สัญญาเลขที่ MRG4980111

รายงานวิจัยฉบับสมบูรณ์

Networking the System: Spatial Consolidation of Urban Areas
A Case Study of Sukhumwit, Bangkok

ผศ.ดร. อภิรดี เกษมศุข

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สนับสนุนโดยสำนักงานคณะกรรมการการอุดมศึกษา
และสำนักงานกองทุนสนับสนุนการวิจัย

Acknowledgement

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Keywords: Bangkok, Sukhumwit, public space, micro-distribution of land-use types

บทคัดย่อ

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Introduction

1.1 Introduction

We all know that cities are different from each other. It is possible to classify them from their dominant functional characteristics such as commercial city, resort city, political city, etc., or from their social and cultural characteristics, for example, cosmopolitan city, heritage city, and so on. For all these classifications, each city is commonly made up of a network of thoroughfares and the inter-relationships among the thoroughfares, buildings and activities which manifest those characteristics. Thus, urban areas of a city can also be differentiated.

An areal differentiation of the city can be carried out through the spatial layouts and morphological differences of the characteristics of the thoroughfares, i.e., streets, roads, paths, etc., and the way in which they form the network. For example, some urban areas are made up of roads that are extended or sequentially connect to other roads to form an internal grid structure, while the others are made up of roads that either discontinue or connect to a very few roads and form a broken grid structure (Kasemsook, 2003). Some scholars suggested that the differences of urban areas' spatial layouts respond to access' provision and control into the interior of areas' blocks (Brown, 1987; Siksna, 1994) or to benefit the functional development of the areas themselves (Kasemsook, 2003). Hillier (2001 & 2003) proposed that in the city development process the city's network has a tendency to evolve to keep extending long roads despite many short roads may have to be built for navigational purposes. He also suggested that the 'live centre – an area associating with commercial and entertainment business' of the city has emerged from the process of 'centrality' where different land-use types take advantage of movement densities inducing from different grid patterns.

With a special reference to Bangkok, a city where urban areas have constantly evolving, this research attempts to try to understand the process of urban area consolidation, particularly that of the former edged areas. With the theory of 'centrality process', i.e., a theory developed by Hillier (2003) concerning the development of urban area, its spatial networks and some micro land-use types which will be reviewed shortly, as a framework, this research investigates the way in which the Bangkok urban areas has developed, and the extent to which the emergence of centrality

process has involved. Most importantly, it tries to establish whether the micro distribution of land-use types associates with the internal grid structure as indicated by Kasemsook's research on areal differentiation of the Bangkok's inner areas (2003). If so, to what extent do they help consolidate the urban areas?

This research consists of five chapters. Chapter 1 is the research introductory which includes the background, the research questions, the research objectives, the key literature reviews and the hypotheses. Chapter 2 is an introduction to the research methodology which concentrates to investigate two major subjects – spatial structure and micro-distribution of land-use types. Chapter 3 presents the findings from the spatial structure study. Chapter 4 presents the findings from the study of the micro-distribution of land-use types and the relationship between the spatial structure and the micro-distribution of land-use types. Chapter 5 is the discussion and conclusion.

1.2 Research objectives

- To understand and establish the ways in which area networks consolidate whether within the areas themselves or with their surroundings.
- To understand the extent to which the development process of the area network's consolidation relate to navigational purpose and other factors that may involve with the development.
- To understand patterns of change caused by the area network consolidation, particular in the case of Bangkok.
- To establish the ways that the changes would be beneficial for the liveability of the city of Bangkok.

1.3 Studied area

Sukhumwit, a specific area of Bangkok, was chosen as the studied area. Sukhumwit area was one of the early developed urban areas in Bangkok. Its name has been called following the name of an arterial road – Sukhumwit Road – connecting the Bangkok historical area and city centre with the eastern peripherals (Figure 1.1). In the past 30 years, Sukhumwit area has transformed from a low-rise and fringe residential area in the east to be a noticeable high-rise residential area as well as a new business and financial centre of Bangkok. It is also well-known for an established retail and dining centre, and the most cosmopolitan area of Bangkok – with its numerous expatriates from various nationals and countries.

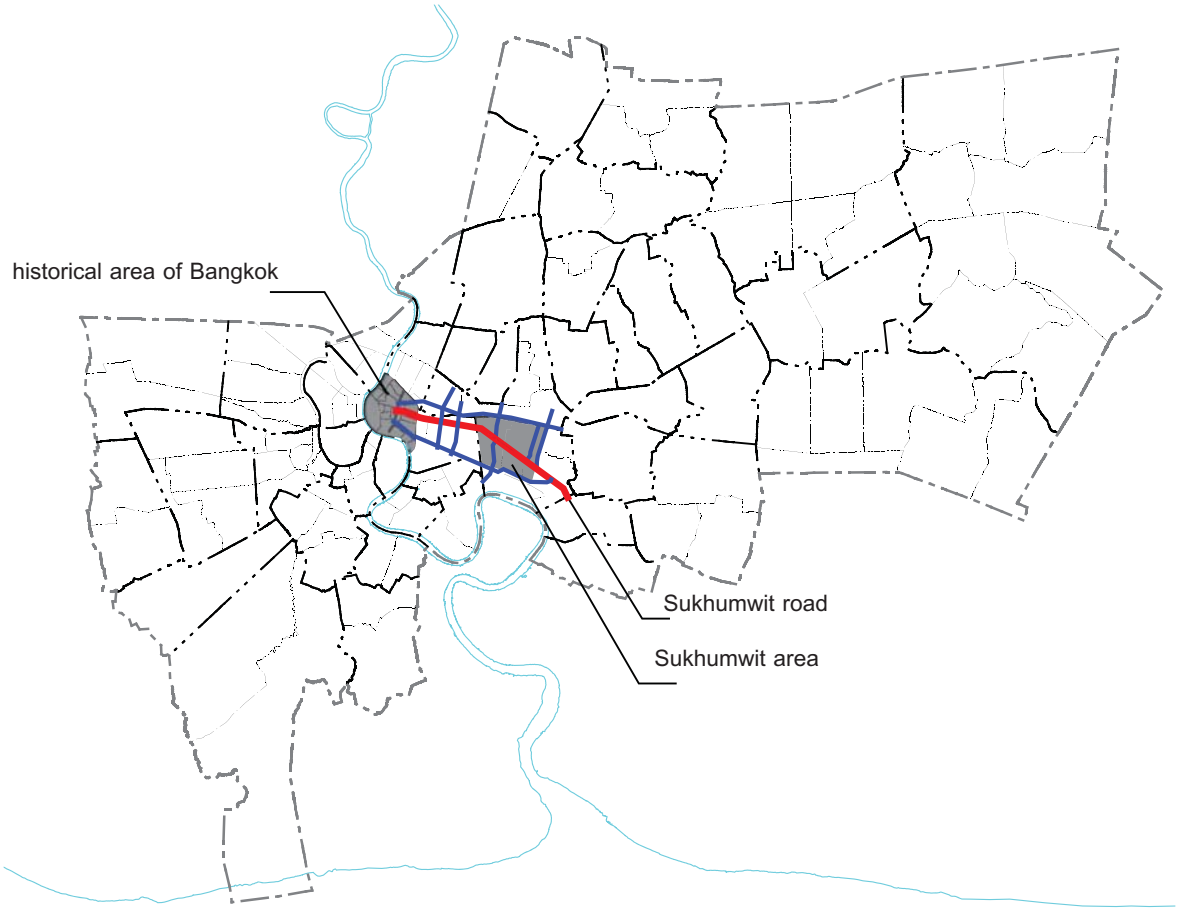


Figure 1.1: Location of Sukhumwit area in relation to the historical area of Bangkok

Physically, a number of roads have also been built, joined and extended within the area until nowadays. The building density of the area has increased; and the variety of the micro land use has soared. The constant evolving gives the area a unique characteristic best suit to be the studied area of this research.

Sukhumwit area as a whole is quite large. However, the studied area of this research is a sub-area within the Sukhumwit. It is the most transformed area of the Sukhumwit in the last 20 years. The perimeter of the studied area is defined as followed: the west perimeter is at Soi Sukhumwit 1; the east perimeter is at Soi Sukhumwit 65 (Klong Ton - Preediphanomyong road); the north perimeter is bounded by Petchaburi Road; and, the south perimeter is bounded by Sukhumwit Road itself (Figure 1.2). The studied area proposed is the most transformed area of the Sukhumwit, and tits details are.

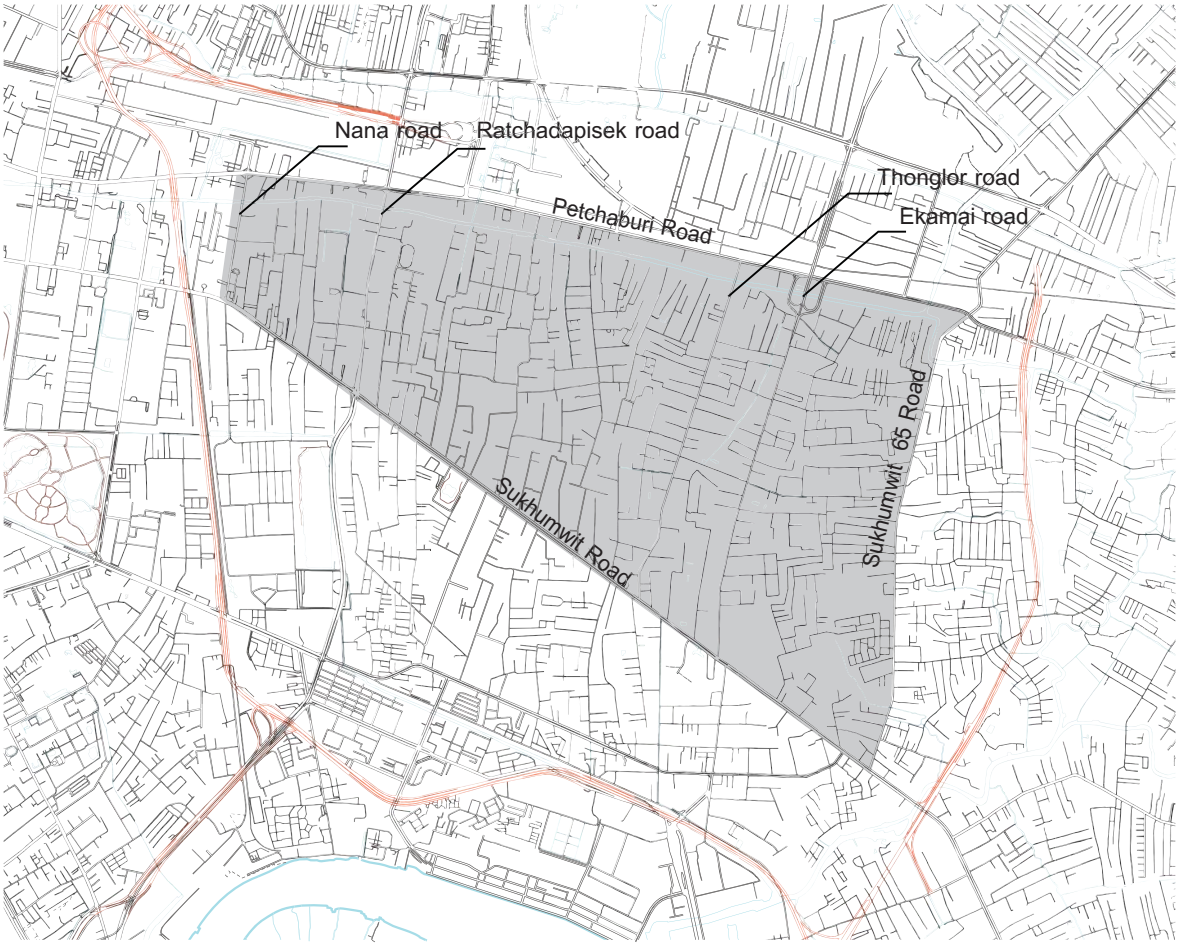


Figure 1.2: Perimeter of the studied area

1.4 Definitions

For this research, there is a need to define some of the terminology. They are:

- 'Urban grid', as defined by Hillier, is 'the pattern of public space linking the building of a settlement, regardless of its degree of geometric regularity' (Hillier, 2001);
- 'Grid pattern' is the 'geometrical pattern' of axial lines that form a spatial system. Four distinctive types of grid pattern could be identified here: orthogonal or quasi-orthogonal, broken, continuous and discontinuous;
- 'Retail' is defined as the commercial function whose business can be of the retail or the wholesale commerce, i.e., the retail shops for the wholesale shopping and the retail shops for the retail shopping.

- A planned shopping centre is an area or a complex where the locations of the all the shops are designed although the types of the shops and the selling products may not be planned.
- An unplanned shopping centre is an organically developed shopping district. The shops in this centre have been gradually built, and the range of their products can be varied. Often, this unplanned shopping district is the traditional shopping area in the city.
- Intra-centre retail location is defined as the distribution of the retail premises within a planned or an unplanned shopping centre.

1.5 Key literature review

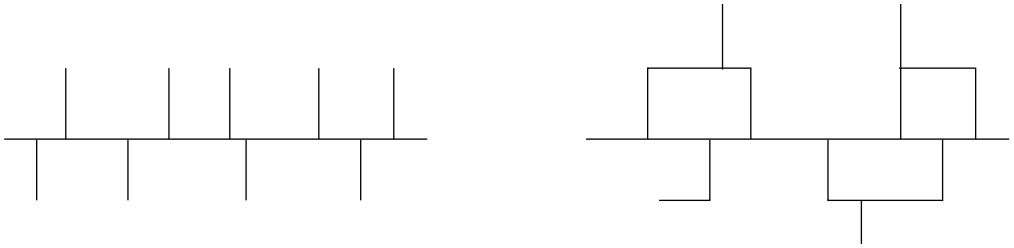
Key literature review for this research mainly focuses on the morphological approach, particularly three theories of urban area's spatial configuration developed by Hillier. They concentrate on the inter-relationship between the grid configuration, movement flow and density, and the attractor development, based on the concept of accessibility. Attractor can be a specific building or a particular land-use type. Generally, the retail and business land-use types are the attractors. As a consequent, a brief review on some key studies of the micro retail distribution will be given. Some findings from Kasemsook's researches (2003, 2006 & 2009-10) will also be presented to give some basic views of the Bangkok urban areas.

1.5.1 Spatial configuration

Hillier's three theories are presented as followed. Theory of 'natural movement' (Hillier et al., 1992; Hillier, 1996b) is a theory which establishes the relationship between the urban grid and movement within the grid. It is proposed that: 'the spatial configuration of the urban grid, that is, about the way in which spatial elements through which people move - streets, alleys, squared, etc. - are linked together to form some kind of global pattern can have effects on movement which are independent of attractors' (Hillier et al., 1992: 29). In other words, this means that, other things being equal, the proportion of movement in each urban space is primarily determined by the spatial configuration of the urban grid itself rather than the presence of attractors, for instance, shops.

Let us demonstrate this theory through Figures 1.3, as presented by Hillier (Hillier et al., 1992: 2). Suppose there is an urban grid, which is composed of a main line, representing a main street, and a series of minor lines, representing secondary streets, and all the minor lines are connected to the main line, but are not connected to each other (Figure 1.3a). If we want to travel from one minor line and another minor line across the main line, the trip would inevitably have to pass one

or more segments of the main line, with the central segments being used most, and the peripheral segments less. Suppose we have another urban grid, which is also composed of a main line and a series of minor lines, but in this system the minor lines are connected both to the main line and to each other (Figure 1.3b). If we then make the same journey, the trip still involves one or more segments of the main line, but the grid layout become less deterministic in route choices, which is a result of the configuration of the new grid.



a. A grid in which most central segments will be used,for travelling between peripheral segments

b. A grid in which central segments will be used,as there are more route choices for travelling between peripheral segments

Figure 1.3: Two types of grids generating different patterns of movement with regard to the frequent use of the central segments when traveling between peripheral segments (Hillier, 1996)

The basic movement generated by the spatial configuration of the urban grid is therefore called ‘natural movement’. It is shown by Hillier that if the grid is represented as a system of axial lines and its configuration is measured using the ‘integration measurement’ of the ‘Space Syntax method’ (a configuration measurement of a topological distance which will be explained in Chapter 2) movement within the grid can be captured by the integration. In other words, the extent of integration can be used to predict the pattern of movement. However, in two systems with similar grid configuration but different grid geometry, i.e., making with different types of line such as short or long lines, both the metric and topological distance must be taken into account. In such a system, the metric properties of the grids will involve with the grid configuration to influence the pattern of movement (Hillier et al., 1992: 2, 30).

