were included to identify the sensitive areas for development impact based on the preferences of zonal communities. The Bangkapi case study was elucidated to demonstrate the ZIA application concerning traffic impacts of developments. The impact distributions were evaluated and visualized for planning process. It was found that ZIA is an alternative tool in balancing between infrastructure demands and urban developments to reach a sustainable community.

Key Words: Times impact assessment, zonal traffic impact assessment, land development control

BACKGROUND

During the past decade, most urban areas in developing countries have continuously grown in size and density. This has led to the infrastructure demand expansion. Many sprawl developments cause various problems for their societies. Particularly, in cities located in the lowland areas, the effects of uncontrolled developments are one of the many issues of urban planning. One good example of this dilemma is found in Bangkok, Thailand. In the city, some development projects, such as shopping center, market etc., were constructed in the inappropriate areas, including in flood hazard prone zones. To provide the public facilities for serving those areas, a lot of natural resources, including canals, green areas, etc., have been replaced by roads and other infrastructures (Liengcharernsit 1992). However, the facility provisions and the city growth management of mega-urban regions still cannot keep pace with their economic and urbanization growths. They create not only traffic congestion problems, but also very severe flooding problems. As Bangkok is located in the lowland areas, there is the disadvantage of poor water drainage. Furthermore, a lot of uncontrolled development projects were constructed, and they block the natural water draining systems. The flooding problems result to more congested traffic with the severe environmental problems, including waste water, air and noise pollutions. These problems become the endless urban planning concerns in developing cities, especially for Bangkok. To effectively manage the urban developments in Bangkok, the planners have recently tried to utilize the Environmental Impact Assessment (EIA) to control land developments and mitigate negative

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impact problems since 1992. Under the Enhancement and Conservation of National Environmental Quality Act of 1992, all new development projects with parking lots more than 300 units or gross floor areas larger than 2,000 square meters have to conduct environmental impact studies. Principally, all impacts of the projects should be reported to the Building Control Division (BCD) of the Bangkok Metropolitan Administration (BMA) and the owners must mitigate the negative impacts of projects based on the suggested recommendations of the BCD for the project approval.

The impact assessments based on the project-base approach are applied to control land developments in Bangkok. Basically, the development impacts can be separated into five aspects, including social, environmental, economic, fiscal, and traffic impact assessments (Burchell, et al. 1994). However, the existing impact assessment methodologies seem to be unproductive in Bangkok, not only because of lack of impact control standards and rigorous enforcements, but also because of its own limitations in managing the unique characteristics of actual urbanization process for developing countries.

Although, there are various kinds of development impacts, this study mainly focuses on the traffic impact assessment (TIA). Based on the discussed matters in this article, the extensions of other impact aspects are expected to be studied in succeeding studies. First, the limitations of TIA are explained together with the proposed solution of an impact assessment alternative, called Zonal Impact Analysis (ZIA) Framework. To cover the critical issue of public participation in the urban planning process, the proposed ZIA framework includes the stakeholder preferences into the identification of sensitive areas towards development impacts. This is followed by an illustration of the case study of the ZIA framework in Bangkok. Finally, the concluding remarks are presented.

ZONAL IMPACT ASSESSMENT FRAMEWORK: AN ALTERNATIVE OF URBAN DEVELOPMENT CONTROL

To harmonize the city growth and infrastructure planning, many planners employed the TIA as a tool to control land developments by scaling down the level of impact analysis to site or local area (Gakenheimer 1993). In developed cities, the TIA is now performing effectively and routinely, as there are comprehensive land use plans, and also strong regulations and enforcements. These are rare in developing ones like Bangkok. Without the comprehensive urban development plans, the project owners tend to not consider the basic land use control rules about types and densities of buildings in Bangkok. This significantly affects the travel behavior of people and traffic conditions in the city. Any development project, regardless of its size and location, can be officially approved as long as it does not violate the basic rules of structurally safe standards in the Building Control Law, on types land use prohibited by City Planning Law, and on the sale of land parceling by Land Subdivision Law. There is no concern about the critical environmental consequences probably caused by the project such as congestions, air and noise pollutions, etc.

Without the comprehensive land use control plan in the macro scale, the applications of impact assessments are insufficient to balance between demands and capacities of infrastructures provided for the whole urban areas. There is no doubt that the impact assessment is a very useful tool for development controls. However, there are some limitations to apply the existing impact assessment approaches in developing cities, particularly for TIA. The impediments can be described as followings:

- Because the land developments in the lowland areas have the tendency to spread rapidly, the impacts of developments are distributed very broadly. The traditional impact assessments are the project-base approach. In a sense that, it mainly emphasizes on the impacts of site area, thus the establishment of an overall land use plan congruent with the infrastructure planning in the macro level is difficult.
- Generally, various development projects have been implemented over the city areas at the same time or in a certain period. The growths result from the simultaneous developments, but the traditional impact assessment frameworks basically concern the impacts in the project-base as an isolated project. This is very obvious for TIA, because it mainly assesses the influenced networks of an individual isolated project. These different analysis levels indicate that the existing frameworks cannot cover the actual urbanization. Eventually, it cannot fully evaluate and control

total adverse impacts generated over the whole city areas.

- Principally, each impact aspect in the development impact assessment is separately considered. It concentrates on its own impact units and analysis approaches only. For example, TIA regularly is based on the network analysis and the impacts are measured in term of levels of service (LOS). This is the traffic engineering perspective only and does not include the secondary impacts of economic, environmental, and social issues. At present, the consideration of specific impacts is insufficient; the integrated impacts should be essentially taken into account to encourage the sustainable developments.

According to these limitations, the traditional impact assessment approach cannot fully function in effectively controlling the sprawl developments. In the next section, the Zonal Impact Assessment (ZIA) framework is proposed to be an alternative tool to improve the capability of urban planning process for land development controls and infrastructure improvement. Since it would be difficult to include all impacts at the early stage of the ZIA framework, it is therefore apt to start the application on traffic problems, one of the significant concerns in lowland areas as in the case of Bangkok. An original idea and concept of the proposed framework can be expanded into other impact assessment problems related to lowland areas.

