ZONAL IMPACT ANALYSIS OF A STRATEGIC PLANNING APPROACH FOR LAND DEVELOPMENT CONTROLS

– A Case Study of Bangkapi, Bangkok –

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Due to rapid urban developments in developing cities, the integration of land-use and transportation planning is very necessary. However, up-to-date land-use and transportation interaction planning is still difficult, because of rapid urbanization and complex relationships. The lack of human resources, budget, and necessary data are some of the hindrances. The planners in Bangkok have tried to utilize Traffic Impact Assessment (TIA) in harmonizing land developments and transportation improvements, but without a complete land-use comprehensive plan, the TIA cannot effectively manage urbanization. This paper intends to propose a Zonal Impact Analysis (ZIA) framework as a strategic planning tool to balance travel demands of land developments and performance of transportation systems over urban areas. First, the land-use planning situation in Bangkok is explained, afterwards the framework is described. The framework is applied into Bangkapi areas as a case study. Both single and simultaneous development cases are considered. It was found that more comprehensive development alternatives were established. The most suitable zone for a single project is Zone 179, as the advantages of location in the center of radial networks, so full accessibility can be provided. Without any network improvements in Zone 179, the simultaneous developments should be implemented in Zone 168 and 173, as high capacities of the expressway are available. The results give a better understanding on the characteristics of land-use and transportation planning in Bangkapi. Finally, it was emphasized that the ZIA framework is a strategic planning alternative to increase the capabilities of growth management for sustainable developments.

Key Words: Traffic impact, Impact assessment, Zonal Impact Analysis, Land-use control, Strategic planning approach

1. BACKGROUND

The transportation improvements and land-use controls of mega-urban regions in developing countries have not kept pace with the economic and urbanization growth for years. It has been pointed out that in developing cities urbanization is very rapid and dramatic, so the integration of land-use and transportation planning is very necessary[1]. However, up-to-date the interdependence of urban forms and transportation networks are still ignored in Southeast Asian cities like Bangkok, Jakarta, and Manila[1-3]. Particularly in the Bangkok Metropolitan Region (BMR), because the gross region domestic product per capita (GRDP) had increased from 1978 to 1988 as shown in Figure 1, it resulted into the growth of population, and the expansion of urbanized areas (see Figure 2).

From Figure 2, it can be seen that the areas within 2.5 km from the city center were saturated, the number of people in this area have increased at a very small rate around 0.1% during 1980 to 1986. In the opposite, the population of districts in the vicinity and suburb an areas were still increased at a rather high rate of about 2-4%. This tendency represents the suburbanization of BMR, that residential areas and activity centers are moving into the suburbs. Although, during the period of the economic crisis, 1997 – 2002, the urbanization process of Bangkok slowed down, after 2002 the growth has been stimulated again. Based on various development projects without any control strategies in suburban areas, Bangkok has become an auto-dependent city with severe traffic congestion spread from its core to suburban districts. This paper aims to propose an alternative strategic planning approach, the Zonal Impact Analysis (ZIA) model, to balance travel demands of land developments and performance of transportation systems over urban areas. First, the land-use planning situation in Bangkok is explained, and followed by the concept of the ZIA framework. Sec-

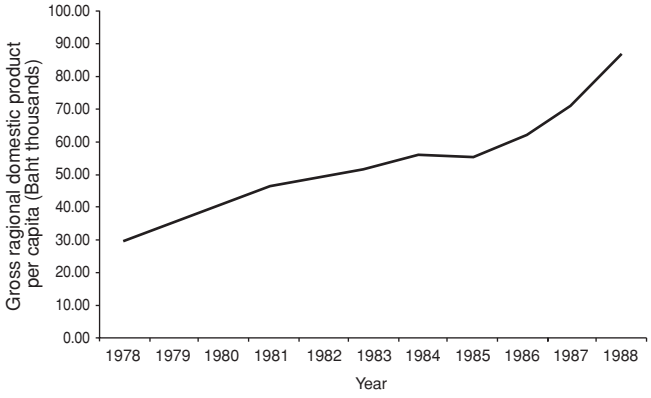


Fig. 1 Trends of increase of GRDP for BMR in 1978-1988

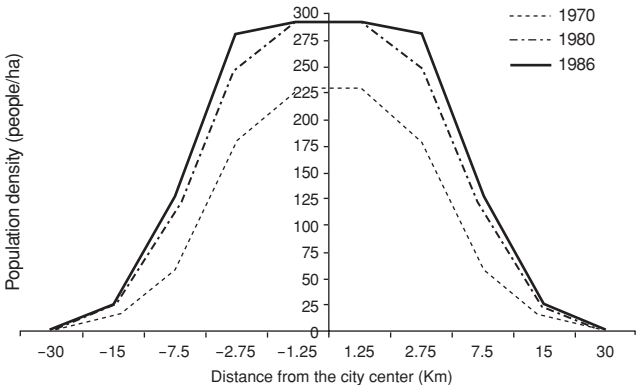


Fig. 2 Population growth for BMR urbanization in 1970s-1980s

ond, the framework application is described through a case the study of the Bangkapi area. Finally, the results of study are discussed and summarized in the conclusion.

2. LAND-USE AND TRANSPORTATION PLANNING IN BANGKOK

Land-use and transportation planning for Bangkok were principally integrated for the first time in the Seventh National Economic and Social Development Plan during 1992-1996. Under this plan, any new development project in Bangkok had to be controlled by the Enhancement and Conservation of National Environmental Quality Act of 1992. This means that the owner of a development project that has a number of parking lots of more than 300 parking units or gross floor areas larger than 2,000 square meters must conduct an environmental impact study, and submit a report to the Building Control Division (BCD) of the Bangkok Metropolitan Administration (BMA). The developer has to mitigate the adverse development impacts based on the suggestions of BCD for the project approval.