At first sight, it would seem obvious to associate movement with attractors - more attractors, more movement - yet Hillier argues that we cannot assume that movement can be explained by attractors until we can be sure that the configuration properties of the grid have not influenced

both the presence of movement and the presence of attractors (Hillier et al, 1992: 30-31). In fact, Hillier suggests that: 'the presence of attractors can influence the presence of people, but it cannot influence the fixed configuration parameter, which describes its spatial location. Similarly, configuration may effect movement, but configuration parameters cannot be affected by it. If strong correlations are found between movement and both configuration and attractors, the only logically possible lines of influence are from configuration to both movement and attractors, with the latter two influencing each other (Hillier et al., 1992: 31). This means that the relationship between spatial configuration, movement and attractor is asymmetrical, while the relationship between movement and attractor is symmetrical; these relationships can be shown as a diagram illustrated in Figure 1.4 (Hillier et al., 1992: 31).

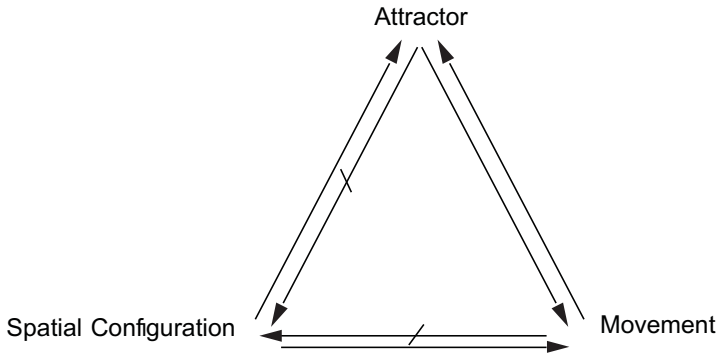


Figure 1.4: Hillier's diagram showing asymmetrical relationship between spatial configuration, movement and attractors and symmetrical relationship between movement and attractors

In the theory of 'movement economy', Hillier (1996a (Chapter 4), 1996b) explains the relationship between the urban grid, movement and attractors, through his observations on the distribution of attractors, i.e., shops. He proposes that the urban grid, movement and attractors relate to each other through a 'feedback process', a process consisting of two related effects: an initial effect of the grid configuration on movement and the impact of movement on the distribution of attractors, and a subsequent effect of the attractors on movement. As the key to this process is movement, Hillier suggests that an urban system, by definition, is a system which has at least some origins and destinations everywhere (Hillier, 1996b: 53). Every trip in an urban system has three basic elements: an origin, a destination, and the series of spaces that are passed through on the way from one to the other - providing a passage. He suggests that we can think of the passage

through these spaces as the by-product of going from a to b, and that at the aggregate level, this movement is determined by the grid configuration, even if the location of a and b is not (Hillier, 1996b: 53).

What is crucial here is the location within the grid. Some locations have more potential than others in terms of the degree to which they can be used as by-product of a trip. This potential depends on the grid configuration, i.e., grid integration, (Hillier, 1996a: 53). The integrated girds will have more potential than those that are segregated. Locations with the integrated grid tend to have high movement density. Locations with high movement density then attract the development of attractors, which in turn attract more movement into the grid. The result of this is a multiplier effect of movement (Hillier, 1996b: 54). The generation of the circle of multiplier effects is why we often perceive attractors to be associated with movement without realising the role the grid configuration plays in this association.

Hillier concludes that the city, which by definition is a structure in which origins and destinations are diffused everywhere, can therefore be seen as a 'movement economy' (Hillier, 1996b: 50-54). He suggests that the root source of the life of cities is the way in which the usefulness of the by-product of movement is everywhere maximised by the grid, in order to maximise the multiplier effect (Hillier, 1996b: 54). The theory itself suggests that the degree to which the by-product of movement is taken advantage of and the extent to which the multiplier effect is created can induce functional types of area. In other words, the theory suggests that land-use choices, or land-use types of area, are generated by the grid configuration through its impact on movement.

In the theory of 'centrality as a process', Hillier (2000) proposes that the movement economy influences the development process of the centre. Centre means an area with a distinctive concentration and mix of land uses, usually found in a prominent location in cities (Hillier, 2000: 107). The theory focuses on live centres, i.e., areas associated with retail, markets, catering and entertainment facilities, because they benefit highly from movement, as opposed to administrative or institution centres (Hillier, 2000: 107). One effect of the movement economy process is the well-defined grid characteristics, i.e., intensive block-structure and highly integrated grid structure, which are the distinctive local grid conditions of live centres, seen against the less-defined grid characteristics, i.e., larger-scale block structure and less integrated grid structure, of residential areas (Hillier, 2000: 108).

Hillier suggests that the movement economy process works at two levels, global and local, in generating a pattern of centrality. He also suggests that the key to the centrality process is 'interaccessibility', which governs the location and formation of live centres. In terms of location, at the global level, interaccessibility is the condition where live centres are accessible from all key directions of the city. This condition is found particularly along radial lines, which are the lines linking central and peripheral areas of the city and which are generally composed of sequential lines connecting at obtuse angles to each other. At the local level, there is a tendency for the live-centre facilities to be developed from and concentrated on the line that intersects with most other lines, i.e., the principal integrator of the local grid, because it is the most accessible location. As for formation, interaccessibility is the condition which generates permeability in terms of use of live-centre facilities within the grids, in the sense that when one comes to use one facility, others are easily accessible. This condition can be created by the compact and convex shapes of the grids of live centres, for instance, the small-scale block structure (initially identified by Siksna (1997)), quasi grids (where grid lines intersect approximately at right angles and continue to form quasi-right angle intersections with other lines) and integration.

The purpose of interaccessibility is to minimise mean trip length, which consists of two types, topological and geometrical. While 'integration' is a configuration measurement of a topological distance, 'metric integration' is a configuration measurement of a spatial system, for instance, an urban grid, which is made up of a group of uniform elements, whose relationship is measured in relation to both geographical and topological distance (see Hillier, 1996a (Chapter 3): 136-139). The higher the metric integration is the shorter the metric and topological distance will be. Therefore, to minimise mean trip length for both the metric and topological distance is to maximise metric integration. It is clear that both the global location and the small-scale block structure and integrated local grid structure of live centres are the result of the maximisation of metric integration. This means that the centrality process uses the metric integration to create interaccessibility at both the global and local scale, in order to generate movement (Hillier, 2000: 116). Globally, the development of live centres take advantage of movement across areas generated by the radial lines which are, more or less, the shortest route from peripheral areas to live centres. The radial lines also help make the local grid of live centres intelligible, i.e., providing a reference in relation to the larger-scale structure within which the grids of live centres are embedded. Locally, the more convex shape and small-scale block structure of the grid of live centres attempts to relate all

origins and all destinations within the grids in order to generate a strong movement economy with the local grid (Hillier, 2000: 118).

1.5.2 Retail distribution

Well-known theories and studies on retail distribution can be divided into three groups: the classic theory, the refined classic-theory study and the study of retail distribution based on the concept of accessibility and land-value theory. The key theory of the classic theory group is the 'Central Place Theory' by Christaller (1933). The key study of the refined classic theory is that of Berry (1959a, 1959b, 1967). The key study of the micro-distribution of the retail shops is that of Scot (1970).

Christaller (1933) developed the central place theory from his study of the distribution system of German towns, which was introduced to English-language literature through Ullman's paper, 'Theory of Location for Cities,' in 1941 (Ullman, 1941). The basic concept underlying the central place theory is that an urban settlement, whether a hamlet, a town or a city, is a central place, or a centre, performing central functions by providing goods and services for its tributary areas. The centre is located at the minimum aggregate distance from its tributary areas, or threshold areas, which the centre can efficiently serve. In a situation of uniform purchasing power and population distribution, consumers pay the price of the goods and travel costs when buying. At the greater distances from the centre, the higher travel costs will reduce consumers' ability to purchase in quantity. As a consequence, beyond the threshold the demand for goods and services will fall to zero. This means demand and amount purchased will continuously decrease from the centre until there is no demand or purchases at the threshold distance, and therefore consumers will purchase goods and services from other centres.

In each centre, there is an ideal range of goods and services provided. But the competition from other centres reduces the ideal range to the 'real range'. The real ranges become the criterion setting the order of the centres in their hierarchical system. The low-order centre is the centre generally providing convenience goods or foodstuffs, i.e., low-order goods, and it is frequently visited by locals. The high-order centre is the centre providing both low-order and specialised goods and services such as wholesale, large-scale banking, etc. The high-order goods are usually bought less frequently and are capable of drawing long-distance consumers. Since the low-order centres provide a limited range of goods and services, they have small threshold areas, or small market areas. Conversely, the high-order centres provide more variety of goods and services, thus

they have larger market areas than the low-order centres. The centrality of a centre is measured by the range of goods and services it provides, i.e., types, qualities and quantities of goods and services.

Because low-order goods are generally provided within the higher-order centres, this leads to the possible nesting of the low-order centres within the higher-order centres, and the creation of a hierarchical system. In other words, the market areas of the low-order centres can be nested within the market areas of the high-order centres. Christaller proposed hexagonal shape for the market areas, as such a shape can efficiently join and cover a served area without overlapping with any other served areas. The centres themselves are located at the vertices of the hexagonal shape. There can be the nesting of the small hexagon system of the low-order centres within the large hexagon system of the high-order centres. In addition, there are three principles determining the pattern of the hierarchical system of centres. These principles are: maximum accessibility for the population to enter the market; transportation; and administration. The principles govern the distance between one centre and another, and order the number of centres in each hierarchical group and across the groups.

In summary, the basic concepts of the central place theory are: a city performs as a central place serving central functions for its tributary areas and population; the quantity, quality and type of goods and services define the order and the degree of centrality of the centre; the differences in order and degree of centrality generate the hierarchy of the centres.

The main contribution of the central place theory to the study of retail distribution is the use of the order and degree of centrality to classify the hierarchical system of the retail centres (Kivell and Shaw, 1980: 108-109). The classification is used to investigate the distribution of the hierarchical retail centres, even though, generally, the central place theory explains the distribution system of cities rather than the distribution system of city elements. This theory was first widely applied to the study of retail distribution, during the 1960s and 1970s (Kivell and Shaw, 1980: 109), despite the fact that the hierarchical system of retail centres had been recognised long before this period (Dawson, 1980: 13).

Berry (1959a, 1959b, 1967) studied the classification types of retail centres and business districts within the city (1959a, 1959b, 1967). Based on his observation of several American city retail centres,

Berry was able to identify the hierarchical types of retail centres as well as the retail development types, or retail conformity types as he called them. The hierarchical types were differentiated by size of retail centre, with respect to service areas and number of served population, and comprised of the neighbourhood shopping centre, community shopping centre, regional shopping centre and central business district - in addition to isolated general stores or grocers. The retail conformity types were differentiated by the ways in which the retail centres had been developed and by their concentration and dispersion within the city areas. The retail conformity types were classified as the nucleated shopping centre, the ribbon development and the specialised areal cluster. Thus, Berry found that type of shop became the significant index in helping to differentiate the retail centres, whether in the hierarchical system or in the conformity system.

While Berry maintained the existence of the retail centre hierarchical pattern as derived from central place theory, he questioned the applicability of central place theory, particularly the theory's definition of hierarchy. He argued that the central place theory may be more applicable when differentiating the hierarchical system of the nucleated shopping centres, for their distribution in relation to tributary areas, rather than the ribbon developments or the specialised areal clusters (Berry, 1959b). From his observations, he found that the ribbon developments were differentiated hierarchically based on the type of street the ribbon developments were located along; for example, highway, urban artery, or automobile row. On the other hand, the specialised areal clusters were differentiated hierarchically based on the shop type in the majority, defining the unique function of the clusters within the city, such as the entertainment district, the exotic market, the furniture district, the medical centre, etc. Yet, Berry realised that the convergence of two or more types of retail conformity was possible, where each type maintained its function and range of shop types.

Nevertheless, Berry's assumption was that the distribution and specialisation of the retail hierarchical and conformity types were influenced by the demand and response to various degrees of accessibility, mainly through the street network, of the retail types. For him, accessibility was seen as the primary influential spatial condition, capable of determining the development and distribution of retail types. The nucleated shopping centres developed to be located centrally to their trade areas. The ribbon developments grew because streets provided access, space and competitiveness for some types of shop, such as petrol stations or garages, to effectively function. The specialised areal clusters developed discretely because they did not need a high degree of accessibility, that is, they may benefit more from spatial exclusiveness. Yet, Berry did not elucidate

or define the spatial characteristics of accessibility; he only mentioned them in terms of street types.

The studies of retail distribution based on the central place theory eventually point to the importance of accessibility in influencing retail-centre distribution and specialisation. However, the importance of accessibility has long been recognised in land-value theory, which suggests that accessibility, in relation to distance from the city centre, is capable of determining land uses and land values – the closer the distance to the city centre the higher the land value. It is the degree of accessibility working through the rent-bidding process that sets the pattern of land-use types, and together they arrange the gradient of land values. Only the land-use types being able to take advantage of the accessibility will be developed in the city centre, for example, the retail or the financial centre. This also means that there is a relationship between the pattern of land-use types and the range of land values. In other words, the identified relationship can be used to clarify the study of retail-centre distribution. A study of retail store locations is by Scot (1970) is a good example of this.

Scot applied the concept of land-value theory to his study of the distribution of retail trade types, through his review of previous studies and observations (Scot, 1970: 18-26). In doing so, Scot introduced two variations into the concept and logic of land-value theory. First, he proposed that accessibility could be equated with movement flows, meaning the higher the accessibility the higher the movement flows. Therefore, the basis of land-value theory, i.e., rental price is determined by accessibility, could be modified to rental price is determined by movement flows. Second, he proposed that the characteristics of shop sites, i.e., corner site or normal street-facing site, could intervene in the bidding process, and affect the distribution of retail types, or the gradient of land values. This means that certain site characteristics thought to assist that particular trade may be preferred by certain retail types when bidding for a location.

By inserting these propositions into his review of several studies of retail land use, Scot was able to devise the concentric ring pattern of the distribution of retail trade types. The peak land-value intersection is the most accessible location and where movement flows are at their highest, and it is the zone of variety stores, thought to profit most from the patronisation of customers. After the peak land-value intersection, in descending order, are the zones of women's clothing, footwear, jewellery, furniture, men's clothing and groceries, which are increasingly less dependent on and less profitable from movement flows. However, the smooth distribution of retail types and

gradient of land values are interrupted twice. First is the interruption of the women's clothing zone by the footwear zone, and second is the interruption of the furniture zone by the men's clothing zone. These interruptions are, according to Scot, the effect of the corner site character. According to Scot, the two-frontage character of the corner site permits greater local accessibility, or better patronisation, and a greater display of products. These characteristics are preferred by the footwear and men's clothing shops because their trade relies significantly on patronisation and display, and as a result they are willing to bid an even higher price for corner sites.

From these findings, Scot concluded that although the distribution of retail types is driven by the rent-bidding process, the local site characteristics could affect both the distribution of retail types and the gradient of land values. Some retail types want to bid for their preferred local site characteristics to maximise their trade and profitability. When bidding for the sites, these retail types force the land value of these sites to increase. As a consequence, the increase in land value prevents other retail types bidding for the sites and disrupts the general smooth gradient of land values, which have previously been generated by accessibility, or movement flows.

Scot believes that land values do not grade or change uniformly along every axis outward from the peak land-value intersection. In fact, land values are significantly different along each axis outward from the peak land-value intersection, and the differences are dependent upon the type of retail shops (Scot, 1970: 22-23). In his study of a shopping district in central Johannesburg, Scot found that each axis of the shopping district was populated with different types of retail shop. Even on the same axis, different shop types were juxtaposed with one another. Where there was a change in type of retail shop there was a substantial change in land value. For example, along the same axis, land values decreased substantially where shops catering for women changed to pet shops, but on another axis land value significantly increased when shops gave way to offices.