The Concept of Zonal Impact Assessment

In balancing between demands and supplies of any infrastructures in the city, planners should consider the whole urban area before regarding any specific sites. To accomplish this goal, the study intends to propose an alternative impact assessment approach by using a zone-based model, namely Zonal Impact Assessment (ZIA) framework. The ZIA framework is defined as a strategic planning process for evaluating the impacts of traffics induced by land development projects at the zone-base. It aims to minimize undesired impacts or consequences of proposed development projects in order to find an optimum development alternative for the city areas. The traffic impacts of project are expanded to appraise other secondary impacts, including economic, environmental, and social impacts, of such new trips. In this article, the economic secondary impacts are focused on travel costs including vehicle operating costs and travel time costs. All impacts are assessed and analyzed in the zonal level. This can improve the incompatibleness between land use and transportation planning levels in order to perform the effective planning integration. The public preferences are also considered in the zone-base, so that the communities can really determine the development impacts of forthcoming projects towards their living conditions. These zonal preferences are determined to estimate the public willingness to accept the undesired impacts for each zone. This is a way to encourage the public participation into the preliminary stage of the urban planning process.

Regarding the development impacts on transportation networks, the ZIA framework can be separated into five parts that are inter-related, consisting of the land use development side, transportation network side, zonal impact assessment, evaluation of land development control plan, and identification of sensitive areas for land development projects, as illustrated in Fig. 1.

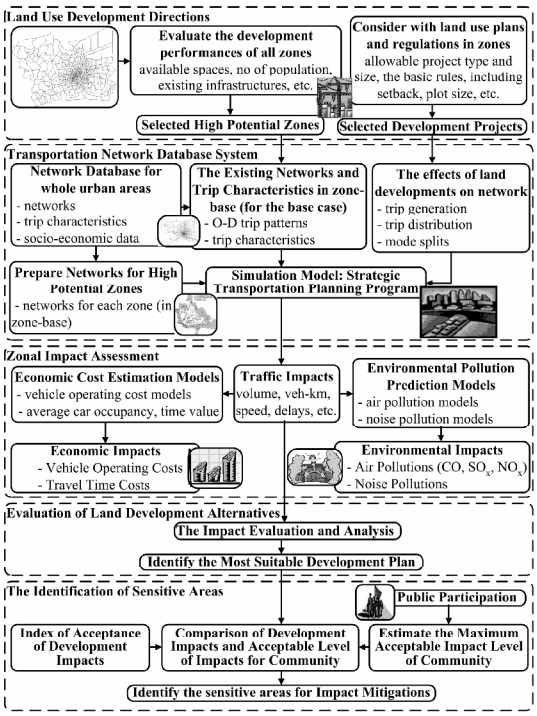


Fig. 1 The framework of Zonal Impact Assessment (ZIA)

The land use development directions

This section considers about the performance of land development in each urban zone based on the zonal characteristics, including available space, number of population, existing infrastructures etc. All zones should be included into the evaluation to investigate the directions of the developments. In case of a big city like Bangkok, the whole urban area can be considered based on the existing boundaries of districts, and then let the authorities of each district conduct the study for their own sub districts. It could be noticed that the necessary data should be in the zonal data format, which is the existing format of urban planning databases for many projects in the most cities. In this case, the data acquisition is not costly compared to the establishment of new necessary database system. The national and regional plans, moreover, should be considered as a base direction in order to have the same development targets and be consistent. For example, the decentralization of Bangkok is the main policy in the present, thus the directions for developing each suburban center must be considered to know which parts of city have high development potentials in the future. After the evaluation, the high potential ones are selected for the next steps. The types, sizes, and other characteristics of development projects must be considered to be compatible with the present and future situations. All possible tendencies must be included in the analysis.

The transportation network database system

Normally, transportation planning is the analysis in macro scale, so the transportation systems are prepared for the whole city areas, not in specific zones or areas. To appraise the impacts in the zonal level, planners need to rearrange the existing network database into the zone-base format. The total networks have to be classified and kept into each zone that they are located. Eventually, the new database can show that any zone occupies which part of entire network. The present condition of urban travel characteristics in the study area, including Origin-Destination (O-D) distribution patterns, mode splits, etc, is utilized as the base case in the impact assessment process. According to the previous step, the anticipated development alternatives are evaluated the effects on the transportation systems in the manners of trip generation and distribution. The traffic simulations for the base case (or without project) and all development alternatives are performed to evaluate the impacts.

The zonal impact assessment

The traffic impacts, such as vehicle-delays, vehicle-kilometers, etc, are quantified in this step by considering the zonal level. Afterwards, these traffic impacts are utilized into the processes of environmental and economic impact assessments. To calculate both secondary impacts, the environmental and economic impact estimation models are essential. The planners may review and collect the information of impact models from other studies in the same study area or in other areas that have the similar conditions. Although, travel cost and traffic pollution impacts are taken into account as economic and environmental impacts in the study, this paper mainly emphasizes on the secondary impact evaluation of travel costs. The assessment of pollution impacts for development alternatives are described in Limapornwanitch et al. (2004).

The evaluation of land development alternatives

After the zonal impact assessment process, the results of all development alternatives are analyzed and compared to find the optimum development option. The most suitable alternative should be the one minimizing the adverse development impacts. Based on this optimum alternative, planners can control the development projects in the study area to be compatible with the plan. This can encourage the balances between access demands of developed areas and transportation network capacities for those areas.