However, the Seventh plan was unsuccessful, due to the fragmentation of the responsibilities of the agencies concerned with: road building, infrastructure program, housing, and land-use plans. In fact, the inefficient plan and ineffective enforcement were also the main reasons for fruitlessly implementing the land-use controls. The plan has little or no control over the intensity of development nor does it suggest the meaningful ranges of density in each area or type of land-use. Worst of all, regardless of the size and location of a project, any development project can be officially approved as long as it does not violate the basic rules, including structurally safe standards in the Building Control Law, types of land-use prohibited by the City Planning Law. The existing rules for planning tools can only control the project as part of the building control system focusing on the building rather than its location that is a very important factor[4]. At present, it is under the Ninth plan (2002-2006), its goal is to decentralize the Bangkok Metropolitan Area into suburban areas like a polycentric city. It can be noticed that most specific contents of each plan in each period are insignificantly different, therefore the weak points of former plans cannot be significantly improved in the latter ones. To coordinate transportation improvements and land-use developments, most transportation projects refer to the land-use zoning plan provided in the comprehensive land-use planning process of BMA as shown Figure 3.

From the process, it is noticed that the transportation components are included into the land-use planning steps as an inactive element. The effects of land-use changes on transportation systems, especially in terms of trip generation, are not taken into account. It can be perceived that the comprehensive plan of BMA is planned without a systematic and analytical approach for transportation components. Any land-use types or regulations mainly come from the consideration of existing conditions, such as the existing land-use characteristics, physical environment of networks etc. The outcomes of this planning approach can be satisfied, if the city growth is not so rapid, and the relationship of urban structural components are not complex. However, this is inappropriate for swift urbanization and complicated interactions of the BMR. It cannot analyze the transportation capabilities in

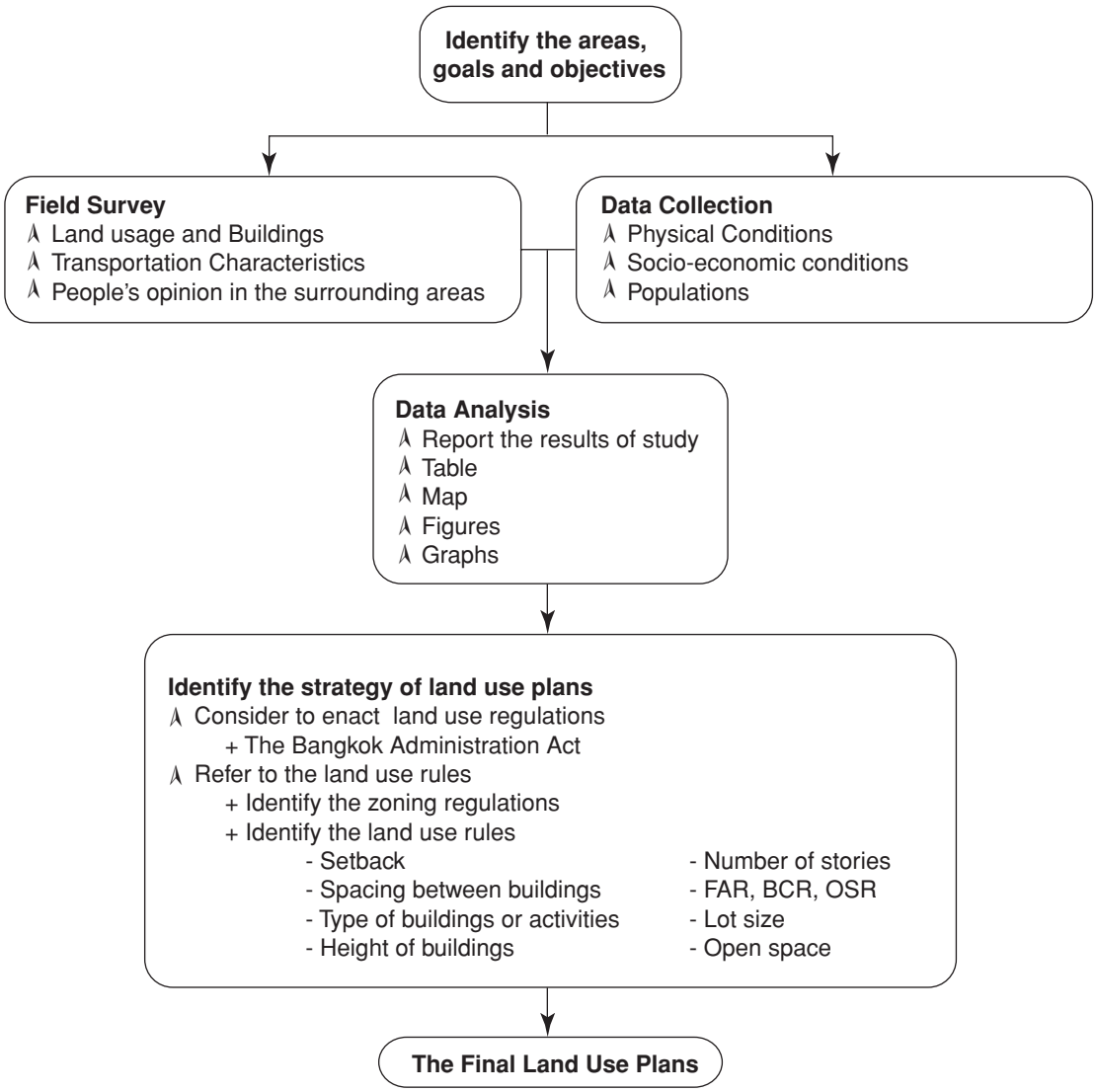


Fig. 3 The process of developing a comprehensive land-use plan in Bangkok

serving the land developments in each area. Particularly, when the government plans to expand Bangkok into suburban districts, it may be leading more ribbon developments along the main routes, and creating more super block areas in the city.

It is realized that to efficiently perform the integration of land-use and transportation planning, their interactions ought to be deliberated through advanced simulation techniques. However, in developing cities, such as Bangkok, Manila, and Jakarta, their urban growth is so rapid and complex, because of high density mixed land usages, hence it is very intricate to do so. In addition, there are the limitations of lack of human resources, budget, necessary reliable data [1]. The recent progress of land-use and transportation planning integration in developing countries are the challenges of traffic impact assessment (TIA) applications[6,7].