With these three groups of retail distribution study, Brown (1992) argues that the classic theory is too broad, and it deals with the retail distribution on the scale of the intra-city, i.e., the hierarchical system of the cities in relation to trading scale. The refined classic theory on the other hand was proposed for a smaller scale, but it deals with the retail distribution on the scale of the intra-urban shopping centre, i.e., the distribution of the shopping centres within the city. It is only the example of Scot's study that involves what Brown called the micro-scale of the retail location. It is this scale that this research focuses.

1.5.3 Basic view of the Bangkok spatial network

In 2003, 2006 & 2007, Kasemsook carried out a series of research on areal differentiation and area specialisation, using Bangkok, and particularly the inner area, as a reference and based on the configuration approach. It was found that Bangkok's spatial network is made up of many short roads. When the percentage of the Bangkok short roads was compared with that of many other cities using the same spatial analytical technique, it was the highest, while the percentages of their long roads were indifferent. Furthermore, the Bangkok short roads seem to connect to one or two other short roads and from a 'fish-scale' pattern, i.e., a broken-grid structure. Rarely do they connect to link between long roads, and very few of them form a grid-like or quasi grid-like structure. A major effect from this network characteristic is that the Bangkok spatial system is segregated and highly unintelligible for navigational purpose.

A vehicular movement density study of a number of Bangkok's areas made up with different types of road, road connections and grid patterns showed that there was a marked link between block sizes, road types, road-connection types, grid patterns and vehicular movement density. Long roads connecting to each other and making up large blocks with continuous semi-orthogonal grid-like structure had significantly higher vehicular movement density than short roads connecting to each other or to long roads and making up small blocks with broken-grid structure. This findings help explain the pattern of traffic flow - and also a major problem - within the Bangkok city area, resulting from its spatial network characteristics: long roads are laden with traffic volume, while short roads are deserted which could lead to other problems such as security.

Furthermore, it is possible to establish the spatial differences among four dominant land-use types of the urban area: residential, commercial, mixed-use and central business district. In the finer scale, every dominant land-use area is more likely to have an internal structure. This structure is often formed by short roads that sequentially connect to each other and to long roads. The interior grid structure tends to have substantial both vehicular and pedestrian movement density and would likely to be occupied with a number of retail shops. By hindsight, this internal structure can be viewed as an emergence of the centrality process, while its retail distribution can be seen as the initial step of the urban consolidation process.

1.6 Hypothesis

From the key literature review, the hypothesis set here is that the micro-scale spatial structure induces the micro distribution of the land-use types and together they consolidate the urban area. The more accessible the spatial structure is, the more intensity the land use types will be, particularly those being benefited from the movement-inducing grid. On the opposite, the less accessible the spatial structure is, the less intensity the land use types will be – more monotonous land-use type. By understanding the process of area's spatial network consolidation and with a special reference to Sukhumwit, it is hope that a body of knowledge can be established for the usage of adjusting the city's road network in a way that some of the spatially related problems of the city can be reduced, while its lively characteristics can be maintained.

Chapter 2
The Research Methodology

The methodology of this research was designed to examine two major elements and cover three subjects. The first was the spatial network study, while the second one was the study of the micro distribution of land-use type survey. The three subjects investigated were: spatial structure, the micro distribution of land-use types; and their relationships. Details of each study and the ways the subjects were analysed are given as follow.

2.1 The Spatial Study

The spatial study focused on the configuration analysis of the spatial network, which is formed by roads or pathways. The spatial configuration is an intrinsic property of any spatial system. The configuration is the relationships of all the spaces in the system. Their structure is capable of influencing pattern of movement flows, land-use distribution, and so on as shown by many studies presented in the Space Syntax International Symposiums throughout the last 10 years.

For this research, the network was analysed for their configuration using the Space Syntax programme, which is a set of computer programmes developed by Unit of Advanced Architectural Studies, University College London (UCL). The procedure to analyse the spatial network started from constructing the spatial model to be analysed on two different scales. One was the embedded system of the Sukhumwit spatial network within the Bangkok network of five kilometres from Sukhumwit area. The other was the independent system of the Sukhumwit spatial network. These two-scale models meant to investigate how the area spatial configuration would perform in relation to its surrounding spatial structure and how it would be by itself without any influence from the city's spatial structure.

These spatial networks were modelled based on the Geographic Information System (GIS) platform. They were also built following the spatial configuration concept of Space Syntax. This means that, initially, the public spaces of the city forming the spatial network were divided into a number of convex spaces – spaces whose fatness allows a gathering of activities (Hillier & Hanson, 1984). Then, the fewest axial lines were drawn to connect most of the convex spaces of the system. An axial line is the longest line of sight and accessibility when one moves through a

series of convex spaces without changing any direction (Hillier & Hanson, 1984). For each change in direction where a new axial line has to be drawn means that the new axial line has one-step depth in relation to the original one. The further two or three lines sequentially link to the original one means the further two or three-step depth. In short, the spatial models were analysed for their configuration property through the axial line network.

An example of the axial map can be seen from Figure 2.1. Figure 2.1 a is a map of a small village in France named Gassin. Figure 2.1 b is a convex map of Gassin's public spaces which in this case are those locating along the streets. Figure 2.1 c is an axial map of Gassin where all its convex spaces are connected through the fewest axial lines. This axial model is now ready to be computerised as Gassin's spatial configuration by the Space Syntax computer programme.

To analyse the axial line network, 'Depthmap', a Space Syntax programme, was applied. The programme will measured the relationships among the spaces in the system, i.e., the configuration of the axial lines, and structure them in relation to their accessibility. This structural accessibility is seen as the ability of the spaces to integrate with one another, i.e., 'integration'.

The configuration is normally measured on three scales. 'Connectivity' is the most local one. On this scale, every space is measured for how many spaces it directly connects to. 'Global integration' is the most global one. For this scale, each space is measured for its connection to all other spaces in the system (radius-n; thus, Integration RN), directly or sequentially. 'Local integration', or Integration R3 (radius 3), measures the direct or sequential connection each space has to the other three spaces from itself (Hillier & Hanson, 1984).

As the integration analysis tends toward centralised measurement, i.e., measuring the centrally located lines more likely to be integrated than the edge located lines, the radius-radius integration is another measuring scale developed to eliminate the edge effect of the integration analysis. The radius-radius integration can be varied from one system to the other systems, for example, one system could have the radius-radius integration at radius 6, while another system could have that at radius 7 (Hillier, 1996). For this research, the radius-radius integration was not carried out due to the small-scale spatial system of the studied area.

Figure 2.1 a

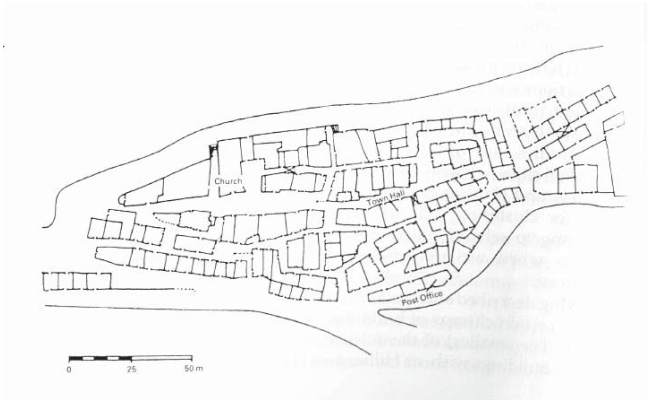


Figure 2.1 b

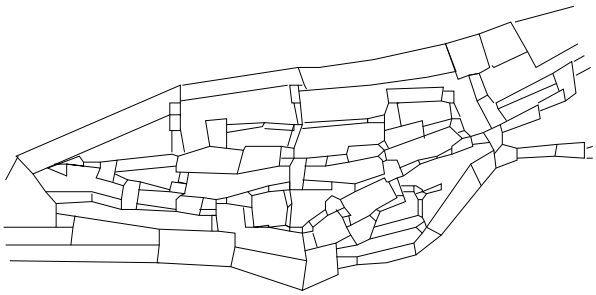


Figure 2.1 c

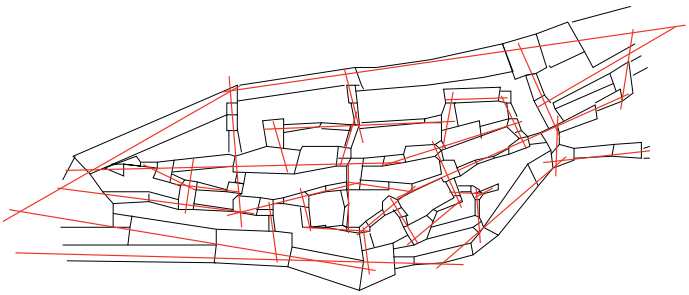


Figure 2.1: A map showing the axial network drawing, using Gassin as an example

The integration can be represented in two forms: numeric and graphic. The numeric representation is the integration value each space has in relation to the measurements themselves, i.e., connectivity value, global integration value and local integration value. The higher the value is, the more integrated the space will be. The lower the value is, the more segregated the space will be. Furthermore, these values are highly useful in the multivariate analysis. They can be used as independent variables against dependent variables occurring within the space such as number

of users, rental prices, floor areas, and so on. For the multivariate analysis will show the degrees of association between the spatial factors and the other factors as well as the influence among them.

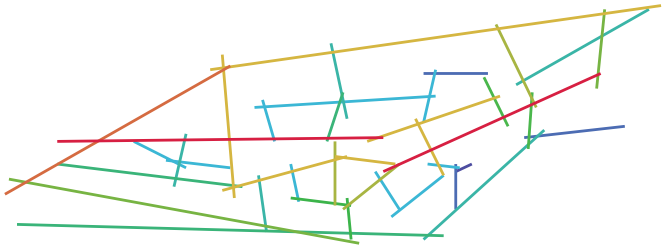


Figure 2.2 a Integration Rn

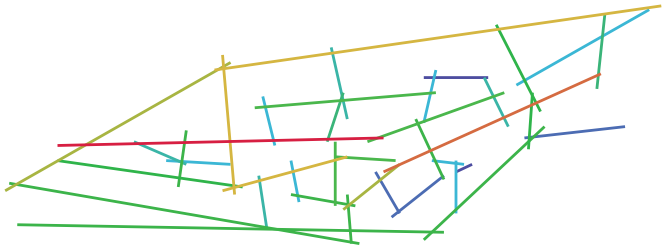


Figure 2.2 b Integration R3

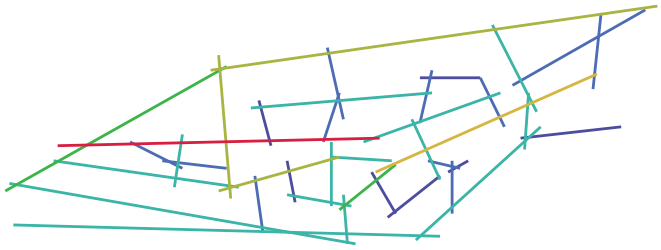


Figure 2.2 c Connectivity

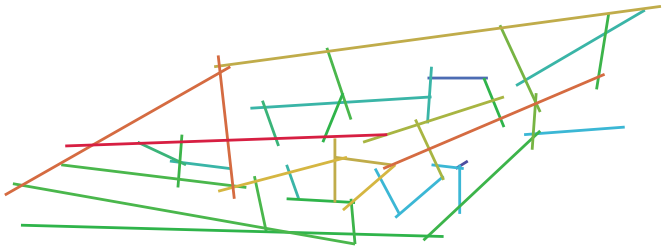


Figure 2.2 d Radius-radius Integration

Figure 2.2: Procedure to analyse a spatial configuration of a city, using Gassin as an example

The graphic representation will show the spaces which have already been structured in relation to their integration values in a range of colours from red to blue. The closer the colour to red is, the more integrated the space will be. The closer the colour to blue is, the more segregated the space will be. Figure 2.2 a, b, c and d shows all the axial analysis maps of Gassin. This axial analysis map is highly useful for visual inspection of the relationship between the spatial structure and the other pattern occurring within the space where the multivariate analysis cannot investigate, for example, the distribution patterns of land-use types or demographic types, and so on.

Overall, connectivity will display the most locally structured spatial configuration. The global integration will show be the whole global structure of city's system. The local integration, perhaps, works in a smaller scale than the global one, and it could give the picture of the spatial structure of urban areas within the city (Hillier & Hanson, 1984). Furthermore, we can also investigate whether or not the locally integrated space is the globally integrated space. If there is such a case, what the pattern found within that space would be. If there is none, what pattern we could find.
In addition to the integration, there are two co-efficient values to be studied. One is 'intelligibility' value which is the co-efficient value of global integration and connectivity. Intelligibility value displays the degree of navigating ability of the investigated spatial network when one travels within it. The value ranges from 0 – 1. The closer the value to 1 will be the easier to navigate the system will be. The closer the value to 0 will be the difficult to navigate the system will be – easier to get lost (Hillier, 1996).

The other is 'synergy' value, which is the co-efficient value of global and local integrations. Synergy value displays the degree of embedding quality between the local and the global property of the system. Synergy value also ranges from 0 – 1. The closer the value to 1 will be the better embedding quality the system will have. The closer the value to 0 will be the poorer embedding quality the system will have – some kind of fragmenting area (Hillier, 1996).

Adding to the integration analysis where the spatial structure is represented based on the axial line network, the segment analysis was also carried out. This segment analysis, which has been recently developed, is based on and computerised by the same logic applied to the axial line analysis – the accessibility, i.e., depth. Instead of analysing the whole line, the segment analysis calculated the accessibility based on the binominal property of the line, i.e., between two

intersections and between an intersection to the end of the line. As a result, a single line can have a numerous segments.

According to Hillier (2006), the segment analysis is a refined technique which could counter the axial line problem that only some parts of the whole stretch are more integrated and capable of inducing higher movement density or more number and more specific land-use types. This means that the integrated segment could become the spatial centre of the sub-area. Consequently, this technique reshaped the research methodology not to make the questionnaire for the delineating the sub-area centres as stated in the original proposal. Furthermore, metric distance of movement flow can be applied to the segment analysis in order to indicate the most likely distances the segment will be passed by. Usually, the studied distances are of 200 or 400 meters – the walking ranges.

The programme to calculate the segments is also 'Depthmap' which uses to calculate the axial lines. However, there is a limit to be set here that all the segments being shorter than 25% of the original axial line length were excluded from the calculation. They would be too short and of insignificant. Furthermore, the segment analysis study was made through the graphic representation only; the numeric representation was not included due to the statistical limitation for the multivariate analysis.

Due to the objective of the research, the spatial study was carried out to examine three periods. These are: 1974, 1987 and 2009. For the 1974 and 1987 spatial studies, aerial photographs of Sukhumwit area were used as the reference, while for the 2009 study the contemporary GIS map of Bangkok was the reference. In addition, the density and number of roads within the area among the three periods were observed and compared. Whilst the spatial configuration is central to the analysis, the pattern of axial line network was examined prior to it. This was made through the visual investigation of the grid pattern and characteristics, for example, being orthogonal or broken grid structure or being made up of long or short lines.

2.2 The micro-distribution of land-use types' survey

The survey was made to record the pattern of micro-distribution of land-use types within Sukhumwit area. Although all the land-use types were recorded, the survey focused on the micro-distribution of the retail premises, i.e., shops, cafes, restaurants, and so on, and those related to business

premises, i.e., offices. The assumption is that the presence of these land-use types will indicate the urban consolidation. The number of premises, units and floors within a building were also noted.

Overall there were 17 major land-use types recorded. These included residential, under-construction and vacant. Each land-use type were further sub-categorised into sub-types. The buildings and stalls were both noted as well as the motorcycle-taxi posts and bus stops. The details of them are given in Chapter 4. Due to the lack of the survey of this detail in the past, the study was made using the contemporary land-use distribution only. Even the published land-use map of Bangkok in 1998 was recorded only 11 land-use types, each of which generally had sub-types.

2.3 The relationships

As the main objective of the research is to try to establish the relationships between spatial structure and land-use types, the results of both spatial study and land-use survey were investigated together for their association. The clustering of the land-use types was examined, first, in association with the axial lines. The analysis, later, focused on the retail, business and cultural land-use types.
The number of premises and the variety of the land-use types were the key to both analyses. The axial analysed maps as well as the segment analysed maps were superimposed on the land-use map. This was an attempt to find out the land-use distribution pattern in association with the types of axial line and segment whether there would be the preferable or strategic locations of the land-use types within the spatial network. Although we do not have the land-use map within the area of the past, the axial analysed map of the past were included within the analysis, for a clear picture of the evolution of the whole land-use distribution.