The identification of sensitive areas for developments

For many times, when a development project is introduced into an area of the city, it can create both positive and negative impacts. While the residents in the developed area gain the benefits from the project, people in other areas may indirectly suffer from its adverse effects. This is unfair for the stakeholders who do not directly earn the advantages of project, but they are unavoidably affected by such undesired impacts. The study realizes the importance of this social issue, so it tries to identify those areas as "Sensitive Area". The definition of sensitive area is explained as area(s) which is affected by adverse impact costs that is larger than a community's willingness to accept such undesired development impacts in that area. According to the definition, the

sensitive area can be determined through the ratio of total development impact costs in a zone to the community's willingness to accept the impacts in that zone as shown in Eq. (1). This ratio is called "Index of Acceptance of Development Impact" (IADI). In evaluating willingness of community, it is estimated based on the acceptable increases of travel cost and time for people. Moreover, it is also assumed that willingness is mainly dependent on the trip productions and attractions in a zone, and the influences of pass-by trips in that zone can be neglected. The willingness estimation will be discussed again in the case study.

$$IADI_j = \frac{TI_j}{W_j} \quad (1)$$

Where $IADI_j$ = Index of Acceptance of Development Impact in Zone j
TI_j = Total Development Impacts in Zone j
W_j = Willingness of Community in Zone j to Accept Development Impacts

As shown in Eq. (1), the zone with an index higher than 1.0 can be identified as a sensitive area. This is because the development impact costs generated in the zone exceed the acceptable level of the community. Therefore, planners should pay more attention to mitigate the negative impacts of land developments in that area. They should compromise between the stakeholder group earning the benefits and the one losing their welfare.

From the discussed ZIA framework, it can be seen that the ZIA framework consists of four characteristics of strategic planning approach. First, it is oriented toward the future. It recognizes that the land-use conditions will change in the future. It is a long range orientation, one that tries to anticipate events rather than simply react as they occur. It is recognized that the future land developments are difficult to be controlled, but argues that by anticipating the future developments, the plans can help to shape and minimize the negative impacts of urban developments. Second, the strategic approach has an external emphasis. Many external components are concerned, such as the influences on national and regional development plans, various secondary development impacts like pollution and travel cost impacts. In fact, it can be extended to cover other external matters such as political and social dimensions etc., as well. Third, the strategic approach concentrates on assuring a good fit between the real land-use conditions and planned ones and attempts to anticipate what will be required to assure continued fit. Under the conditions of rapid urbanization in developing cities, the ZIA framework can be quickly and continuously re-assessed and modified based on the evolving situation. Finally, this proposed framework is a process. It is continuous and recognizes the need to be open to changing goals and activities in light of shifting circumstances within the urban growth conditions. It is a process that requires monitoring and review mechanisms capable of feeding information to planners continuously. The strategic planning approach is not something that can be applied only once and forgotten or ignored.

To illustrate the ZIA application, it was applied into Bangkapi, Bangkok, as a case study. The details of case study are described in the next section.

THE APPLICATION OF ZONAL IMPACT ASSESSMENT: A CASE STUDY OF BANGKAPI AREAS

This section aims to demonstrate the application of the ZIA framework through the Bangkapi areas as the case study. The study areas include all zones of Bangkapi district and some of Wangthonglang district. Before 1998, these zones were under Bangkapi District, hereafter all of them are referred as "Bangkapi areas". They are located in the low areas, which have a pan shape. There are three reasons for selecting Bangkapi areas as the case study. First, these areas are the sub centers in Bangkok with various activities, including education, business, and commerce. They are accepted as the high potential development areas in Bangkok together with various negative impacts. Second, because of lack of efficient land use control measure in Bangkapi, it results to the generation of many shopping centers and markets along the road sides of main routes. They cause the severe traffic congestion problem, especially during the peak hours. Therefore, it should find some measure to control or mitigate the adverse impacts of land usages. Third, it is because the advantages of data availabilities, including transportation network database and impact estimation models.

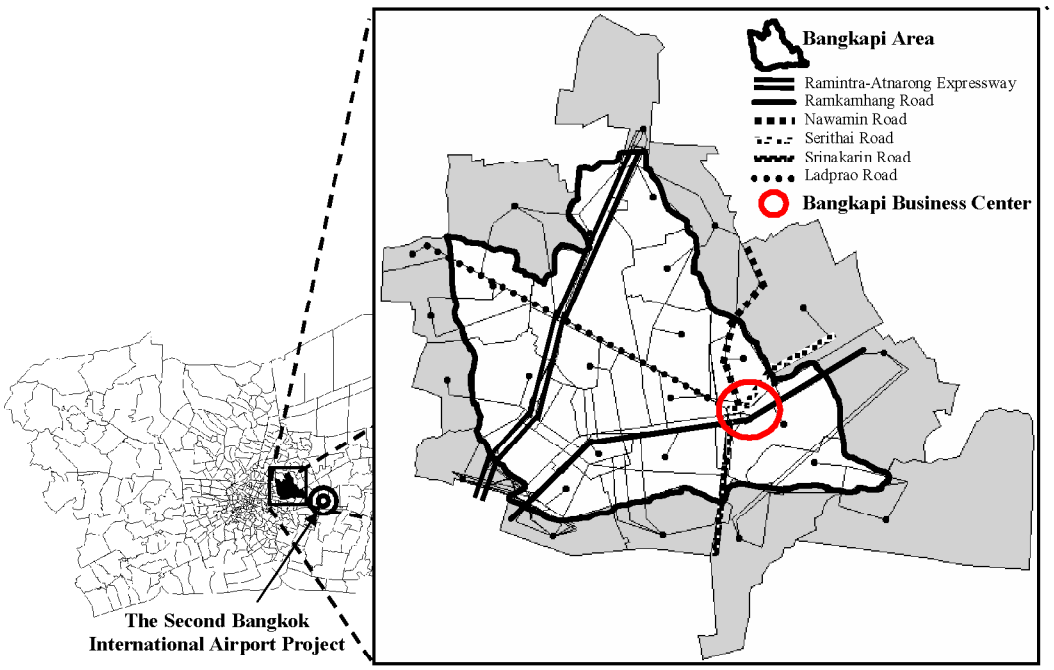


Fig. 2 The location and transportation networks of Bangkapi areas

In order to analyze the characteristics of the study area, it was essential to review the general information. This intended to draw the present situation of the areas, and to investigate and assess the development potentials to represent the future directions. The high potential zones are selected and analyzed in the next step. The analyzed development project is selected and its characteristics are explained. To cover all development cases, all possible strategies of analysis are developed and simulated by the traffic simulation program. After the simulations, their impacts are quantified in the process of zonal impact assessment. To identify the sensitive area for development impacts, the step of data collection for public preferences and the statistical analysis are performed to determine the community's willingness to accept total negative impacts in each zone. Finally, the implication of study is discussed to draw some useful findings.