3. ZONAL IMPACT ANALYSIS: A STRATEGIC PLANNING ALTERNATIVE FOR LAND-USE AND TRANSPORTATION PLANNING

As explained before, the comprehensive land-use planning process in Bangkok neglects to systematically determine the land-use effects towards the transportation performances in each area. This leads to omit the basic land-use control rules about types and densities of buildings, which can have significant effects on traffic. Some

examples of existing basic rules are limits on floor area ratio, building setback, plot size, and spacing of entrance or exit from the properties to main roads. To cope with the development densities, only the basic rules about giving the allowable percentage of non confirming use within any zone is utilized, for example in a commercial area, other uses are limited to increase up to 10% of the total area for each of them. There is no mention of a traffic plan in the comprehensive plan, or no serious concerns about the network capability carrying travel demands in a developed area.

The direction of land-use developments and transportation improvements in developing countries is ambiguous. Most actions in their planning skills are just trying to apply some successful practices from other developed countries into those countries without a systematic planning process. Similar to the applications of TIA in Bangkok, although planners attempt to employ it to balance between travel demands and facility capacities, but they will not be able to avoid the situation of demand exceeding supply over urban areas. As the TIA concentrates on a site specific impact analysis, it cannot examine the harmonization of land-use developments and transportation performance at the macro level or whole urban area. It is pointless to discuss the lack of TIA standards, experts, and rigorous enforcements in Bangkok. For developed countries, the TIA can function well to mitigate the negative impacts of a project, because they have very complete comprehensive land-use plans, and also strong regulations and enforcement. Therefore, what the planners in developing countries urgently need is a strategic planning tool to develop their complete comprehensive land-use plan.

3.1 A strategic planning approach: Zonal Impact Analysis model

Generally, strategic planning is defined as a set of concepts, procedures, and tools designed to help planners or decision makers think and act strategically[8]. To improve the comprehensive land-use plan at the macro level of BMR planning, the strategic planning approach is vital. This paper intends to propose an alternative tool of strategic planning approach, **Zonal Impact Analysis (ZIA)** framework, to systematically control or design the land-use into the desired direction of sustainable development cities.

The ZIA framework, as shown in Figure 4, aims to assess the effects of land developments on the networks in each zone. It can aid planners to know the development capacities in each area, and limit their suitable sizes or types of development. Furthermore, the ZIA framework is designed to evaluate not only traffic impacts, but their secondary impact, including environmental and economic impacts. The framework is separated into four parts, consisting of land-use development directions, transportation network database system, zonal impact assessment, and evaluation of land development alternatives. The details of each part can be described as follows:

The land-use development directions: This part considers the performances of land development in each urban zone based on the zonal characteristics, including available spaces, population, the existing infrastructure etc. All zones should be included in the evaluation to investigate the direction of land development. The necessary data, including land-use, travel, and socioeconomic data, is in the zonal base, an existing data format of urban planning databases for most metropolitan cities. In this case, the data acquisition is not costly compared to the establishment of a new database system. Moreover, the national and regional plans should be considered as a basic direction to provide a consistent plan with the same development goal. For example, the decentralization of Bangkok is the main policy at present, thus the directions for developing each suburban center must be considered to know which parts of the city have the development potential in the future. The type, size, and other characteristics of land-use projects must be considered based on the real situation. All possible tendencies should be included in the analysis.

The transportation network database system: The transportation database system usually is prepared for the whole city area, not for the zone-bases. To appraise the zonal impact, planners need to rearrange existing databases into the zone-base formats. The total networks have to be classified and kept into the zones where they are located. Eventually, the new databases can represent which zone occupies which parts in the total network. The present conditions of urban travel characteristics in the study area, including Origin-Destination (O-D) distributions, mode splits etc., are utilized as the base case in the impact assessment process. According to the previous step, the expected development projects appraise the effects on the transportation systems, such as trip generation and distribution for the project. The traffic simulations for the base case (or without development project) and with project cases are performed to evaluate the impact.

The zonal impact assessment: The traffic impact, such as vehicle-delays, vehicle-kilometers, etc., are quantified in this step by considering the zonal level. Next,