Finally, in addition to the map analysis a multi-variate analysis was carried out using the regression analysis in order to check the association between the integration values of the axial line and the number of premises, number of floors and number of land-use types. This analysis does not only pin point the spatial factor most associated with the land-use distribution, but also ascertains the findings found from the map analysis.

Chapter 3
Sukhumwit & Its Spatial Structure

This chapter consists of three parts. The first part is a brief introduction of Sukhumwit area. This will be followed by a comparative study on the aerial photographs to give some general view of the area evolution. The third one is the comparative study of the three spatial patterns from three periods: 1974, 1987 and 2009. The last one is the comparative study of the three periods' spatial structures. The analyses were carried out in order to establish the spatial evolution of the studies area.

3.1 A brief introduction to Sukhumwit area

Sukhumwit Road is a regional road of Thailand. Originally, the road had been built in 1936 and connected Bangkok to Samutprakarn, an eastern neighbour of Bangkok; and it had been called Bangkok-Samutprakarn Road. Later, the road was extended to Trad Province, and since then has linked all the eastern seaside provinces to Bangkok. It was then numbered as Highway no. 3 and renamed in 1950 after Pra Phisan Sukhumwit (Prasop Sukhum), an aristocrat who was well-known as the first Thai engineering graduated from the MIT, USA (BMA CPD, 2005).

Spatially, Sukhumwit Road has to be considered with three more roads that sequentially connect to each other and link the Grand Palace in the historical area of Bangkok to the eastern periphery. These three roads are: Bumrungmuang Road, Rama 1 Road and Ploenjit Road. Bumrungmuang Road was one of the very first paved roads constructed in Bangkok. Rama 1 Road directly connects to Bumrungmuang Road, and was named after King Rama 1, to commemorate his victory over Cambodia and marched through the road. Ploenjit Road is a short road linking between Rama 1 Road and Sukhumwit Road.

Due to this sequential connection of the four main roads coupled with their alignment being parallel to a major canal, San Saab Canal, during the very first expansion period of Bangkok around 150 years ago, in the reign of King Rama 4, a holiday palace, Sra Prathum Palace, was constructed and located along Rama 1 Road (Figure 3.1; ONEP, 2004). Around 50 years later, Chulalongkorn University, Thailand's first university, was built just to the south of the palace.

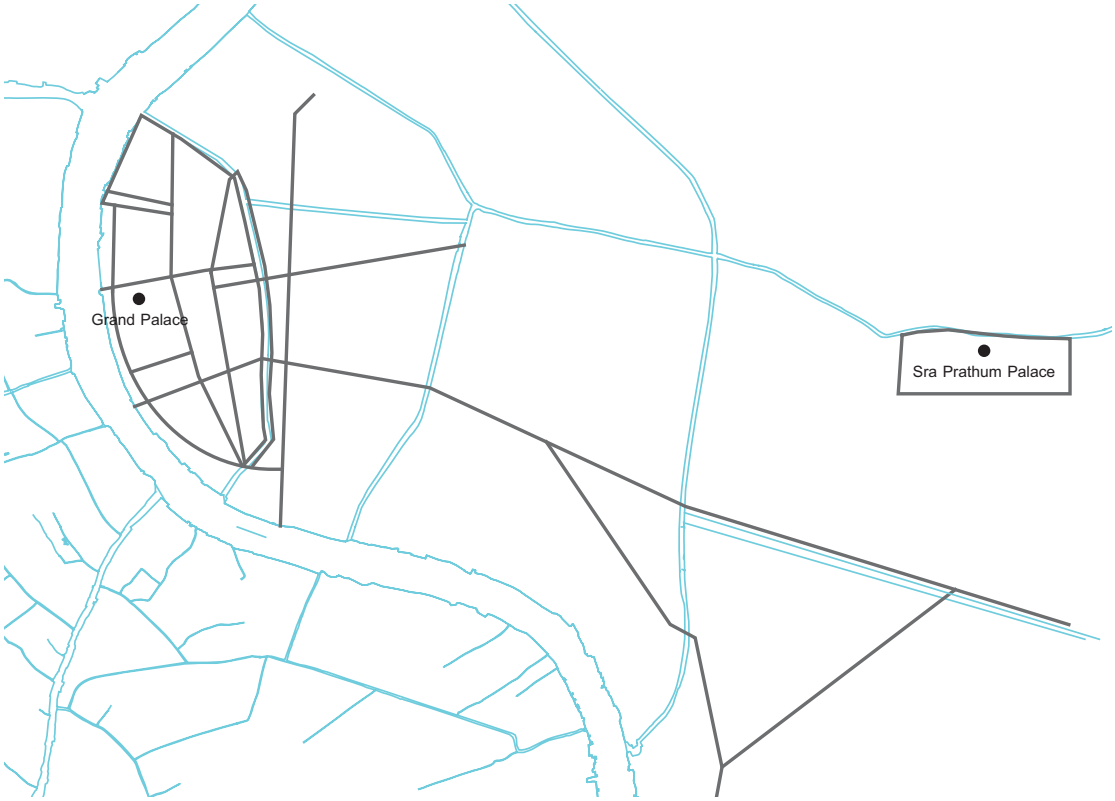


Figure 3.1: Map showing Bangkok during the reign of King Rama 4 and the location of Sra Prathum Palace

Gradually, a number of Bangkokians moved to relocate in the eastern area further than the holiday palace and the university. Some of them were the aristocrats, the other were the commons. They became the residents of the area. Along with the established eastern residential area of Bangkok, a number of fresh market or shopping centres were built as well as movie theatres and hospitals to facilitate the residents. It could be said that the continuous line of Rama 1 Road to Sukhumwit Road has the highest clustering of big shopping centres in Bangkok nowadays, 15 having been already constructed (Tesco-Lotus, Mahboonkrong Shopping Centre, Siam Square, Siam Discovery, Siam Centre, Siam Paragon, Central World, Kasorn Plaza, Erawan Shopping Centre, Amarin Plaza, Central Chidlom, Home Pro, Times Square Shopping Plaza, Emporium Shopping Centre and Major Cineplex Sukhumwit) and one being under-construction.

In terms of the spatially constructed infrastructure, there are three events that have transformed Sukhumwit area. The first was two major road constructions: the construction of Ratchadapisek

Road and the construction of the expressway. The second was the extension of a number of the short roads to create some by-pass internal route of the area. The third was the construction of Bangkok Transit System (BTS), the city's first mass transit rail.

Ratchadapisek Road was a ring road named to commemorate the 25th anniversary of King Rama IX on the throne (BMA CPD, 2005). The idea was to create the accessibility through all the areas of Bangkok in one circular road. For this circle to be completed, some sections were constructed, while the other were extended and enlarged. In the case of the road section in Sukhumwit area, the road was enlarged from a street named Asokamontri Road, he being an aristocrat who gathered a number of friends and families to donate the land for the original road building. For a common understanding, the section of Ratchadapisek Road in Sukhumwit area will be called Asokamontri Road throughout this research to identify the analysed section from the other sections of the road (Figure 3.2). A similar kind of this donation for a road building programme is the construction of Nana Road, which was named after the Nana family. Since the enlargement of Asokamontri Road to be included for the Ratchadapisek Ring Road, this section has been densely occupied with numerous high-rise residential buildings, hotels and offices. It is viewed as the second business and financial hub of Bangkok.

Figure 3.2: Contemporary pictures of Ratchadapisek Road of the Asokamontri Section

Around the late 1980s, the traffic situation in Bangkok was getting worse due to the expansion of the city. The then Bangkok mayor initiated a programme to extend some short roads to connect to the two arterial roads, Petchaburi Road in the north and Sukhumwit Road in the south, and to each other. This was a continuing pattern from the previous Bangkok road network development but with an accelerated speed. The extension of Thonglor Road to Petchaburi Road provides another major access of the interior towards the arterial road, as similar to the extension of Ekkamai Mai Road and Nana Road. The internal extension and connection were those of Prompong Road and the sequential roads connecting Asokamontri Road to Ekkamai Road. These extensions and connections programme created not only the internal road network but also the accessibility to the interior. The secondary network was aimed to reduce the cars from Sukhumwit Road from none working trip. It could be said that the network of these internal roads is one of the factors shaping the social-dimension characteristics of the Sukhumwit area nowadays.

The construction of BTS by the end of 1990s accelerated the transformation of Sukhumwit area further from the road construction (Figure 3.3). Prior to the construction, it was quite evident that Sukhumwit area became the expatriate hub of Bangkok. An Arab town has been firmly developed around Nana Road, following the local Muslim settlement along the San Saab Canal and Nana Road. A Japanese town has been developed around Sukhumwit Soi 31 to Soi 55 (Thonglor Road). The European and the American has spread throughout the area. With the BTS, a numerous high-rise residential buildings have been constructed to replace the aristocrats' houses. These high-rise residential buildings are occupied by both the expatriates and the local Thais.

Figure 3.3: Pictures of Sukhumwit Road with the BTS line

These road construction programmes and the BTS construction have transformed Sukhumwit area to become a unique area of Bangkok. Nowadays, it is well-known not only as the second business and financial hub of Bangkok, but also as an entertainment area. Numerous cafés and restaurants disperse almost throughout the area. They are of high standard and good quality that are sought after by the Bangkokians. Thus, a number of new types of shopping complex which blends itself as a public space with the surrounding have been sprung out, particularly along Thonglor Road (Figure 3.4; Kasemsook, 2006). The building and land-use development will be discussed further in detail in the next chapter.

Figure 3.4: Pictures of Thonglor Road

3.2 A comparative aerial photograph study

The evidence of the area evolution in general can be best presented by the aerial photographs of the area. Although it was mentioned earlier that the comparative study would focus on from three periods – 1974, 1987 and 2009, the 1952 aerial photograph of the area is included in this part for a clear understanding of the area development; this is the oldest photograph of the area being obtainable. Likewise, an aerial photograph of the area in 2000 will be the evidence of the contemporary development even though many buildings have been built. This is the latest aerial photograph being obtainable. However, the result of the survey in the next chapter has corrected this problem with the un-up-to-date aerial photograph. Figure 3.5 is an aerial photograph of Sukhumwit area in 1952. Figure 3.6 is an aerial photograph of Sukhumwit area in 1974. Figure 3.7 is an aerial photograph of Sukhumwit area in 1987. Figure 3.8 is an aerial photograph of Sukhumwit area in 2000.