This study mainly utilized the transportation databases of networks, areas, and socio-economic data for the Bangkok Metropolitan Region. The necessary data were available from the Urban Transport Database and Model Development (UTDM) Project established in 1998, and the Transport Data and Model Center (TDMC) Project in 2000 (OCMLT 1998 and 2000). Moreover, the data of land use planning were also included into the analysis.

The Background of the Study Area

The study area consists of two sub districts of Bangkapi, Huamark and Khlongchan sub districts, and one from Wangthonglang sub district. They cover the areas of 16.46, 12.79, and 19.66 square kilometers, respectively. There are many main transportation facilities implemented, particularly for the Ramintra-Atnarong expressway, Ramkamhang, Nawamin, Serithai, Srinakarin, and Ladproa roads. These networks promote this area to be the business and activity centers. Moreover, according to the Second Bangkok International Airport Project, it significantly supports the development potentials that expanded from the Bangkok centers into the Bangkapi areas (see Fig. 2).

To prepare transportation database for zonal impact assessments, the study areas could be separated into 14 internal zones as shown in Fig. 2. However, the study also included 13 external zones in the simulation systems in order to consider the trips going in and out of study area. In addition, zonal code and its total number of populations in each internal zone can be demonstrated in Fig. 3.

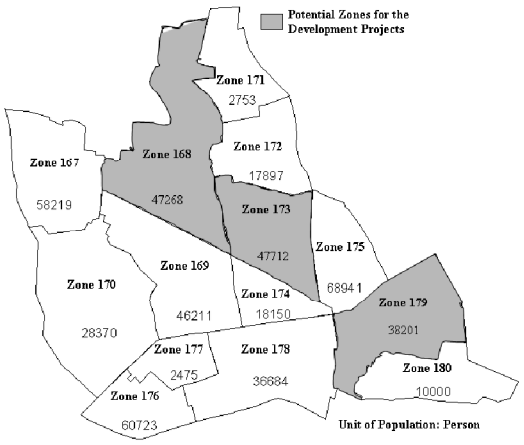


Fig. 3 Populations in each internal zone and the location of Zones 169, 173, and 179

The Land Use Conditions of the Study Area

In Bangkapi, the agricultural areas and vacant spaces are about 15.46 % of total land areas. This indicates that most of the areas are dedicated for buildings and activity areas. The houses or villages are the highest proportion of land usages, about 73.41 %, and the second is for office buildings, about 21.24 %. The rest includes the commercial houses, industrial and store areas, and others. The land prices of these areas are gradually raised as the results of economic benefit increases. By considering the location of Bangkapi, and its infrastructure performances, it is believed that Bangkapi has a full potential for land developments. Especially, it can play the role as the transition zone to connect between inner and outer Bangkok areas in the Eastbound approach (DCP 2002).

The Characteristics of Analyzed Development Projects

To analyze the impacts of development projects, this study considered a shopping center project as the analyzed development project. Due to a lot of residents living in this study area, many projects of shopping centers have been proposed by developers. The research conducted the field surveys to investigate the possible locations for project developments. In addition, the present characteristics of each zone, such as number of populations, present land use conditions, provided infrastructures, available spaces etc., were also considered to evaluate those possible locations. Eventually, there were three potential zones, including Zone 168, 173, and 179, selected for demonstrating the ZIA application as shown in Fig. 3.

Due to the influences of Ramintra-Atnarong expressway, it can be expected that the zones next to the expressway, Zones 168 and 170, are going to be built up in the forthcoming future. Nevertheless, because of high number of population, only Zone 168 was selected into the analysis. In fact, this zone is controlled as the low residential areas, but the land use regulations are very weak, so some big land development projects are expected to be established. For example, if the commercial project provides the right of way from the main road more than 18 meters, the project can be approved. In addition, if there is the proportion of proposed land development project in the area not more than 10 % of total area, then it is also acceptable. For Zone 173 and 179, they are located near the Bangkapi Business Center promoted by BMA and the direction of eastbound developments along Ramkamhang and Serithai roads, there is no doubt to include them into the study.

Based on the reviews of shopping center projects in Bangkok and Bangkapi, the basic characteristics of shopping center project in this study were assumed as shown in Table 1.

Table 1 The characteristics of the shopping center project

Item	Information
Type of Land Use	Shopping Center
Gross Floor Area (m^2)	200,000
Generated Trips during Evening Peaks for Weekday (pcu-trips/100 m^2/day)*	2.96
Estimating Factors	Floor Area
Land use unit as activity measure	Not Considered
Service Hours -10:00 AM-10:00 PM (hours/day)	12
Assumption of New Traffic	Yes
Assumption of Primary Trips	Yes
Peak Hour Selection	Evening Peak

* Source: Chaiyasate (2000)

From Table 1, the conventional trip rate analysis method based on floor area of the shopping center, 2.92 pcu-trips/100 m^2/day, was utilized to predict the

amount of generated traffics. It was assumed that all trips generated by proposed shopping center are the new trips, and because of the evening peak conditions, these new trips should be assumed primary trips. Regarding traffic conditions in Bangkapi, it was found that many shopping trips are made after daily working, therefore the effects of induced trips on road traffic should be taken into account for evening peak period on weekday. In addition, to cover all possible development cases, not only the cases of single development in a single zone were considered, but the simultaneous developments, often occurring in Bangkok and other developing cities, were also included as shown in Table 2. All simultaneous development cases referred to the same type and size of projects in order to determine the actual effects of transportation capabilities in serving travel demands of each zone. These development alternatives were simulated and analyzed into the steps of traffic simulations and impact assessments. The base case (without project) was also simulated for the purpose of alternative comparisons. The base O-D trip distribution for Bangkapi is illustrated in Fig. 4. To perform the traffic simulations, we have developed the Strategic Transportation Planning Program in this study.