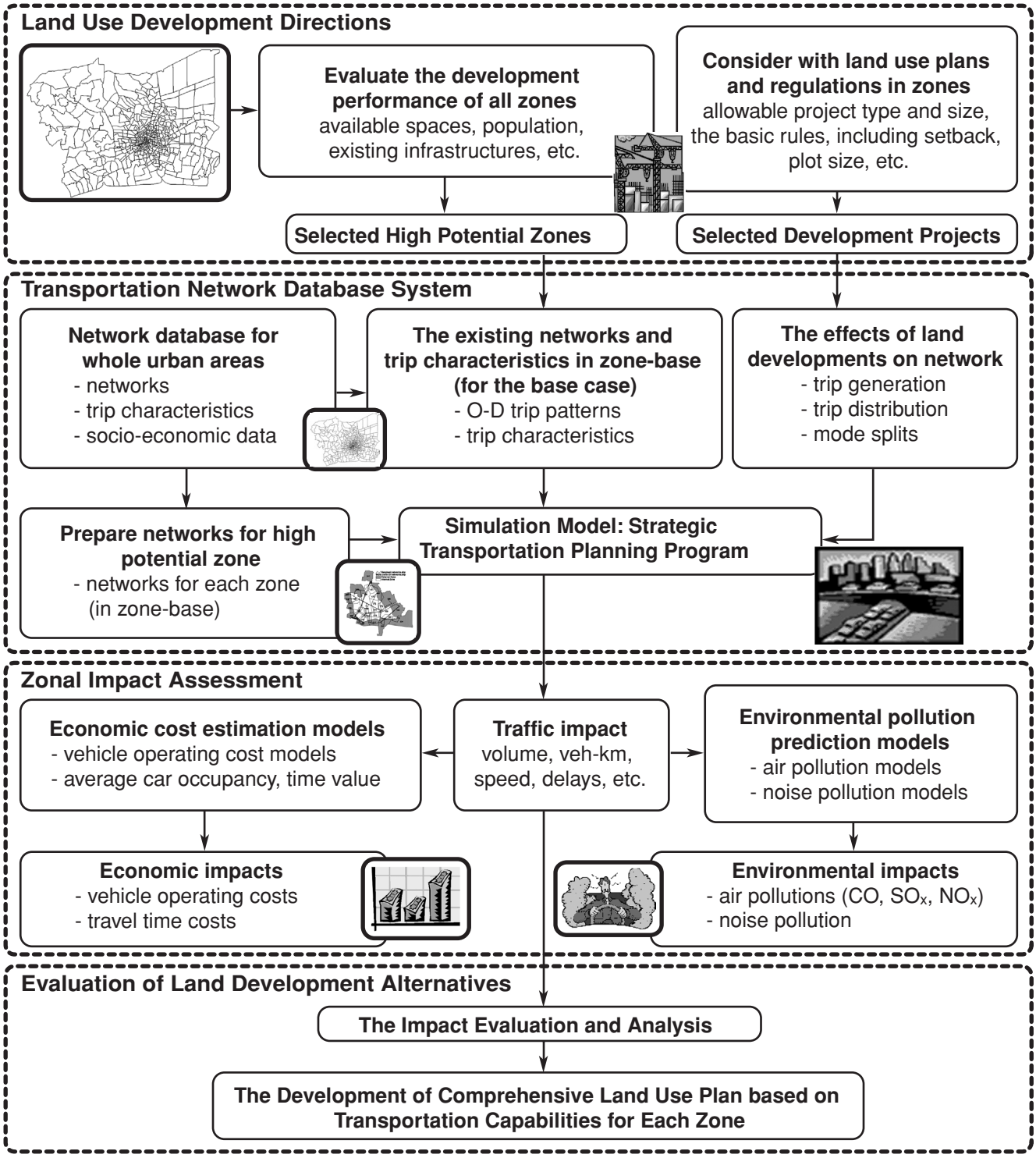


Fig. 4 The framework of Zonal Impact Analysis (ZIA) model

these traffic impacts are utilized into the processes of environmental and economic impact assessments. To evaluate both kinds of secondary impact, the inventory data of essential models, parameters, basic information, such as air pollution prediction models, vehicle operating cost estimation model, and value of time, in the study area must be collected and reviewed.

The evaluation of land development alternatives: After the zonal impact assessment process, the results of all cases are analyzed and compared to find an optimum development alternative, which maximizes the social benefits or minimizes the social costs. Based on the selected alternative, the comprehensive land-use plan can be performed to harmonize between land developments and transportation capabilities for each area of a city. The undesired impacts, including more congestion, high travel costs, environment degradation, should be diminished to lead the city into sustainable development.

To illustrate the application of the proposed ZIA framework, a case study was conducted. The study was applied to Bangkapi District of Bangkok to illustrate how to employ the proposed framework to improve the existing land-use planning by concerning transportation issues. The details are explained in the next section.

4. THE APPLICATION OF THE ZONAL IMPACT ANALYSIS MODEL: A CASE STUDY OF BANGKAPI AREA

This section aims to demonstrate the application of the ZIA framework through a case study. The study area includes the zones of Bangkapi and Wangthonglang districts. As these zones belonged to Bangkapi District before 1998, hereafter they were called Bangkapi area in this paper. Based on the ZIA framework, the study is explained step by step. First, to analyze the characteristics of the study area, its general information is reviewed. This intends to draw the present conditions of Bangkapi, and investigates the development potentials to represent future tendencies. The high potential zones are selected and analyzed in the next step. Second, the samples of development projects are selected and their characteristics are explained. To concern every development case, all possible analysis strategies are prepared and simulated by the traffic simulation program. After the simulations, their impacts are quantified in the process of zonal impact assessment. Finally, the analysis of impact assessments is conducted to interpret the results of the study.

This research mainly utilized the transportation database networks, geographical data, and socio-economic data of BMR. The necessary data was available from the Urban Transport Database and Model Development (UTDM) Project established in 1995, and the Transport Data and Model Center (TDMC) Project in 2000. Moreover, the indispensable data of land-use planning were also included in the analysis.

4.1 The background of study areas

The study areas are located in the middle of two development directions of BMR, the North and South-East development directions. They include Huamark, Khlongchan, and Wangthonglang sub districts with areas of 16.461, 12.788, and 19.655 km^2 respectively. There are many main transportation facilities implemented, particularly for the Ramintra-Atnarong expressway, Ramkamhang, Nawamin, Serithai, Srinakarin, and Ladproa roads. These networks promote the Bangkapi areas to be a business and activity center. Moreover, according to the Second Bangkok International Airport Project, it significantly supports to urbanize the city from the core of Bangkok into the Bangkapi area (see Figure 5).

Based on the databases of UTDM project, the study areas were separated into 14 zones, and the population for each zone in 2003 was estimated in Figure 6. The total population of the study area is about 483,604 people. The zoning system of Bangkapi area follows the existing transportation databases, both UTDM and TDMC projects. The projects separated the sub districts from the land-use plan into the zonal level in order to perform the urban travel simulation. The current growth rate of population in the study areas is about 1.40% annually.

4.2 The land-use conditions of the study area

In Bangkapi, the agricultural areas and vacant spaces are about 15.46% of the total area. This represents that most of the Bangkapi area is dedicated for buildings and activity areas as shown in Figure 7. The houses or villages are the highest proportion of land usage, at about 3,734,668.05 m^2 or 73.41% of the total activity area. The

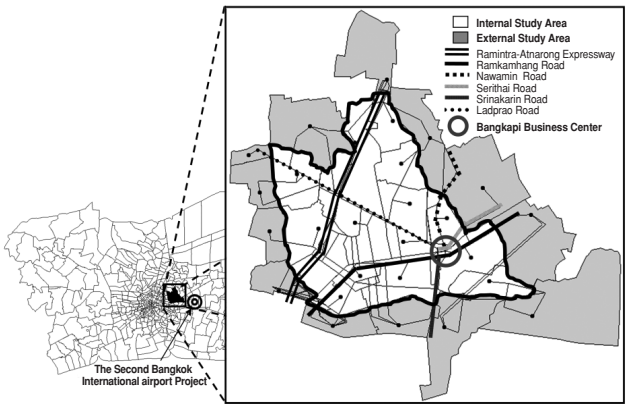
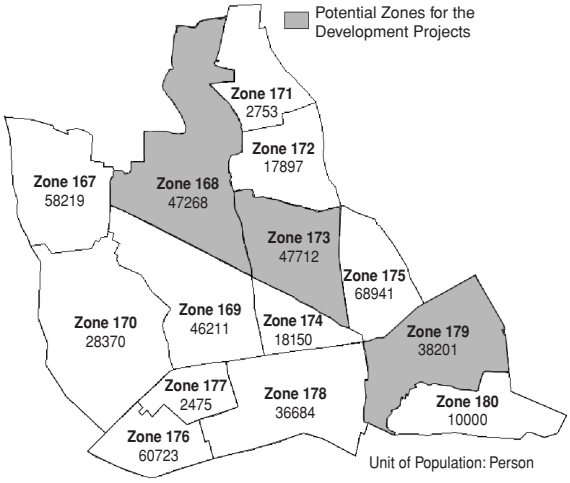