Figure 3.5: An aerial photograph of Sukhumwit area in 1952

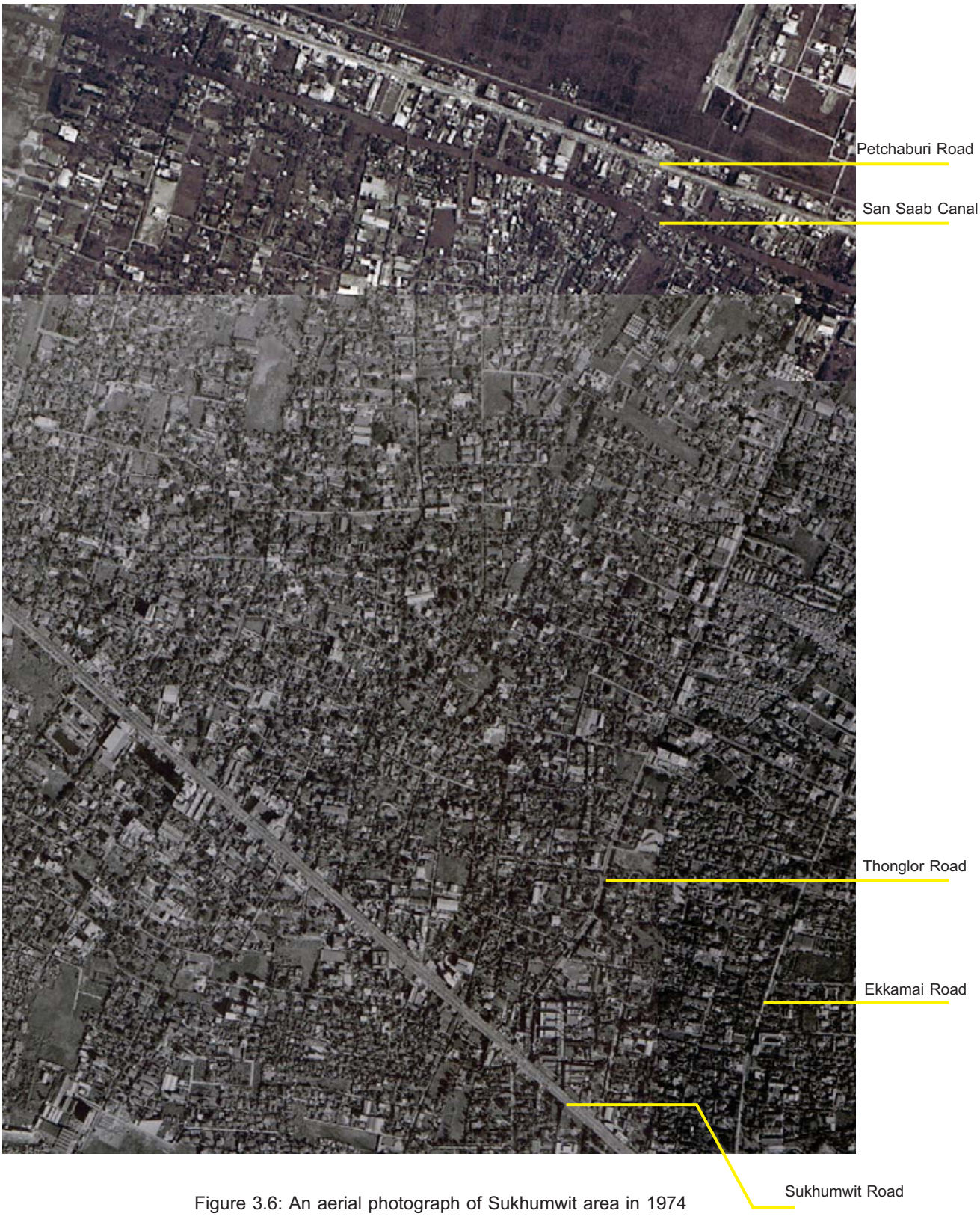


Figure 3.6: An aerial photograph of Sukhumwit area in 1974

Figure 3.7: An aerial photograph of Sukhumwit area in 1987

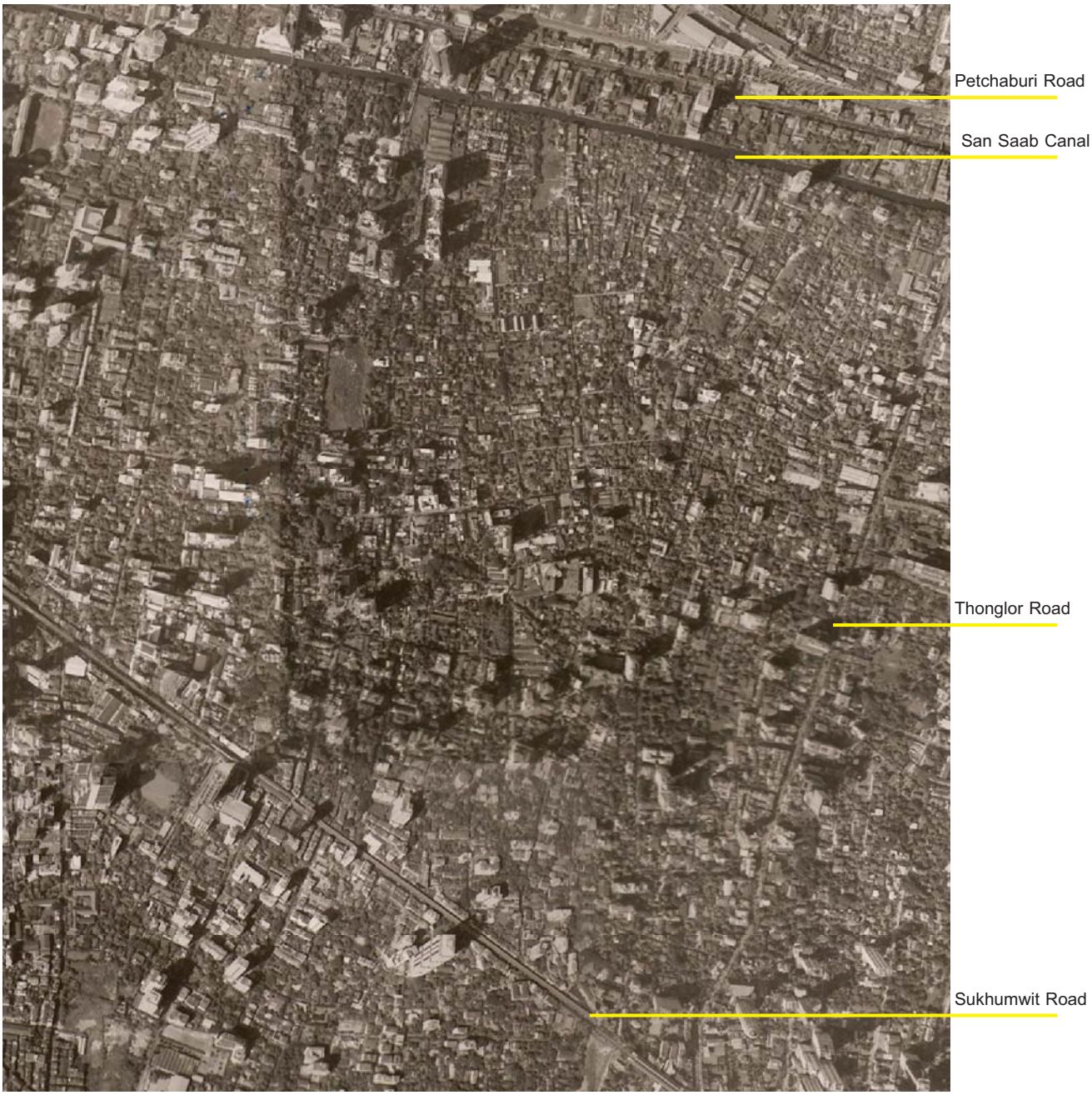
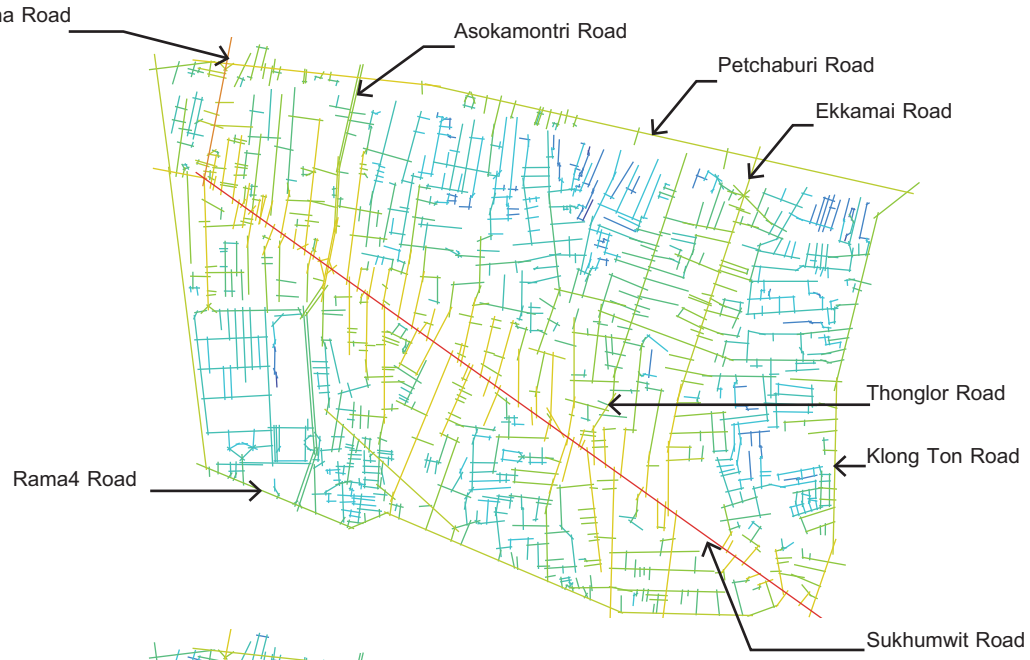


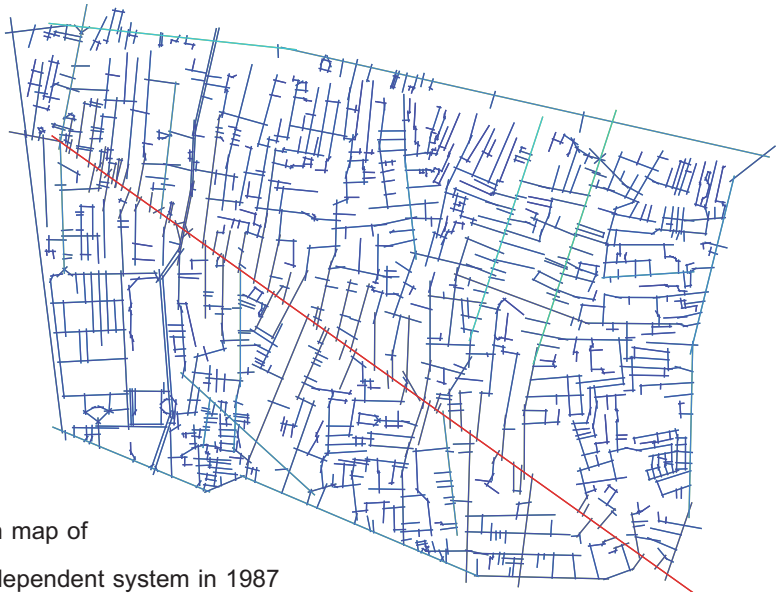
Figure 3.8: An aerial photograph of Sukhumwit area in 2000

a: Global Integration



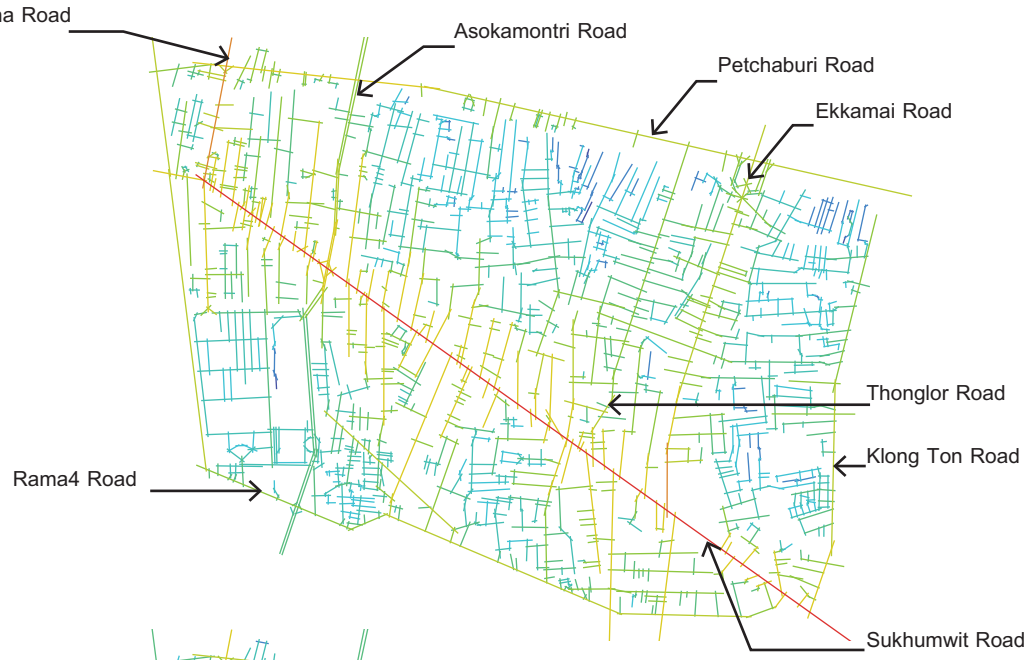
b: Local Integration

c: Connectivity



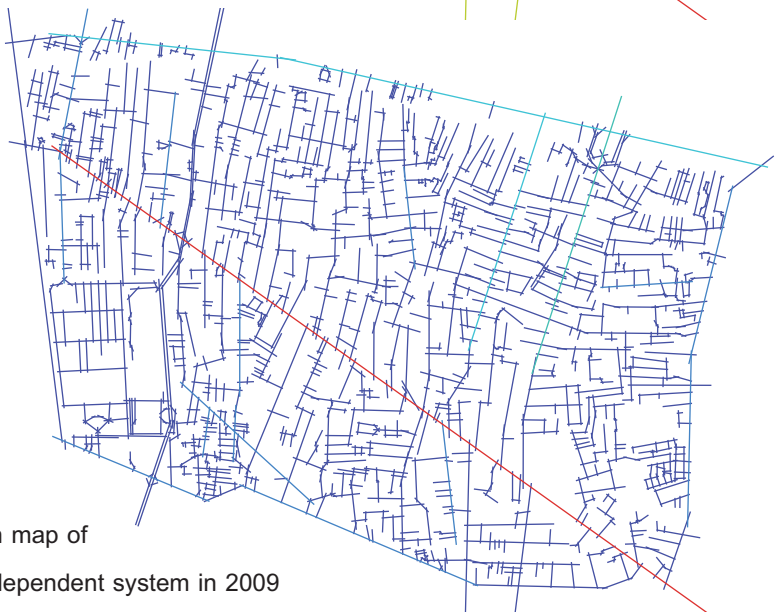
Figures 3.16: A spatial configuration map of
Sukhumwit area analysed as an independent system in 1987

a: Global Integration



b: Local Integration

c: Connectivity



Figures 3.17: A spatial configuration map of Sukhumwit area analysed as an independent system in 2009

Table 3.1 indicates four important findings. First, as noticed in the last two sections, the spatial system of Sukhumwit has almost completely developed since 1974. The number of axial lines just slightly increases from 1974 to 1987 and to 2009. Average line lengths of the whole area from each of the three periods are almost identical whether the spatial system was analysed as the embedded or the independent system.

Second, despite of this growth, the later the area has developed, the more integrated the area will be, globally and locally, although the average integration value of the area increases just slightly. The spatial system of the area in 2009 is more globally and locally integrated than the system in 1987 is. Likewise, the system of 1987 is more globally and locally integrated than the system in 1974. This pattern is similarly found from both the embedded and the independent system study.

Third, the spatial structure of the area in general is unintelligible. It is difficult to understand and makes it hard to navigate within. This is seen from the very low intelligibility value which indicates the degree of spatial understanding for the ability to navigate within the system. Throughout the last 30 years, the changes in the spatial layout have not helped the area to be more understandable and easier to navigate at all. The intelligibility values of the three studied periods are so insignificantly different whether from the embedded or the independent system studied. Among the three studied periods, the spatial system of 1987 is the most intelligible of all.

Fourth, Sukhumwit area is well linked with the city spatial structure as shown by the synergy values. Moreover, the degree of linkage is maintained throughout the last 30 years. Nevertheless, we shall see from the integration pattern whether this linkage is made from the whole area's line network or from some important lines within the area. This is because mean depths of the area from the three periods are quite high.

If the spatial system of Sukhumwit area is compared with the other six spatial systems of Bangkok as studied by Kasemsook (2006), a marked contrast emerges. Sukhumwit area is the most segregated spatial system among them. This is against the facts that Sukhumwit area's system is as equally connected, intelligible and well-linked with the city system as those six other systems. Its system is also made up of lines with similar length in general to those of the six other systems too. Thus, its mean depth is as similar to those of the system with an equal axial line size. Its

mean depth is very much lower than those of the Ratchada, the Greater Ring Road, the Eastern and the Western system, which are a very large system.

As for the configuration patterns of Sukhumwit area being embedded with the city structure, Figures 3.12 – 3.14 show three distinctive patterns. First, the medium length and long lines are more globally integrated than the short lines when the area is embedded with the city. If we classify the global integration pattern into three ranges, the top range of the globally integration is of those two east-west long lines of Sukhumwit Road and Petchaburi Road; for they are the most and the second most globally integrated lines. The second range consists of the five north-south medium length lines of Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road. The third range consists of the internal short lines. These six globally integrated lines form the integration core of the area. However, the fact that the internal short lines are less integrated means that Sukhumwit area has a strong edge and weak internal spatial structure.

Second, if we take a closer look at the internal area of Sukhumwit, the maps (Figures 3.12 – 3.14) show that some short lines are more globally integrated than many other lines. Lines directly connecting to Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road are more globally integrated than those that do not. This also suggests that the axial lines that locate quite a distance from Sukhumwit Road and those six roads are the segregated ones. Accordingly, an internal structure can be established within the studied area. This internal structure is composed of the short lines that sequentially connect to each other and to Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road or Klong Ton Road.

Third, lines which have been extended to connect to those six roads and particularly to Petchaburi Road as seen in the cases of Thonglor Road and Prompong Road are more globally integrated than when they had not (Figures 3.12 – 3.14). Some of them form the internal structure of the area with the sequentially linked east-west lines. Interestingly, the integration core of the internal structure is formed by the sequentially linked east-west and the north-south extended lines, as pointed out in Figure 3.14. This core subdivides the whole area into smaller blocks from those made of Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road. It also helps reduce the broken-grid structure and creates the quasi-orthogonal grid structure.

Likewise, the patterns of the local integration of Sukhumwit area studied as the embedded system from the three periods are similar to those found from the global integration. The long and medium length lines of Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road are more locally integrated than the short lines. The short lines sequentially or directly connecting to the long and medium length lines of Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road are more locally integrated than those that do not. The lines having been extended through time to connect to the lines of those six long and medium length roads are more locally integrated than when they had not. These sequential internal short lines and those extended lines form the internally integrated core of Sukhumwit area.

The fact that the globally integrated lines are also the locally integrated lines indicates that the spatial structure of Sukhumwit area is more dependent on the edge lines, particularly Sukhumwit Road. This is confirmed by the connectivity of the area which shows that Sukhumwit Road is most connected (Figures 3.12 – 3.14). Even Ekkamai Road, the second most connected, is markedly less connected than Sukhumwit Road.

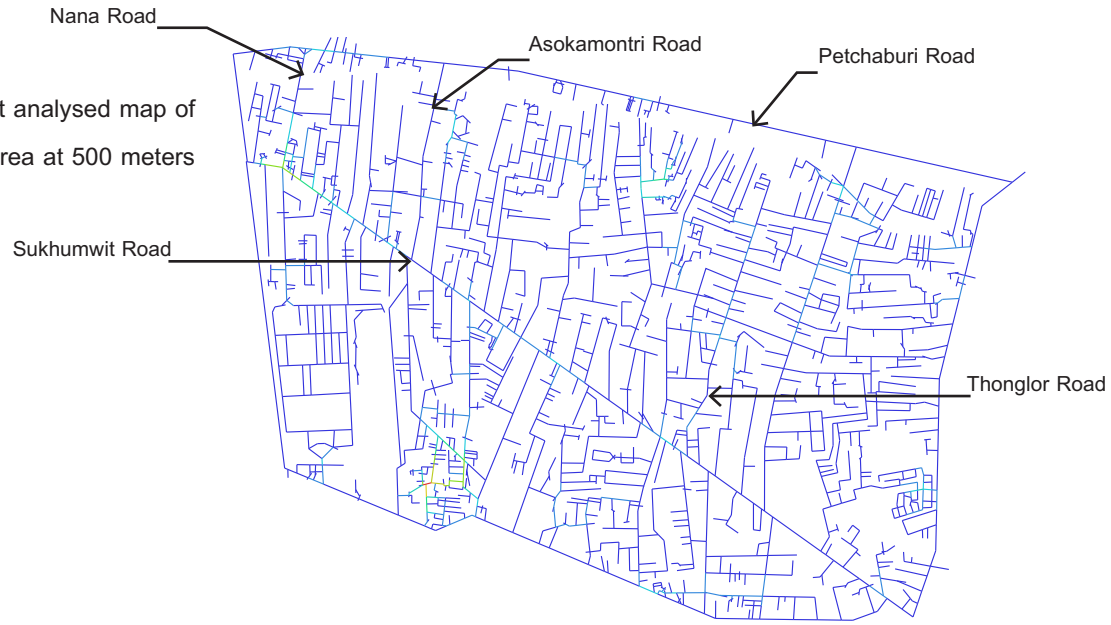
When the area was studied as the independent system and compared among the three periods, the patterns found are not different from those found from the comparative embedded systems (Figures 3.15 – 3.17). The similarity between the spatial configurations being analysed as the embedded and the independent system suggests that Sukhumwit area seems to be autonomous from the city's spatial structure. It can be said that the whole area is more dependent on Sukhumwit Road than the city structure; Sukhumwit Road is the principal link of the area to the city.