Table 2 The Development Alternatives for Zonal Impact Assessments

Type	Group	Analysis Case	Zone		
			168	173	179
Base Case	Without Project	No. 1			
Single Development	One Project	No. 2	○		
		No. 3		○	
		No. 4			○
Simultaneous Developments	Two Projects	No. 5	○	○	
		No. 6	○		○
		No. 7		○	○
	Three Projects	No. 8	○	○	○

○ means the project is implemented in the zone.

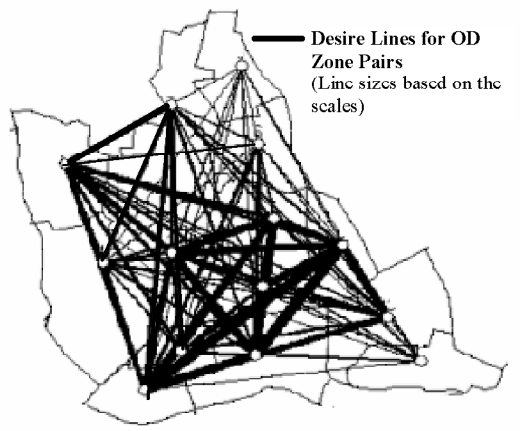


Fig. 4 The O-D distribution in the internal study areas of Bangkapi for the Base Case

The Zonal Impact Assessment for Development Alternatives

After the simulations, the traffic conditions of each analysis case were examined. Basically, the numbers of, pcu-hr/hr, vehicle-kilometer (Veh-Km: unit of pcu-km/hr), vehicle-travel time (Veh-Time: unit of pcu-hr/hr), average speed (Ave. Speed: unit of km/hr), and total flows (unit of pcu/hr), are considered as the indicators of traffic impacts, because they represent the quantity and quality of networks, respectively. As shown in Table 3, it can be seen that all development alternatives gave the increased traffic indicators for total networks in the internal and external zones. It presents that as the results of development projects, more trips were made in the internal and external study areas, and the traffic conditions of some areas were more congested. These results were reasonable because when the new trips had been induced by the shopping center project in the system, more traffic should be added together with higher number of Vehicle-Kilometer and Vehicle-Travel Time. While some alternatives might increase the traffic indicators more than the others, the highest traffic indicators should belong to Case No. 8. This happens because all of three zones were implemented by new shopping center projects. Although, the numbers of vehicle-kilometer and vehicle-travel time in Case No. 4 and 5 were higher than in the base case, it was found that the average speeds of total areas were improved from 7.57 km/hr in the base case to 7.60 km/hr in the other two

alternatives. This might be because the traffics were reassigned in the networks more efficiently. The better equilibrium stages of system could be re-established and the congestions could be alleviated. However, these results were insufficient to evaluate the land development alternatives, so it was necessary to conduct more analyses. Further analysis considered the impacts generated in 14 internal zones only, the impacts of external zones were neglected for the discussion.

Table 3 The total traffic indicators of internal and external zones for each development alternative

Case	Veh-km	Veh-time	Ave. Speed	Total Flows
No. 1	749,397	98,960	7.57	1,656,150
No. 2	779,862	105,430	7.40	1,721,747
No. 3	764,493	103,327	7.40	1,681,464
No. 4	753,372	99,100	7.60	1,663,542
No. 5	756,046	99,492	7.60	1,669,236
No. 6	766,157	103,974	7.37	1,687,941
No. 7	779,158	102,771	7.58	1,703,579
No. 8	784,528	106,995	7.33	1,747,249

These traffic impacts generated in each internal zone for each development alternative were employed to assess the secondary impacts of travel costs. The impact appraisals were conducted by separating the single and simultaneous developments. To estimate the travel costs imposed into each zone, the study utilized the value of time and vehicle operating cost estimation models developed by Department of Highway (DOH), Thailand (2000). Due to data limitations, the values of time for each trip purpose were not available in this study. The costs of travel time was estimated based on the total O-D trip data and the proportions of working and non-working trips, so it was assumed to consider only the values of travel time for working and non-working trips. This assumption might be not completely realistic, but it was possible to represent the tendencies of travel cost changes in each development alternatives. It was estimated that in 2003 the values of time for working and non working trips are 59.603 and 14.903 Baht/hour/person, respectively. The average car occupancy rate for Bangkok was estimated to be about 1.4 passengers/car. Figure 5 shows the estimation models of vehicle operating costs for year 2003 that employed in this study.

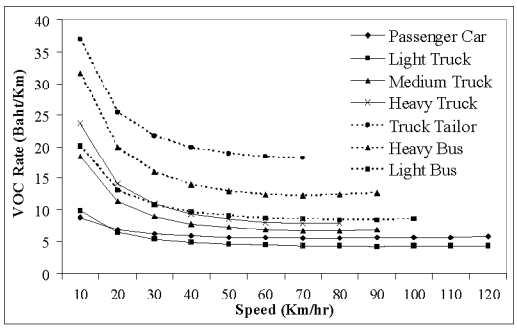


Fig. 5 The O-D distribution in the internal study areas of Bangkapi for the Base Case

The total travel cost impacts in each zone of single and simultaneous developments are illustrated in Table 4. Moreover, these zonal impacts could be normalized among the impacts in all zones of each alternative by using Eq. (2) and (3) in order to obviously demonstrate the travel cost impact distribution as shown in Fig. 6. In Fig. 6 (a)-(c), the values of impact indices in each zone were classified into five levels, consisting very low (0.000-0.040), low (0.041-0.080), medium (0.081-0.120), high (0.121-0.160), very high impacts (0.161-0.200), respectively.

$$\varsigma_{i,j} = \frac{I_{i,j} - \check{I}_j}{\theta_j} \tag{2}$$

$$N_{i,j} = \frac{\varsigma_{i,j}}{\sum_{1}^{j} \varsigma_{i,j}} \tag{3}$$

Where

θ_j = $\hat{I}_j - \check{I}_j$

$I_{i,j}$ = Impacts in Zone j of Developmen t Alternativ e i.