Fig. 5 The location and transportation networks of Bangkapi area

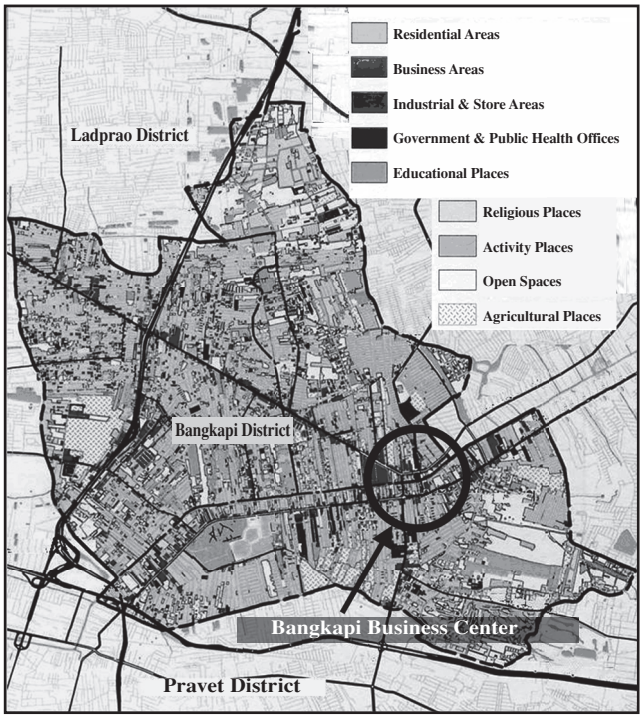
second is for office buildings, about 1,080,560.75 m^2 or 21.24%. The remaining includes the commercial houses, industrial and store areas, and others. The land prices of these areas are gradually raised as the results of economic benefits increase. By considering the location of Bangkapi, and its infrastructure performance, it is believed that Bangkapi has full potential for land development. In particular, it can play the role as the transition zone to connect between inner and outer Bangkok areas in the Eastbound approach[9].

The main transportation networks in Bangkapi are the arterial roads connected as a radial network by approaching the Bangkapi Business Center. These roads are connected together by local roads and small streets in the area. Based on the economic growth, many commercial areas are expanded along main roads. Due to its own potential and the growth direction of BMR, the planners decided to develop the Bangkapi Business Center as the main center in this area. They also proposed to develop the commercial area along Ramkamhang road. These land de-



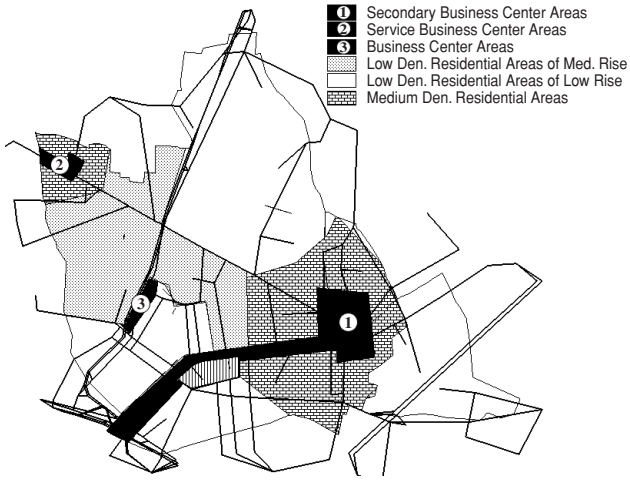
Source: estimated from UTDM

Fig. 6 Populations in each zone and the location of Zones 168, 173, and 179



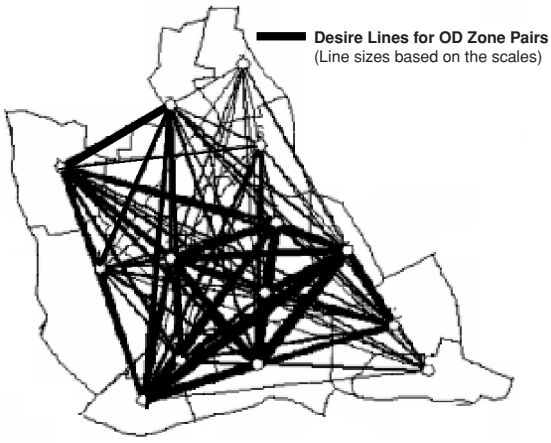
Source: DCP, 2002[9]

Fig. 7 The existing land-use conditions in Bangkapi area



Source: DCP, 2002[9]

Fig. 8 The land-use plan and transport networks of Bangkapi area



Source: estimated from TDMC, 2000

Fig. 9 The O-D distribution in the internal areas of Bangkapi area

velopment plans of BMA can be illustrated in Figure 8.

4.3 The characteristics of the analyzed development projects

To analyze the impact of development projects, this study chose to consider a shopping center project as the analyzed development project. Due to a lot of residents living in Bangkapi area, many projects for shopping centers have been proposed by developers. The research conducted field surveys to investigate the possible locations for development projects. In addition, the present characteristics of each zone, such as populations, present land-use conditions, provided infrastructure, 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 the consequences of expanding transport networks, like the Ramintra-Atnarong expressway, it can be expected that the zones next to this expressway, Zones 168 and 170, will be built up in the future. Nonetheless, because of a large number of people, only Zone 168 was selected for the analysis. In fact, this zone is controlled as a low residential area, but the land-use regulations in the study area are very weak. As the exception, if a big commercial project can provide the right of way from the main road more than 18 meters, the project can be approved by the administration. In addition, if in the area there is the proportion of such land-use project less than 10% of the total area, the project can be approved. For Zone 173 and 179, because they are located in the promoted areas of Bangkapi Business Center and also the direction of eastbound developments along Ramkamhang and Serithai roads, there is no doubt to include them in the study.