To summarise, the axial analysis show that Sukhumwit is a segregated area of Bangkok. It has not changed very much in the past 30 years, spatially. Although the area may be well linked with the city, within the area itself its spatial structure is unintelligible to navigate. Sukhumwit area has evolved to be emerged as an independent town within the city of Bangkok. We shall see, in the next chapter, the degree to which the centrality process has involved with the micro-distribution of land-use types in the area from its large to medium scale quasi-orthogonal grid structure.

3.4.2 The segment analysis

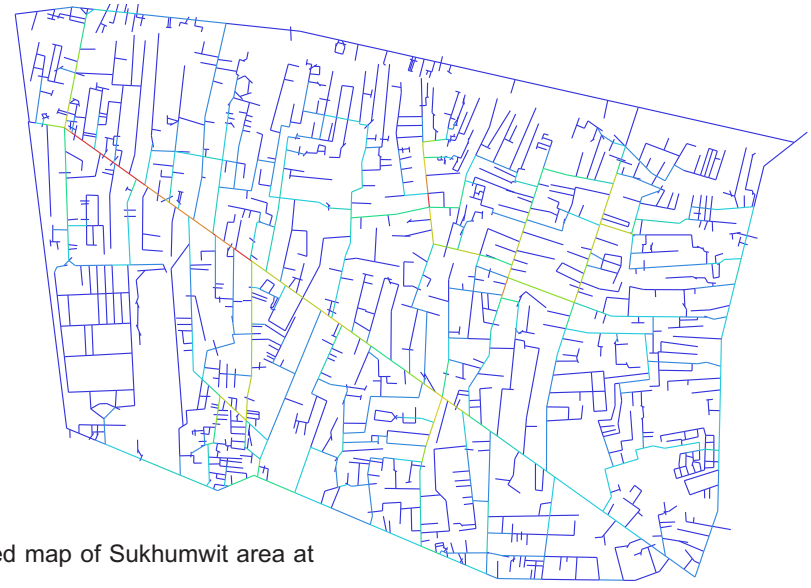
The last analysis of the spatial structure is the segment analysis. The axial analysis is made to investigate how the area performs within the city's spatial system. According to the three theories of Hiller reviewed in Chapter 2, this means that the axial lines, particularly the global integrated ones, induce the movement into the area, and then the local grid structure generate the movement within the area so that the movement economy can occur. This movement economy has the impact on the attractors' distribution. The segment analysis takes on from here that once one is in the local grid the metric distance is no less or can be equally important for the movement economy. The segment analysis therefore identifies which segments within the studied area are more likely to be passed through if the metric and the topological distance is taken into account (Hillier et al., 2007). Usually, the metric distance is set as a series of the walking distances, for example, 200, 400, 800 meters and so on in the analysis. For this research, the metric distances applied were of 500, 1000 and 1500 meters respectively. The topological distance calculated is the integration analysis from the connection of the segments instead of the lines. As we are now focus on the internal development with the area, the segment analysis was applied to study the independent system only. Figures 3.18 – 3.20 are the segment analysed map of Sukhumwit area at 500, 1000 and 1500 meters from the three periods. Again, the focus of the comparative study is on the segments located within the boundaries of the studied area, those locating to the north of Sukhumwit Road.

a: A segment analysed map of Sukhumwit area at 500 meters



b: A segment analysed map of Sukhumwit area at 1000 meters

c: A segment analysed map of Sukhumwit area at 1500 meters



Figures 3.18: A segment analysed map of Sukhumwit area at 500, 1000 and 1500 meters in 1974

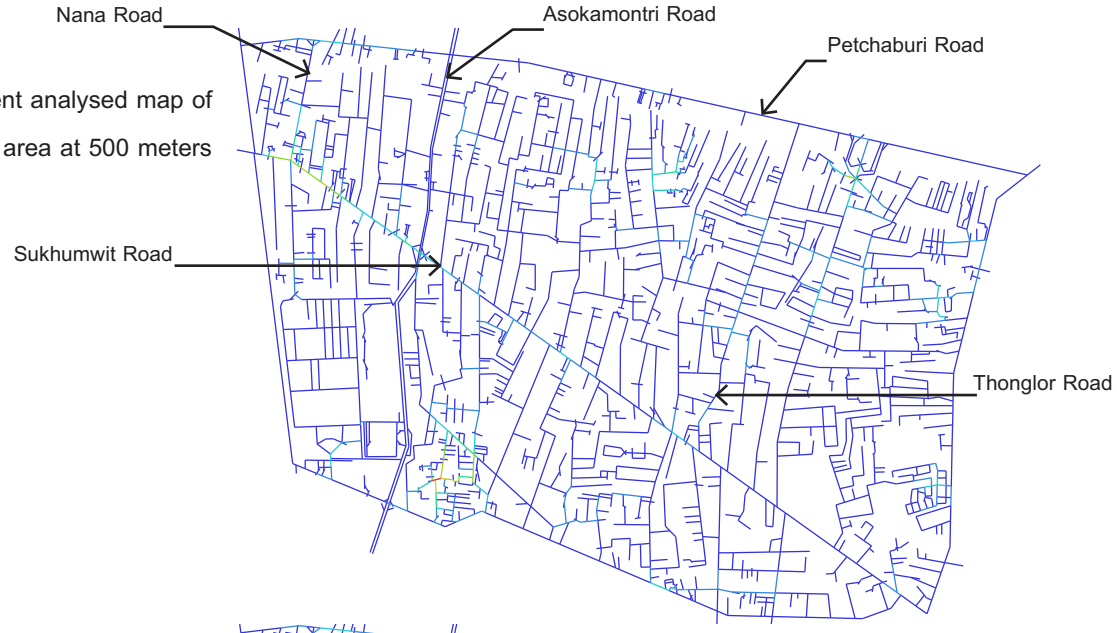
a: A segment analysed map of Sukhumwit area at 500 meters

b: A segment analysed map of Sukhumwit area at 1000 meters

c: A segment analysed map of Sukhumwit area at 1500 meters

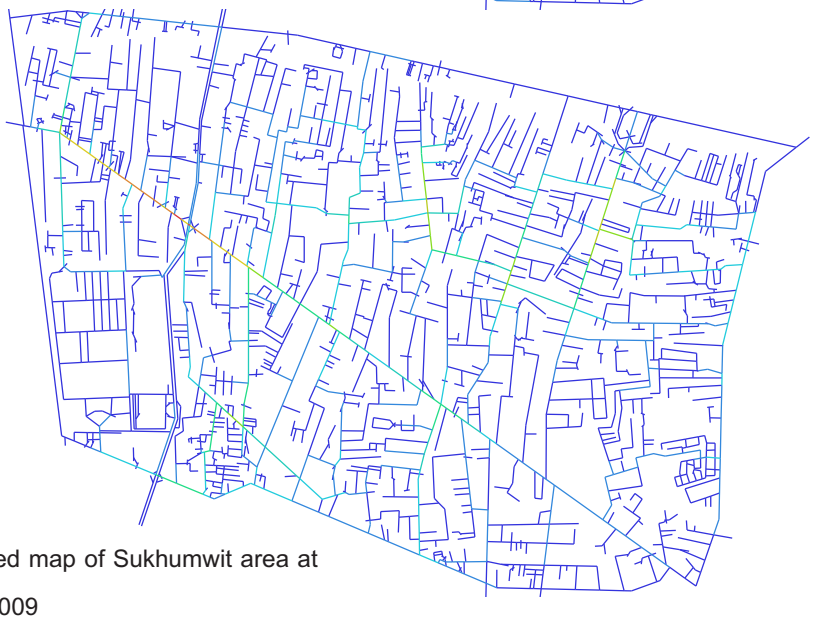
Figures 3.19: A segment analysed map of Sukhumwit area at 500, 1000 and 1500 meters in 1987

a: A segment analysed map of Sukhumwit area at 500 meters



b: A segment analysed map of Sukhumwit area at 1000 meters

c: A segment analysed map of Sukhumwit area at 1500 meters



Figures 3.20: A segment analysed map of Sukhumwit area at 500, 1000 and 1500 meters in 2009

The segment analysed maps (Figures 3.18 – 3.20) identify three distinctive patterns. First, Sukhumwit Road seems to have an integrated segment in each of the metric distance studied throughout the three periods. However, the longer the distance was studied the more integrated segment the Sukhumwit Road would have. In contrast, the shorter the distance was studied, the more integrated segment the internal area would have.

Second, among the three distances studied from the three periods, the distance of 1500-meter choice seems to be the best to pick up the internally integrated segments within the studied area as well as those of Sukhumwit Road (Figures 3.18 – 3.20). The internally integrated segments of the 1500-meter choice are more pronounced in the system of 1974 than those of the other two periods studied.

Third, when the area evolves, the later the development is the more integrated segment the internal area will have (Figures 3.18 – 3.20). This is quite clear, particularly from the 1500-meter choice of the segment analysis. As described earlier, the system of 1974 has some obvious internally integrated segments because there are a number of red and orange segments found. However, when we look at the system of 2009, we find more number of internally integrated segments but they are less obvious than those of the 1974 system.

By far, the findings of the segment analysis seem to confirm what have been found in the axial analysis. The segments of Sukhumwit Road are more integrated than those of the internal area. Of the internally integrated segments, the segment analysis, however, identify a ring of segments that seem to be the internal core of the area. Some of these segments are of the internally integrated lines, but the others are not. In the next section, both the axial and the segment configuration will be studied with the micro-distribution of land-use types. We shall see the extent to which they will relate to each other.

Chapter 4
Relationships between Spatial Structure and Micro-distribution of Land Uses

The analyses presented in this chapter are from the visual inspection and the multivariate analysis. The visual inspection is applied to the study of the micro-distribution of land-use types and their relationships to the axial and the segment analysed pattern. The multivariate analysis is applied to the study of the relationship between the integration value and the variety of the land-use types.

This chapter, therefore, consists of three sections. In the first section, the micro-distribution of the land-use types is presented as well as the variety of them. The second section is divided into two parts. Both are the studies on the relationships between the micro-distribution of land-use types and spatial structure, one with the integration pattern and the other with the segment pattern. The last section is the multivariate analysis of the spatial variables, obtained from integration values of the embedded and independent system analyses of the axial lines, and the land-use variables.

Prior to present the analyses and their findings, there are two pre-assumptions needed to be clarified. First, due to the spatial barriers indicated by the spatial structure study in the last chapter and the study's focus on the internal area of Sukhumwit, the survey of the micro-distribution of land uses was carried out within a smaller parameter than that of the studied area. This means that the land uses recorded were those being distributed within the perimeter of Asokamontri Road to the west, Ekkamai Road to the east, Petchaburi Road to the north and Sukhumwit Road to the south.

Second, as the land uses recorded were of those existing ones, the study used the contemporary land-use distribution as the basis. This means that they were investigated in relation to the spatial structures of 1974, 1987 and 2009. This is for examining the impact of the contemporary spatial structure on the land-use distribution and the changes in the spatial structure on the land-use distribution.

4.1 Micro-distribution of land-use types

The land uses recorded from the survey are displayed in Figure 4.1, which is a map showing all the major land-use types distributed within the indicated area studied, (a) with the building blocks, and (b) without the building blocks – for the clarity of the clustering and the distribution. There were 18 land uses found in the area, excluding house but included stalls, vacant, under-construction, motorcycle-taxi post and bus stop. For the presentation in this chapter, when the term 'land use or land uses' are mentioned, they will exclude the house/residential type. Table 4.1 shows the classification of the land-uses types found in the area except house.

Among the 18 land uses, there were five land uses which were more likely to be found within the area. Figure 4.2 is a map showing the selected land uses being more likely to be found in the area. They are: convenience/grocery (1,181 premises), eatery (493 premises), business office (190 premises), services (190 premises), and stall (252 stalls). However, there are a significant number of premises with fabric/fashion, appliances and vacant which were also found in the area, even of the significant lower in number than those five. In addition, there are 38 motorcycle-taxi posts found in the area, and one police check point (cop). Figure 4.2 is a map showing the selected six land uses being more likely to be found in the area. Table 4.2 is a table showing the number of premises of each land use found in the area. It should be noted here that these premises may vary in sizes.

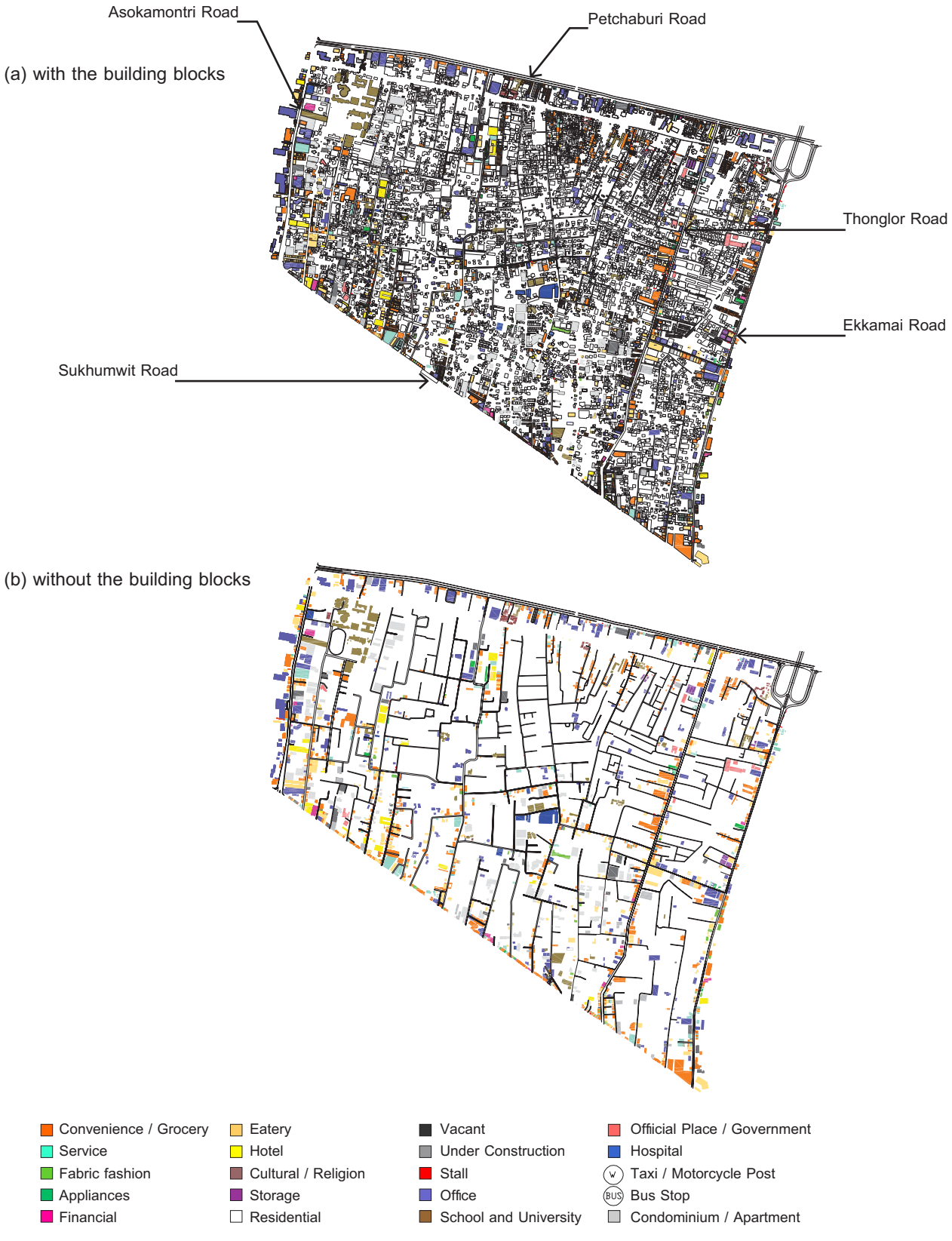


Figure 4.1: Map showing micro-distribution of land-use types within the studied area;
(a) with the building blocks, and (b) without the building blocks

categories of landuse	code	function
convenience / grocery (a)	a1	department store
	a2	delicatessen
	a3	snack/drink
	a4	convenience store
	a5	flower
services (b)	b1	pharmacy
	b2	toy/internet
	b3	spectacles/watch
	b4	luandry
	b5	barbershop/knife sharpening
	b6	massage
	b7	dental clinic
	b8	film processing
	b9	stationary/music record
	b10	gas station
fabric fashion (c)	c1	general apparel
	c2	bag/handbag
	c3	cosmetic
	c4	gold jewelry/jewelry
	c5	fabric
	c6	school uniform
	c7	traditional dress
	c8	apparel/accessories
	c9	shoe/hat/umbrella
	c10	tailor dressmaker
appliances (d)	d1	household (bed/bed linen/general household appliances/furniture)
	d2	eletrical appliances
	d3	other (equipment hairdressing/china ware/ silver ware)

Table 4.1: A classification of the land-uses types found in the studied area

categories of landuse	code	function
financial (e)	e1	bank
	e2	atm
eatery (f)	f1	coffee shop
	f2	restaurant
	f3	rice/noodle
	f4	boozer/battle cruiser
hotel (g)	g	hotel
cultural/religion (h)	h1	shrine
	h2	temple
storage (i)	i	storage
residential (j)	j	resdential
vacant (k)	k	vacant
under construction (l)	l	under construction
stall (m)	m1	produce stall (fruit/flower)
	m2	delicatessen (delicatessen/food/drink/snack)
	m3	good stall (clothes/cosmetic/bag/shoe/fabric/ apparel accessories/gift/china ware/ fragrance)
	m4	service stall (watch/CD/spectacle/radio/tag/ lighter/pocket knife)
office (n)	n	office
school (o)	o	school
government office (p)	p	government office
hospital (q)	q	hospital

Table 4.1: A classification of the land-uses types found in the studied area (Cont.)