$\check{I}_j$ = The Minimum Zonal Impact Compared with All Zones in Alternativ e i.

$\hat{I}_j$ = The Maximum Zonal Impact Compared with All Zones in Alternativ e i.

$\varsigma_{i,j}$ = Intermedia te Impact Index of Zone j in Alternativ e i.

$N_{i,j}$ = Index of Normalized Impacts in Zone j of Alternativ e i.

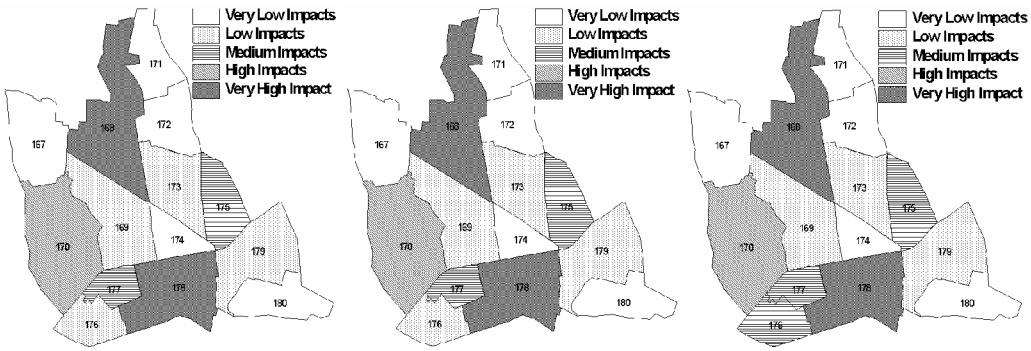
The Single Development Cases

Based on the total zonal travel cost impacts, it was found out that for single development alternatives, Case No. 4, the implementation of project in Zone 179, was the most suitable area for the proposed new shopping center, as shown the minimum total impacts, 8,222,212 Baht/hr. Zone 179 is located in the center of radial networks in Bangkapi, approached by many main roads, therefore this zone has fully the

Table 4 The zonal travel cost impacts of all development alternatives in Bangkapi areas

Zone	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
167	346,832	389,714	307,989	312,834	329,464	361,739	311,115	334,426
168	1,408,328	1,396,296	1,416,941	1,387,170	1,364,772	1,457,486	1,400,076	1,445,479
169	509,282	509,914	480,469	525,175	488,253	453,476	484,007	497,546
170	969,616	1,034,292	1,209,672	1,112,627	992,707	1,076,335	1,033,791	1,092,472
171	243,424	236,114	206,492	184,185	221,600	246,793	242,499	257,086
172	71,133	69,745	75,018	69,678	63,690	60,545	80,107	70,134
173	519,060	508,950	515,515	486,812	508,636	518,607	480,540	504,515
174	194,107	178,119	168,832	169,867	178,784	167,626	198,967	167,220
175	688,174	716,079	690,475	689,038	709,647	707,760	792,666	761,371
176	600,895	727,130	647,841	587,414	711,952	673,207	549,102	547,395
177	810,952	773,276	846,451	753,048	745,472	807,618	833,259	803,179
178	1,330,295	1,399,460	1,379,745	1,341,170	1,342,304	1,367,754	1,456,931	1,425,107
179	372,522	408,110	368,115	383,311	389,632	398,117	418,786	447,170
180	230,663	228,893	280,567	219,883	215,865	267,637	258,076	305,730
Total	8,295,283	8,576,092	8,594,122	8,222,212	8,262,778	8,564,700	8,539,922	8,658,830

Unit: Baht/hr



(a) Case No. 1 (b) Case No. 4 (c) Case No. 5

Fig. 6 The normalized travel cost impact distributions of (a) Case No. 1, (b) Case No. 4, and (c) Case No. 5

accessibilities from other zone in the study area. For Zone 168 and 173, they were the second and third suitable zones, respectively. Zone 168 was more suitable than Zone 173, because the better transportation systems, the Ramintra-Atnarong expressway, are located in the zone and effectively distribute the traffics for Bangkapi areas.

The Simultaneous Development Cases

As shown in Table 4, if there were two similar projects implemented in two zones at the same time or a certain period, the best case was the implementation of projects in Zone 168 and 173. It might be because the case of development projects in Zone 168 and 173 could attract some trips that are concentrated in the areas of Zone 176 and 178. The later two zones are very crowded commercial areas along Ramkamhang road, to their areas. Many trips that ever travel through Zone 170, 176, and 178, could go directly to the new activity areas, eventually it helped to efficiently rearrange traffic distributions in the network. Consider the case of developing Zone 173 and 179, Case No. 7, it generated higher impacts than in the case of Zone 168 and 173, Case No. 5, because Zone 173 and 179 are located near the center of Bangkapi that has the severe congestions. The new trips getting into these zones had to travel through Ladprao and Ramkamhang roads which were so

congested already. As the results, the performances of networks around the Bangkapi Business Center could not handle those travel demands and they created the huge travel cost impacts. There was no doubt that the case of developments in all of three zones had the most severe travel cost impacts.

Comparing the zonal impact distributions of the best single and simultaneous development alternatives with the base case in Fig. 6 (a), it was found that for Case No. 4 in Fig. 6 (b), the project implemented in Zone 179 would insignificantly increase travel cost impacts in each zone. The levels of zonal travel costs were not changed obviously as shown by the similar zonal impact levels between Case No. 1 and 4. For the simultaneous developments, Fig. 6 (c) presents that the level of impacts in Zone 176 was evidently changed from low to medium levels after implementing the new shopping centers in Zone 168 and 173.