Regarding the research of traffic generation of shopping center projects located in suburban centers of Bangkok, the average trip generation rates for weekdays and weekends were estimated about 2.92, and 3.36 pcu-trips/100 m^2/a day, respectively[10]. It was assumed that the analyzed shopping center project occupies a service area of about 200,000 square meters. From the field survey, it was found that the critical period of the Bangkapi area, particularly for traveling to shopping or commercial areas, is the evening peak hour of weekdays. Therefore, the study conducted traffic simulations and impact assessments by considering the evening peak period on weekdays.

To cover all possible development cases, not only the cases of single development in a single zone were considered, but the cases of simultaneous developments, often occurring in Bangkok and other developing Asian cities, were also included as shown in Table 1. All simultaneous development cases referred to the same type and size of project in order to determine the real effects of transportation capabilities in serving travel demands of each zone. These cases were simulated and analyzed into the steps of traffic simulations, and impact assessment and analysis, respectively.

4.4 The traffic simulations of analysis cases

The traffic simulations were performed based on the network and trip databases of the TDMC project. The necessary network and trip data for the zones inside of and surrounding Bangkapi area were provided as the data for 14 internal and 13 external zones, respectively (See Figure 5). The transportation networks and the present O-D trip distribution patterns of the internal areas of the case study are demonstrated into Figures 8 and 9. To simulate the present travel behaviors and the traffic generated by the project, the Strategic Transportation Planning Program was developed and employed for this research. In Table 2, it shows the simulated traffic indicators, including vehicle-kilometer (pcu-km/hr), vehicle-travel time (pcu-hr/hr), average speed (km/hr), and total flows (pcu/

Table 1 The analysis cases of the Zonal Impact Analysis

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

Note: — means that the development project implemented in the zone.

Table 2 The total traffic indicators of internal and external zones for each analysis case

Case	Vehicle-kilometer	Vehicle-travel Time	Average 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

hr), for the whole study areas consisting of internal and external zones.

From the results, all development cases were increased in all indicators when compared to the base case without the project. This indicates that more trips were generated in the internal and external study areas, so traffic conditions in some areas become more congested. Case No. 8 should be imposed by the most severe traffic impact, as the new shopping center projects were implemented in all three zones. Although the numbers of vehicle-kilometers and vehicle-travel time in Case No. 4 and 5 were higher than in the base case, their average speeds of the total area could be improved from 7.57 km/h in the base case to 7.60 km/h. This might be because the traffic was reassigned in the networks more efficiently. These traffic indicators were not only evaluated for the whole area, but they were also performed in each zone so that the zonal impact distributions could be evidently considered. Particularly, they were utilized to estimate the zonal economic impacts caused by development projects in the next step. However, this study mainly focuses on the impacts of land developments in Bangkapi area, so the economic impacts generated in only 14 internal zones are estimated. The impact of external zones were neglected in this article. Therefore, the traffic indicators and economic impact of internal zones in each development alternative might be increased or decreased from the base case.

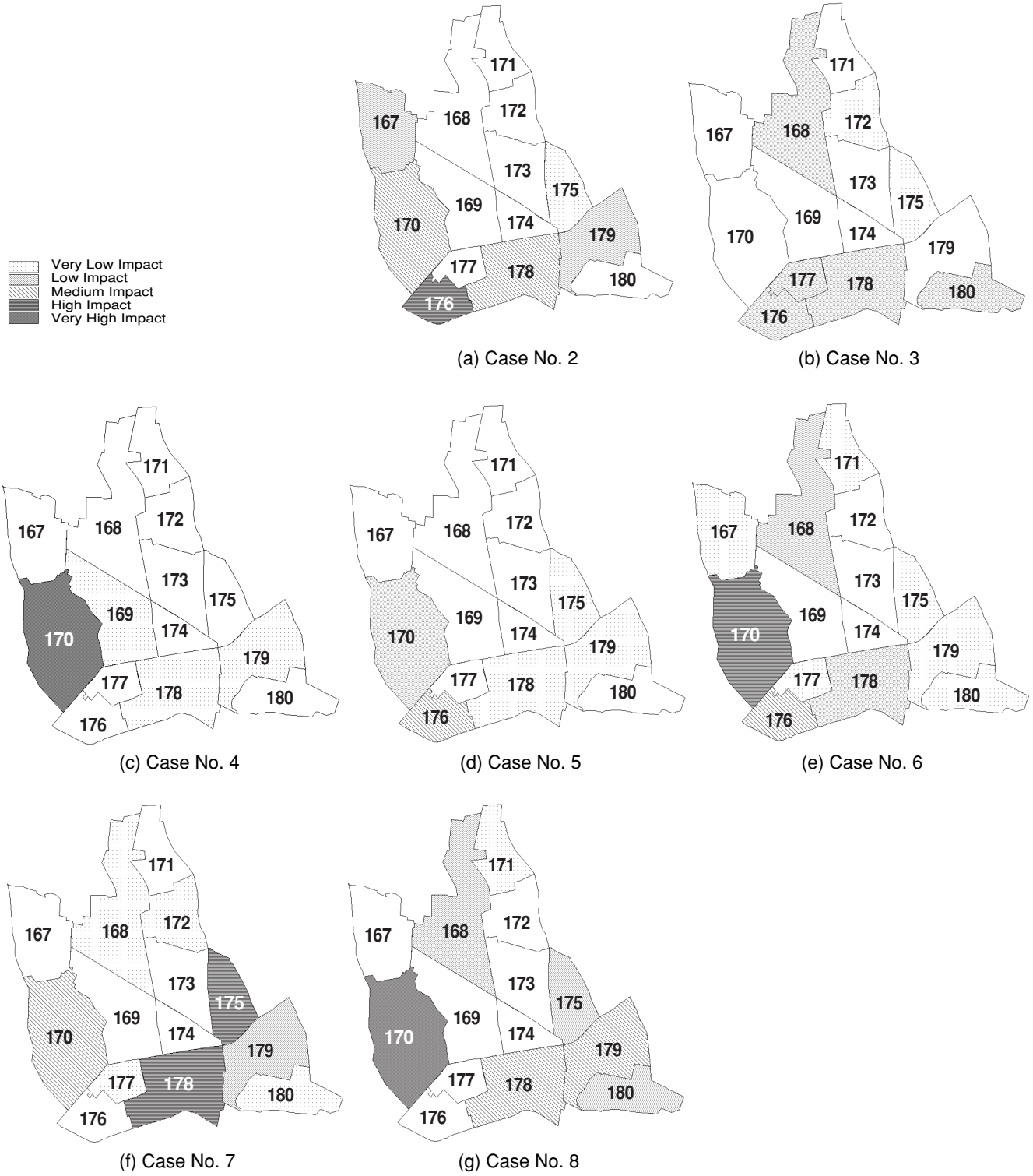
4.5 The Zonal Impact Assessment for the development projects