Figure 4.2: Map showing the five selected land uses tending to be found in the area

landused categories	quantity
convenience/grocery	1181
service	190
fabric fashion	61
appliances	62
financial	22
eatery	493
hotel	24
cultural/religion	10
storage	10
vacant	72
under construction	18
stall	252
office	230
school/university	30
office place/government	8
hospital	24
taxi/motorcycle	38
bus stop	11
police check point	1

Table 4.2: A table showing the number of premises of each land use found in the area.

Although quite a number of premises with commercial and business land uses have been developed in Sukhumwit area, Figure 4.1 shows that Sukhumwit area is still a residential area. It is also quite obvious that majority of the land uses were clustered along or near the major roads, Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road, particularly the land uses that occupied large buildings. Within the internal area, there are a significant number of land uses found. Majority of them occupied small buildings.

When the distributions of the five land uses being more likely to be found in the area were examined (Figure 4.2), convenience/grocery type was found throughout the whole area studied. The premises of this land-use type were clustered both along the seven main roads and the internal roads. Eatery type was more likely to cluster within the internal area. The distributions

of stall and service types were also similar to that of the eatery. As for the business office type, they were found throughout the area studied. However, it is clear from Figure 4.2 that the large business premises tended to cluster along Asokamontri Road and Petchaburi Road. Only a few of large business premises were found along Ekkamai Road, Sukhumwit Road and internal area. The small business premises are more likely to be found within the internal area.

To summarise, there are quite a variety of land-use types found within the studied area. Most of these land-use types were distributed throughout the area. Some of them were more likely to cluster along the main roads, the edges or the internal main roads. A few of them tended to disperse within the internal area along some sequentially connecting short roads which also connect to the main roads. In the next section we shall see, what kind of configuration these road have which may affect the land-use distribution.

4.2 Relationships between spatial structure and the micro-distribution of land-use types

4.2.1 The relationships based on the integration pattern

The investigation on the relationships between the integration pattern of the studied area and the micro-distribution of land-use types is based on the existing land uses, as mentioned earlier. The integration patterns examined are of the contemporary period and from the two analysed systems – embedded and independent. However, the integration patterns of the two periods in the past will also be looked at, to establish the changes in spatial structure that may affect the current development and distribution of land uses.

Figures 4.3 and 4.4 are maps showing the integration patterns of the embedded and the independent system analysis which is superimposed by the land-use distribution. Figures 4.5 and 4.6 are maps showing the five selected land uses, which were more likely to be found in the area, being superimposed on the integration patterns. It was found that majority of the land uses were clustered along the integrated lines whether they are of the embedded or the independent system, or of globally or locally integrated – the main roads as indicated in the last section. However, a significant number and variety of land uses were found in the internal area and along the less integrated lines. Of this pattern, most of the land uses tend to be found along the sequentially connected and integrated internal lines – the roads forming the internal core.

a: Global Integration

b: Local Integration

c: Connectivity

Figure 4.3: Map showing the 2009 integration patterns of the embedded system analysis being superimposed with the land-use distribution

a: Global Integration

b: Local Integration

c: Connectivity

Figure 4.4: Map showing the 2009 integration patterns of the independent system analysis being superimposed with the land-use distribution

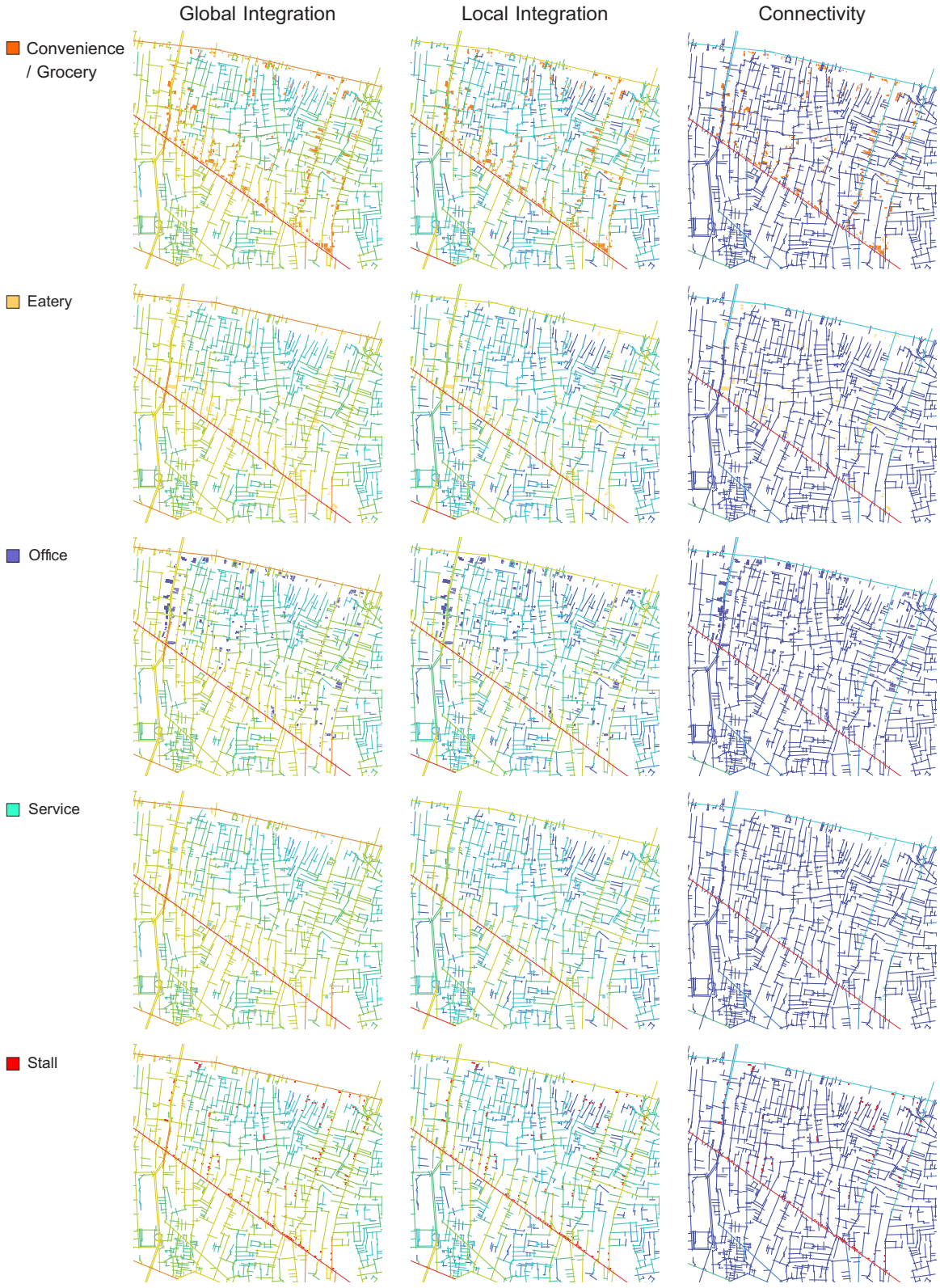


Figure 4.5: Map showing the 2009 integration patterns of the embedded system analysis being superimposed with the five land uses being found more in the area studied

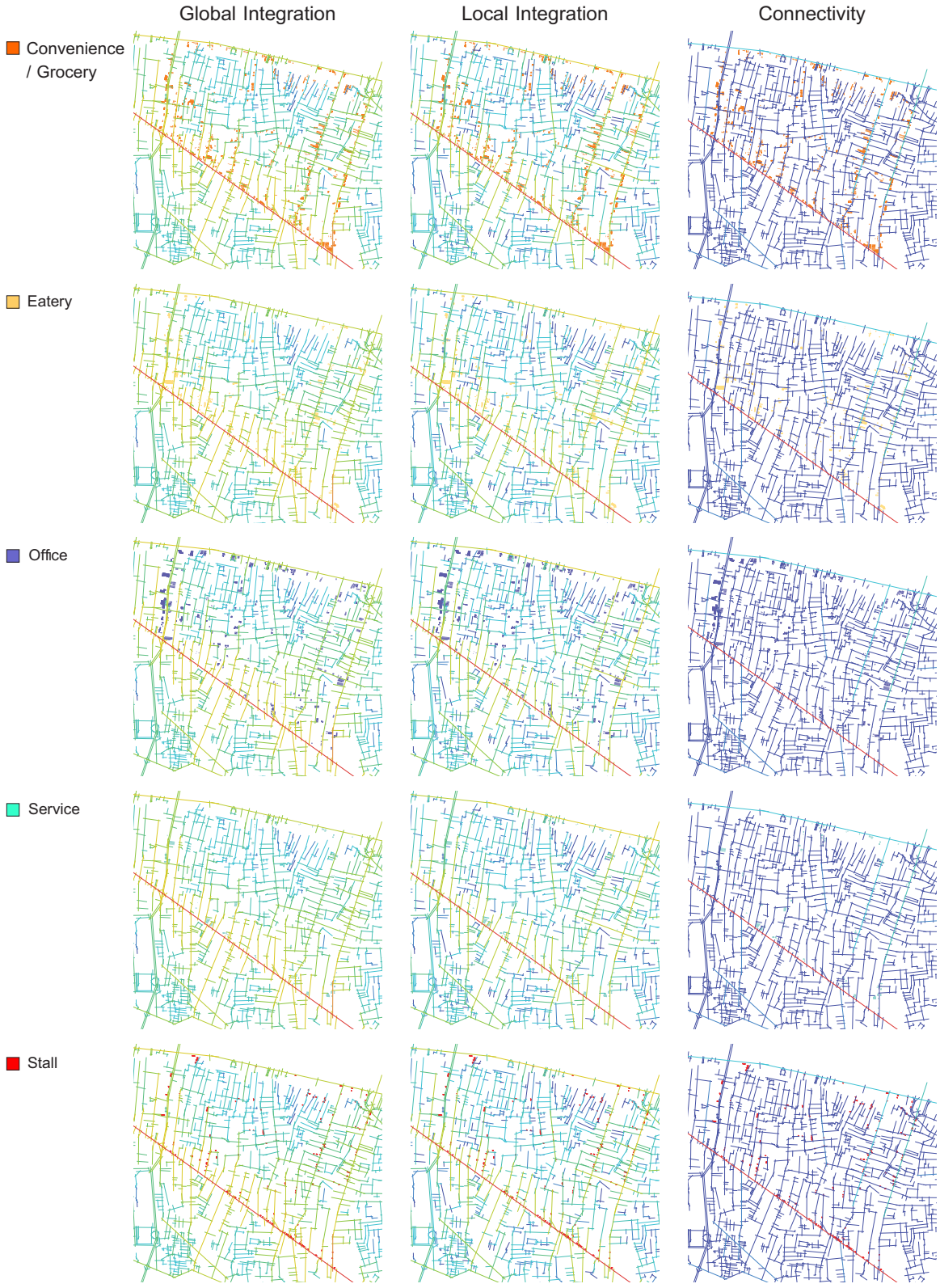


Figure 4.6: Map showing the 2009 integration patterns of the independent system analysis being superimposed with the five land uses being found more in the area studied

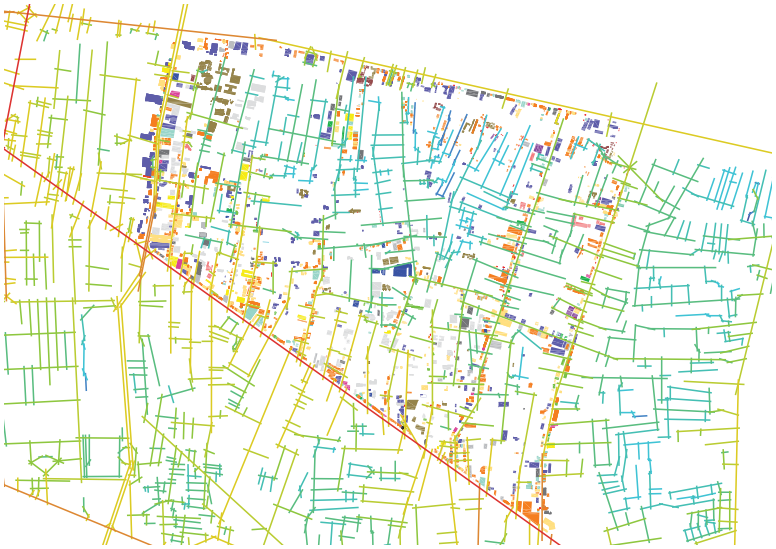
If the selected five land uses were examined Figure 4.6, it is found that convenience/grocery premises spread throughout the area, on both the integrated and the segregated line. This pattern is also found with the distributions of eatery and services premises. It is understandable giving that these three land-use types serve both the local resident and the passer-by for their business. In that sense, they can be anywhere and their tributary area can be quite close. Some of them may want to take the advantage of the movement economy the local grid provided. The other may not if they can have a good business along the segregation lines of the internal area. However, the integrated lines seem to have more number of the three land-use types' premises than the segregated lines. And, the density of the premises along the lines varied in relation to the total number of each of the three land uses.

As for the business offices, majority of them clustered along the globally and locally integrated lines, of the edges or the internal area. However, quite a few of them are found along the segregated lines of the internal area, as similar to some of the convenience/grocery premises but to a lesser degree. Again, some business types do not need to take advantage of the movement provided by the grid. They would rather have the privacy given by the segregated lines.

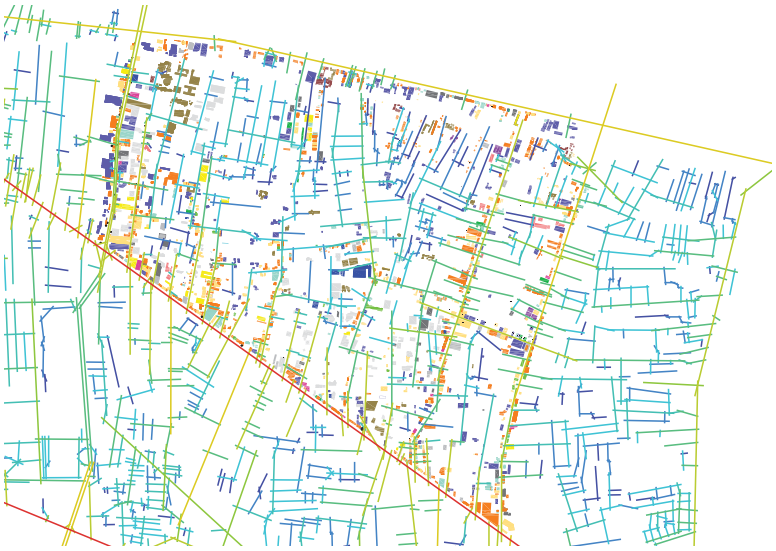
In the case of stalls, they were mainly found along the globally and locally integrated lines, of the edges or the internal area. Only a few of them were found along the internally segregated lines. Interestingly, the stalls tended to cluster together as a group rather than spread out. These groups of stalls seemed to locate around the intersections of two integrated lines as well.