Although, the zonal impact levels of development alternatives were not changed obviously, it could be seen from the changes of zonal travel costs in each alternative compared to the base case in Table 4 that when the project located in Zone 179, the travel costs in Zone 170 was hugely increased. This might be because of the attractiveness of the good networks in this zone. The networks of Zone 170 connecting Ladprao to Ramkamhang roads for approaching to Zone 179 make many travelers to pass through the zone with higher travel costs. Moreover, Zone 169, 175, 176, 178, and 179, were increased in the travel cost impacts. In the case of projects in Zone 168 and 173, the travel costs in Zone 176 were observably increased as shown in Table 4. The travel costs in Zone 170, 175, 178 and 179, were increased by the small amounts compared with Zone 176.

From these assessments, it is very obvious that the capabilities of transportation systems in and around the developed zones should be considered for planning and controlling urban growths. This helps to balance the travel demands for any activity area and its own network capabilities. It was found that the ZIA framework can evaluate the zonal development impacts to find an optimum development alternative of the city areas. The impact distributions were illustrated to investigate that how impacts of proposed development project(s) are distributed from the developed zone(s) to the other zones. Next, to identify the sensitive area of development projects, the economic impacts from Case no. 4 and 7 were utilized. In addition, the stakeholders in Bangkapi were included into the process of public participation in order to estimate the willingness to accept the development travel cost impacts.

THE IDENTIFICATION OF ACCEPTABLE LEVEL OF MAXIMUM NEGATIVE IMPACTS

To identify the sensitive zones towards the economic impacts generated by the developments, the willingness of community to accept the travel cost impacts has to be determined. To do so, the questionnaire surveys were conducted to collect the public opinions and their preferences. First, it was believed that the preferences of stakeholders in each zone can be different, thus their willingness can be different as well. The study separated the data collection into two levels. The first level focused on the data collection of whole study area in order to cover the stakeholders' preferences in each zone, therefore the cluster sampling method was utilized into the study area. This method separated Bangkapi areas into 14 internal zones as same as the zoning system of the existing transportation planning databases. The second level concerned about collecting data in each zone. Based on the assumption of homogeneities inside of the zones, the random sampling method was employed to collect the data from each community.

To estimate the number of samples in each zone, the income of people in Bangkapi was assumed to represent the characteristics and attitudes of people in the study areas. The income data of other studies in Bangkapi areas were utilized to estimate the required numbers of samples (N) by using $N = [Z_{1-\alpha/2}*\sigma/E]^2$. The data for this study were collected from the questionnaire surveys conducted. Of the total 1,450 questionnaire sets distributed, 1,064 (about 73.4%) were retrieved and after the data preliminary verification was done only 972 were found to be valid, which was roughly 91.4% of the obtained samples, as shown in Table 5. In the questionnaire surveys, the stakeholders were asked to answer the information for estimating the acceptable levels of maximum economic impacts for their areas, as can be shown the related questions in Fig. 7.

Table 5 The number of samples (person) in the questionnaire surveys

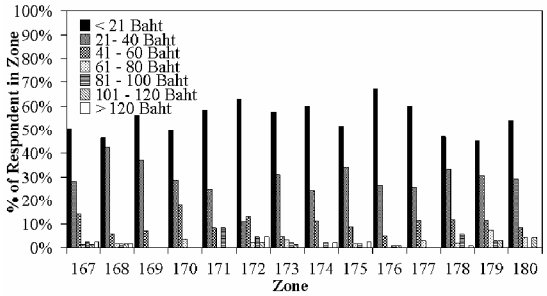
Zone	Required Samples	Obtained Samples	Final Samples
167	66	90	85
168	54	79	71
169	51	84	73
170	33	60	56
171	6	15	12
172	21	54	46
173	54	95	90
174	21	51	45
175	78	135	129
176	69	143	128
177	3	38	35
178	42	111	109
179	42	79	69
180	12	30	24
Total	552	1,064	972

A. If a development project is implemented in this area, and create more congestion with the increase of travel cost. How much is the maximum cost increased that you can accept?
□ less than 21 Baht/Trip □ 21-40 Baht/Trip □ 41-60 Baht/Trip
□ 61-80 Baht/Trip □ 81-100 Baht/Trip □ 101-120 Baht/Trip
□ more than 120 Baht/Trip

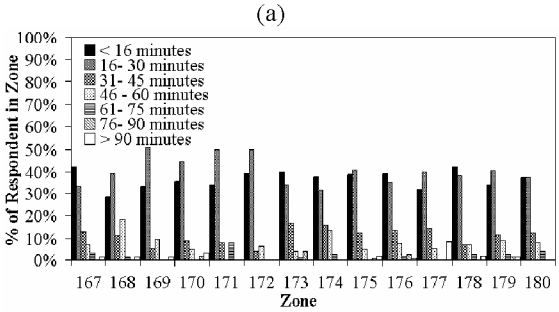
B. If the project also causes to increase travel time. How much is the increased maximum travel time that you can accept?
□ less than 16 Min./Trip □ 16-30 Min./Trip □ 31-45 Min./Trip
□ 46-60 Min./Trip □ 61-75 Min./Trip □ 76-90 Min./Trip
□ more than 90 Min./Trip

Fig. 7 The questions in the surveys to estimate the willingness to accept the travel cost impacts

From the surveys, the distributions of maximum increases of travel time and travel cost impacts for the stakeholders in each zone were determined and are given in Fig. 8 (a)-(b). In order to determine the relationships between the acceptable maximum impact levels and the zones or areas of stakeholders, the Pearson Chi-Square (χ^2) tests were performed as shown in Table 6. It was found that the values of Asymptotic Significance were higher than the significance level at 0.05 (α) for travel time and travel cost impacts. Therefore, in both cases the hypotheses, H_0, were accepted. These explained that the acceptable maximum increases of travel cost and travel time for the stakeholders were not dependent on the zones or locations of stakeholders. It might be because the traffic congestion is spread over for the whole Bangkok City, which indicated that the stakeholders could face the same problem in everyplace, not dependent on the location. Therefore the maximum acceptable impacts were not for any specific places, but they were for the whole city area. Eventually, it was unnecessary to individually estimate the maximum levels of negative economic impacts for each zone. The average levels of acceptable maximum impacts for travel time and travel cost were calculated for the overall study areas as 24.691 Baht/Trip, 23.349 Minutes/Trip, respectively.