The impacts are defined as the changes of traffic indicators in the network. The zonal impact of vehicle-kilometers, vehicle-travel time, and total flow can be estimated as their summations from all links in a zone. For average speed, it is averaged by travel distances and travel time in a zone. These impacts were used to estimate the secondary economic impacts in the internal zones of Bangkapi area. They included travel time and vehicle operating costs in evaluating development plan alternatives. To estimate the economic costs, the value of time and vehicle operating cost estimation models developed by the Department of Highways (DOH), Thailand (2000)[11] were applied in the study. It was estimated that in 2003 the value of time for working or educational trips, and non working trips are 59.603, and 14.903 Baht/hour/person respectively. The average car occupancy rate for Bangkok was estimated at about 1.4 passengers/car. The distribution patterns of additional travel impact costs for each zone can be illustrated in Figures 10(a)-10(g). In the figures, the impacts arranged into 5 levels, from very low (0-40,000 Baht/hour), low (40,000-80,000 Baht/hour), medium (80,000-120,000 Baht/hour), high (120,000-160,000 Baht/hour), and very high impacts (160,000-200,000 Baht/hour), respectively. To find the suitable development conditions, the total economic impact for all cases was considered in the analyses as illustrated in Table 3.

However, this study has some limitations of developed traffic simulation program, as it can not simulate the internal trips and the effects of junction delays. Therefore, when the internal trips in the developed zones were increased, because of higher attractiveness, it would reduce the number of trips going out from the zone. This might make the traffic conditions in that zone seemingly less congested than before, but not actually. If the effects of internal trips and the intersection delays can be considered, more realistic impacts can be presented. These require improving the performance of the simulation program in order to cover the capabilities of micro simulations for further research.

4.6 The single development case

Based on the total zonal economic impact, it was found out that in the single development case, Zone 179 was the most suitable area for the proposed shopping cen-



(a) Case No. 2 (b) Case No. 3

(c) Case No. 4 (d) Case No. 5 (e) Case No. 6

(f) Case No. 7 (g) Case No. 8

Fig. 10 The negative economic impact distribution of each development case

Table 3 The comparison of total economic impact for all development cases

Type	Group	Development Case	Rank	Total Zonal Economic Impacts
Single Development	One Project	Case No.2	2	375,651
		Case No.3	3	394,187
		Case No.4	1	-92,966
Simultaneous Developments	Two Projects	Case No.5	1	-3,370
		Case No.6	3	348,072
		Case No.7	2	308,178
	Three Projects	Case No.8	4	385,675

Unit: Baht per Hour

ter project, due to its location advantages. Zone 179 is located in the center of the radial network in Bangkapi, there are many main roads approaching this zone. However, the additional travel cost impacts caused by the project was imposed into Zone 169, 170, 178, and 179, respectively as illustrated in Figure 10 (c). This might be because these zones have good networks connected to Zone 179, so travelers want to pass through them. Especially for Zone 170, because of the located expressway, many travelers pass through the zone with a very high impact. For Zone 168 and 173, they were the second and third, respectively. Zone 168 was more suitable than Zone 173, as it has a better transportation system, the Ramintra-Atnarong expressway. It was noticed that most trips to Zone 168 produced from Zone 167, 170, 176, 178, and 179, and also in these zones there were networks to access Zone 168 easily, hence a lot of economic impacts generated along these areas as demonstrated in Figure 10 (a).

4.7 The simultaneous development case

As shown in Table 2, if there were two of the same project implemented in two zones at the same time or in a certain period, the best case was the implementation of projects in Zones 168 and 173 as shown by reduced travel cost impacts, -3,370 Baht/hour. It might be because the case of development projects in Zone 168 and 173 could attract some trips that concentrated in the areas of Zone 176 and 178, very crowded commercial areas along Ramkamhang road, to their areas. Many trips that travel through Zone 170, 176, and 178, could go directly to the new activity areas, eventually it facilitated to efficiently rearrange traffic distribution in the network. The developments in Zone 173 and 179 were the second suitable alternative. They generated higher negative impacts than in the case of Zone 168 and 173, this might be because Zone 173 and 179 are in the central areas that are very crowded and congested, especially along Ladproa and Ramkamhang roads. The performances of networks around Bangkapi Business Center could not handle the access demands of projects, so more congestion was spread out along the two main roads. As demonstrated in Figure 10 (f), Ladprao road in Zone 175 and Ramkamhang road in Zone 178 were significantly affected from the land development projects. In addition, the expressway in Zone 168 connecting between Ladprao and Ramkamhang roads were also more congested, due to the new developments in Zone 173 and 179. Finally, there was no doubt that the case of development in all three zones had the most severe impact as illustrated in Figure 10 (g). From the assessments, it was very obvious that the capabilities of the transportation system in the developed zones should be evaluated to control or balance between the travel demands of any activity area and their own network capabilities.

From the results of impact assessments, it was found that the locations of zones can influence the performances of areas serving land developments. The areas located near the high capacity networks have the full capabilities to handle the access demands of forthcoming activity centers, and the impacts generated in such zones will be insignificant. This point is realized by planners in Bangkapi, and they planed to implement Zone 179 as the business center. The zone is in the center of radial networks connected by five main roads, so the complete network performances are sufficiently provided. However, in approving simultaneous developments, planners must improve the performance of infrastructure in Bangkapi to catch up with the demands of multi-projects. They can continue to promote Zone 179 as the center, but other projects in other zones have to be seriously prohibited as the comprehensive plan. Otherwise, those developments will create a lot of adverse impacts for society. Without any network improvements in Zone 179, two shopping center projects should be implemented in Zone 168 and 173, as the better transportation services can be provided by the high capacities of the expressway in Zone

168. The ZIA framework can evidently demonstrate the zonal impact distributions to show which zone will be significantly affected from any land usage. It was found that the zone occupying the better networks will play the role as the main impact distributor to allocate or mitigate the impact. As shown in Zone 170, it is the zone mostly influenced by traffic impact of the proposed project(s). In addition, after implementing any projects, the overcrowded zones around a developed area are more significantly affected than the less congested zones. This was indicated in Zone 178 often imposed by severe development impacts for analysis cases. Planners should pay more attention to these zones.

The existing approach of planners in BMR cannot cope with the complex development situation, especially when more than one project is implemented over the city area. Only the considerations of existing physical conditions consisting of land-use and networks in the present land-use planning process are insufficient, so the ZIA framework was proposed to improve the planning ability. The ZIA framework is beneficial to enhance the powers of regulations and plans for land-use planning. By conducting various simulations, the influences of project size can be covered in the planning process. Therefore, the suitable limitations of development sizes for each area can be determined and referred to as the rules or standards in the land-use control plan. The transportation improvement plans can be determined so that they are compatible with the planned land developments or not. If the plans fit with the directions of urban expansion, the traffic impact of developments should be minimized and mitigated efficiently.

It can be noticed that the ZIA framework consists of four characteristics of a strategic planning approach[12]. 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 future land developments are difficult to be controlled, but argues that by anticipating future developments, the plans can help to shape and minimize the unfavorable impacts of urban developments. Second, the strategic approach has an external emphasis. Many external components are concerned, such as the political 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. 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 quickly and continuously be re-assessed and modified as the situation evolves. Finally, the ZIA 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. The planners can apply the ZIA framework to assess the land development impact on transportation networks, and try to control proposed land developments together with the enhancement of network performances in the focused areas every 5 years the same as the planning horizon of the National Economic and Social Development Plan and the National Transportation Plan as illustrated in Figure 11. It attempts to minimize the undesired consequences of urbanization in some zones or for the whole study area. The growth in developing cities is very rapid, so direct long term planning may not be suitable, due to a lot of uncertainties. The proposed framework can be expected to investigate the influences of land-use developments, and supports planners to mitigate adverse impacts. Although it may not be able to reach the planned target in the short term, it can provide the direction to manage the growth and gradually implement some control or mitigation measures for any activity areas in the comprehensive land-use plan. Eventually, it will create the balances of land developments and infrastructure provisions with good living environments for the cities.

5. CONCLUDING REMARKS

This paper intends to present the Zonal Impact

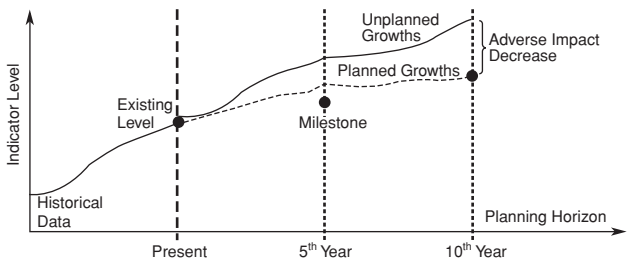


Fig. 11 The multi planning stages of ZIA framework in strategic planning approach

Analysis (ZIA) framework to improve comprehensive land-use planning for balancing land developments and transportation performance in developing cities. The land-use planning process in Bangkok and its problems were mainly explained as a case study. Although, the Bangkokian planners have tried to apply the traffic impact assessment (TIA) to mitigate the impact of development projects, it is insufficient to effectively control the urban growth, as the TIA focuses on the specific site level only. In particular, the situation worsens, when the land-use planning process does not seriously concern the effects of land developments on the networks. It was pointed out that what the planners need is the tool to systematically establish the effective comprehensive land-use plan in controlling land developments of each area to be compatible with their transportation performances.

The ZIA framework was defined as a tool for a strategic planning approach. Under the framework, the impacts generated by the developments were evaluated based on the zone base model. To demonstrate the framework application, it was applied to the Bangkapi District, Bangkok. It was found that the zonal impact assessments help to find an optimum development alternative to cooperate between transportation planning and land-use planning that mainly a uses zoning system in land-use control. The zonal impact distributions were also obviously demonstrated so that planners can prepare some impact relieving measures in advance, especially in the significantly affected zones.

In the results of a ZIA case study, more comprehensive development alternatives were established and their zonal impacts could be evaluated. It was recommended that the most suitable zone for a single project is Zone 179. Because the zone is located in the center of a radial network, full accessibility can be provided to serve the forthcoming project. However, in simultaneous developments, if none of any network improvements in Zone 179, two projects should be implemented in Zone 168 and 173, as the high network capacities of the expressway are available. In addition, Zone 170 and 178 would be significantly imposed by the severe development impacts, so planners should pay more attention to mitigate in these zones. Especially for Zone 170, because of its high quality of transportation services, it attracts more additional trips to the zone as bypass trips together with a more congested situation. These results indicate the better understanding on the characteristics of land-use and transportation integration planning in Bangkapi than in the traditional process. Finally, it was emphasized that the ZIA framework is a useful tool for strategic urban planning in developing counties. It should be realized that based on the existing transportation and land use database system, the effects of internal trips and intersection delays in each zone are not taken into account to consider the zonal impact assessment. To evaluate real zonal impact, we need to develop more complete databases and simulation programs. However, this might be difficult to implement for planning processes, especially in developing countries, because there are several limitations of technical knowledge, as well as budgetary restrictions.

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