(a)



(b)

Fig. 8 The distributions of acceptable maximum impacts of (a) travel cost and (b) travel time for each zone

Table 6 The results of the Pearson Chi-Square tests for the interrelations between impacts and zones

Hypothesis H_0	Asymp. Sig.	Sig. Level	Results
The travel cost impact is independent from the zones	0.076	0.05	Accept H_0
The travel time impact is independent from the zones	0.204	0.05	Accept H_0

To calculate the willingness to accept the travel cost impacts, consisting of travel time and vehicle operating costs, for each zone, some necessary information was employed, such as number of zonal

trip attractions and productions, average car occupancy rate etc. The willingness to accept the economic impacts could be estimated and illustrated in Table 7. In addition, Total Development Impacts of Zone j (TI_j) in Eq. (1) could be estimated by Eq. (4) to calculate the IADI index for identifying the sensitive area. The zones that had increased in travel cost impacts in the best development alternatives, Case No. 4 and 5, were considered for the IADI calculations. As the stakeholders in such zones were affected by the adverse effects of travel cost increases, they might oppose the planned development alternatives, if there were no other measures to relieve the undesired impacts in their communities. Therefore, planner should realize that which zone is sensitive towards the impacts generated by proposed developments, and try to find some mitigation plans for that area. The results of IADI calculations could be illustrated into Table 7.

$$TI_{j,i} = I_{j,i} - I_{j,1} \quad (4)$$

Where $I_{j,1}$ = Impacts of Zone j in Base Case (Baht/hr)
$I_{j,i}$ = Impacts of Zone j in Alternative i (Baht/hr)

As shown in Table 7, Zone 170 was the sensitive zone in the case of single development in Zone 179, because of its IADI, 1.279, higher than 1.0. For the simultaneous developments in Zone 173 and 179, there was no the sensitive zone, as all values of indices were less than 1.0. However, it was noticed that the indices of Zone 176 and 170 were much higher than in the other zones. Therefore, planner should seriously pay attention to Zone 170 and 176 in mitigating the development impacts. Particularly in Zone 170, as there are not many resident areas and activity centers, so the populations and numbers of trip productions and attractions are very small. Based on this condition, the stakeholders would have the low willingness to accept the impacts. On the contrary, because of the attractiveness of high quality networks, Ramintra-Atuarong Expressway, in the zone, many trips going to the new shopping center pass by this zone. They generated the high travel cost impacts. If planners in Bangkok try to mitigate the impacts occurred around the site specific areas only, it seems to be unfair for the stakeholders in zone 170. The planners should provide some mitigation measures to relieve the adverse impacts in the zone. Someone may argue that the new traffics that pass through Zone 170 can create some economic benefits for the community, such as new business areas, increase of land price, etc. However, those benefits cannot be approved obviously in the short period, but the undesired impacts of more congested conditions are foreseeable in the near future. It is not only the increase of travel costs, but also the air and noise pollution issues, traffic safety matters can directly effect to the community. Planners cannot ignore the responsibilities to alleviate the problem for this sensitive area.

Table 7 The public willingness to accept travel cost impacts and the Index of Acceptance of Development Impact (IADI)

Zone	W_j *	Base Case	Case No. 4		Case No. 5	
		$I_{j,1}$ *	Project in Zone 179		Projects in Zone 168 and 173	
			$I_{j,4}$ *	$IADI_{j,4}$	$I_{j,5}$ *	$IADI_{j,5}$
169	268,660	509,282	525,175	0.059	-	-
170	111,784	969,616	1,112,627	1.279	992,707	0.207
175	356,703	688,174	689,038	0.002	709,647	0.060
176	411,323	600,895	-	-	711,952	0.270
178	283,639	1,330,295	1,341,170	0.038	1,342,304	0.042
179	155,873	372,522	383,311	0.069	389,632	0.110

*Unit: Baht/hr
- The impacts of the zone were not considered.

CONCLUSIONS

We have proposed the Zonal Impact Assessment (ZIA) framework as an alternative tool for effectively controlling urban developments in the city areas. It was found that the traffic conditions of zones can influence the performance of areas in serving the land use developments. The areas located near the high capacity networks have the higher capabilities to handle the travel demands of forthcoming activity centers. Particularly, when their traffic conditions are not congested, the impacts generated by the projects in such zones will be insignificant. This can be seen that the suitable single development should be implemented in Zone 179. Because it is located in the center of main radial networks, it is provided by the full accessibilities, thus the minimum travel cost impacts were generated. In the case of simultaneous developments, it emphasized again that the performances of networks in the zones have to be thoroughly considered when many projects are introduced for many areas of city. As shown, Zone 179 was the suitable location for one project, but if many projects were implemented in the vicinity areas, like in Zone 173 and 179, they would create huge travel cost impacts. Eventually, two shopping center projects were recommended to be located in Zone 168 and 173. Therefore, if planners want to promote Zone 179 as the center of Bangkapi, they should strictly prohibit other developments in the adjacent areas. Alternatively, they should improve the network performances in these adjacent zones. Otherwise, they should promote the projects for Zone 168 and 173.

The impact distributions can be demonstrated by the zonal impact assessments. This helps to investigate how the impacts of development project in a zone can affect other zones. It also proposed an alternative to identify the sensitive area based on the willingness of community in each zone. By using the proposed Index of Acceptance of Development Impact (IADI), Zone 170 was the area that planner should provide more attention to mitigate the impacts for both single and simultaneous developments. Zone 176 should be taken into account for mitigating impacts in the simultaneous development case. These sensitive areas pointed out that planners should not only be concerned with the impacts of the areas near by the site location only, other far zones should be considered into the impact mitigation plan as well. In the further study, the ZIA framework can be expanded into the study of integrated development impacts. Various impacts should be concerned, such as environmental aspects etc. Additionally, the powers of stakeholders are included into the integration of impacts.

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