To summarise, there seems to be the association between the global and local integrated lines and the clusters of land-use types. There are some exceptions that some land-use types have developed along the segregation lines of the internal area. However, their densities are lower than those found on the integrated lines. We also noted that some types of land use have clustered around the intersections.

a: Global Integration



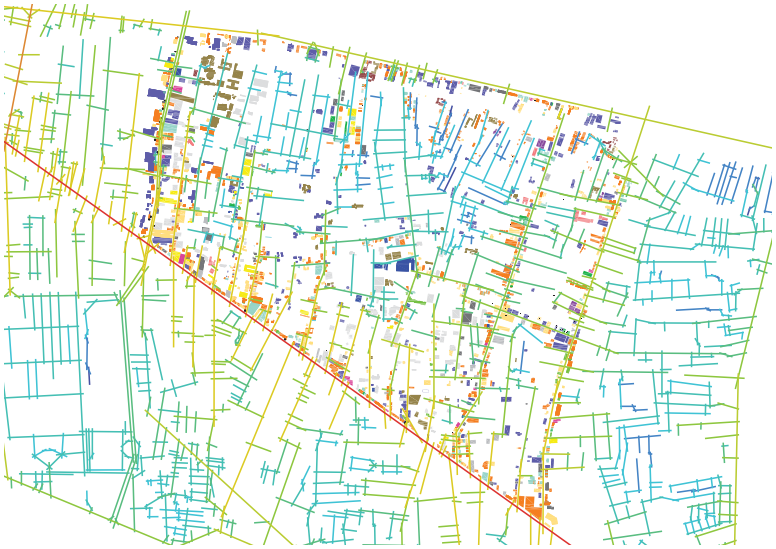
b: Local Integration



c: Connectivity

Figure 4.7: Map showing the 1987 integration patterns of the embedded system analysis being superimposed with the land-use distribution

a: Global Integration

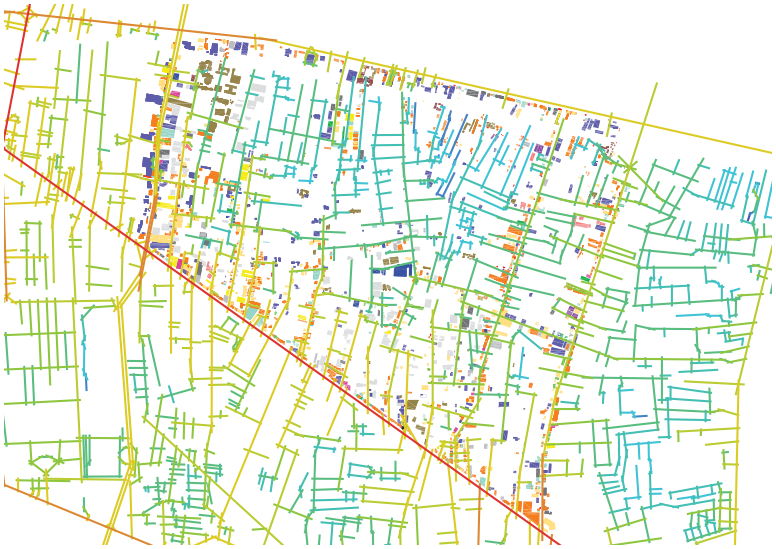


b: Local Integration

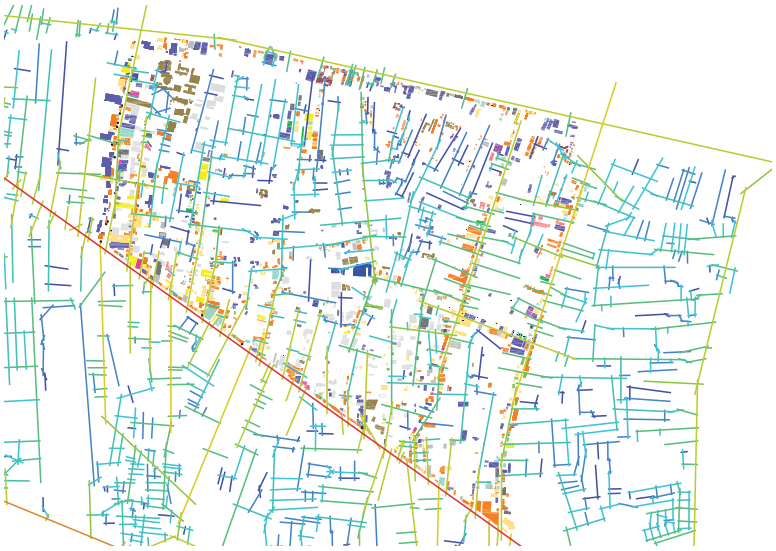
c: Connectivity

Figure 4.8: Map showing the 1987 integration patterns of the independent system analysis being superimposed with the land-use distribution

a: Global Integration



b: Local Integration



c: Connectivity

Figure 4.9: Map showing the 1974 integration patterns of the embedded system analysis being superimposed with the land-use distribution

a: Global Integration

b: Local Integration

c: Connectivity

Figure 4.10: Map showing the 1974 integration patterns of the independent system analysis being superimposed with the land-use distribution

When the land-use distribution was superimposed on the integration maps of 1987 and 1974 (Figures 4.7 – 4.10), the superimposed maps show that most of the lines that have spatial changes to be more integrated whether by being extended to the edge lines or by being connected to form the sequential links also have some land-use types developed. However, the variety of them may be of some limited types. In contrast, quite a number of the segregated lines without any spatial changes have no land-use types developed along them at all, except for house/resident. This is an evidence of the spatial change that induce the development of land use types along the integrated lines.

4.2.2 The relationships based on the segment pattern

The study of the relationships between the segment pattern and the micro-distribution of land-use types was carried out based on the segment analysis of the 2009 spatial structure. Distances of 1000 and 1500 choices were selected to study with the micro-distribution of land-use types. Figure 4.11 is a map showing the micro-distribution of land uses superimposing on the segment pattern. It shows three significant findings. First, segments along the edge roads tend to have a high clustering of land-use development, whether these segments may be integrated or not. For example, the slightly integrated segments of Sukhumwit Road within the studied area have a variety of land-use types and a vast number of premises, as similar to the segregated segments of Petchaburi Road.

Second, the integrated segments of the internal area were markedly occupied with land-use types and premises. This is even more apparent for the segments of the axial lines which sequentially link Sukhumwit Road, Petchaburi Road, Nana Road, Asokamontri Road, Thonglor Road, Ekkamai Road and Klong Ton Road one way or another. They form the internal core. On the contrary, some integrated segments, which located further away from the internal core though may link to it, may not have any land-use types or premises being developed at all.

Third, it is quite obvious that there were very few numbers of land-use types and premises being developed along the segregated segments within the internal area. This is not the cases for fresh markets and some planned shopping areas. Nevertheless, a clear clustering of land-use premises can be found where the segments intersect and whether or not the segments are integrated.

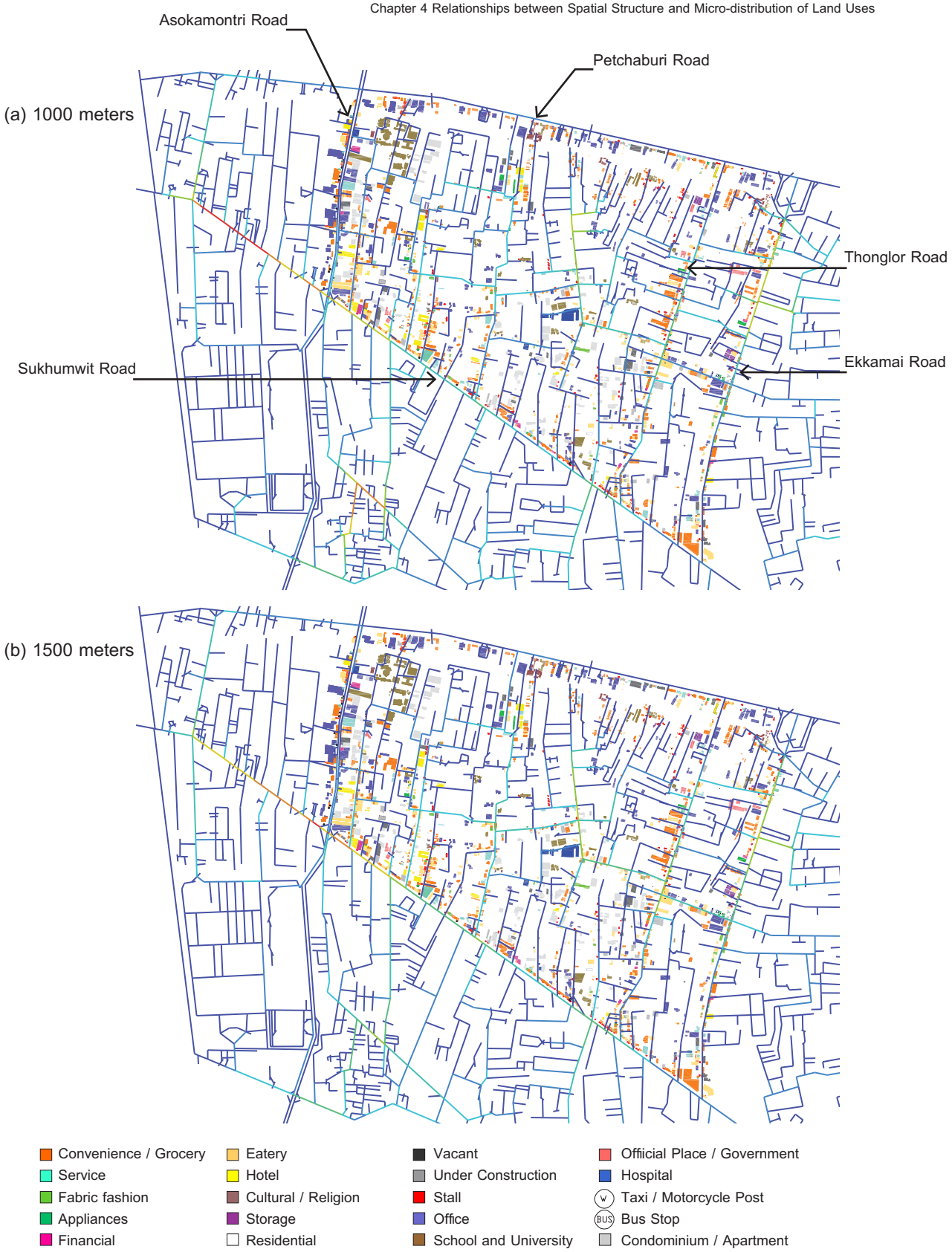


Figure 4.11: Map showing the 2009 segment patterns being superimposed with the land-use distribution

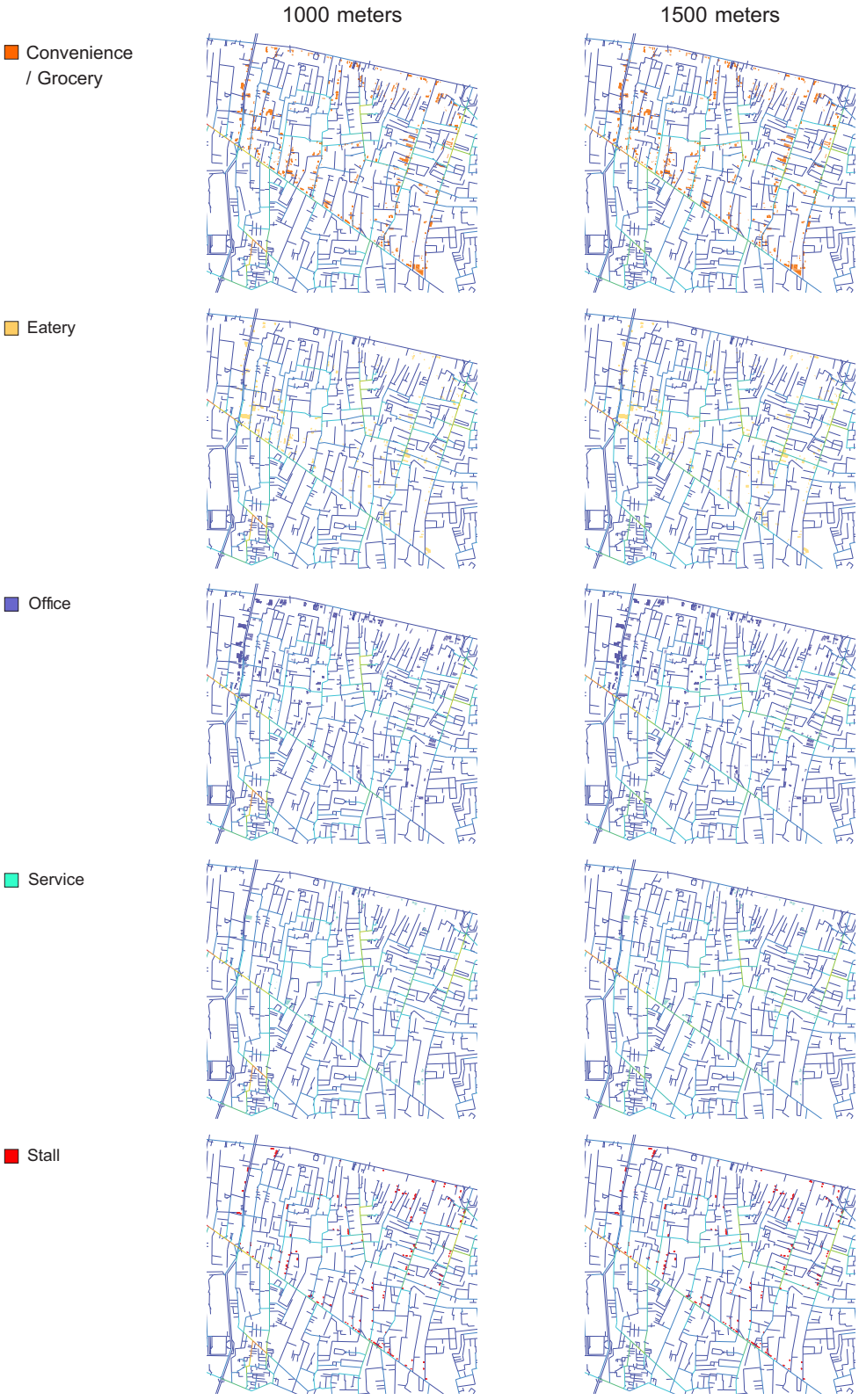


Figure 4.12: Map showing the 2009 segment patterns being superimposed with the five selected land uses

When five selected land uses were examined in relation to segment pattern as shown in Figure 4.12, the relationship patterns found are similar to those the integration pattern. Convenience/ grocery, eatery and service types and premises were found throughout the area. However, they tended to cluster along the integrated segments more than the segregated ones, except the segregated segments are those of the edges or internal core. This is not the case for business offices, majority of them were found to locate or cluster along the segregated segments, particularly those locating within the internal area. This indicates that office may be less needed to locate along the integrated segments than the other three land-use types mentioned. As for stalls, they were mainly found to cluster at the intersections of the segments. This pattern is similar for the intersections of the integrated or the segregated segments.

The integration and the segment pattern studied in relation to the micro-distribution of land-use types allow us to establish some relationships between spatial structure and land-use distribution. Variety of land-use types as well as the number of premises tended to be found along the integrated lines or segments. There are some cases that the land-use variety and the number of premises clustered along the segregated lines and segments. In that case, the land-use types developed are of those being beneficial on both the movement economy of the grid and the tributary serving area. The internal core will have a variety of land uses developed, and premises tend to cluster along the lines or segments the sequentially link to the edges, particularly at the intersections of the segments.

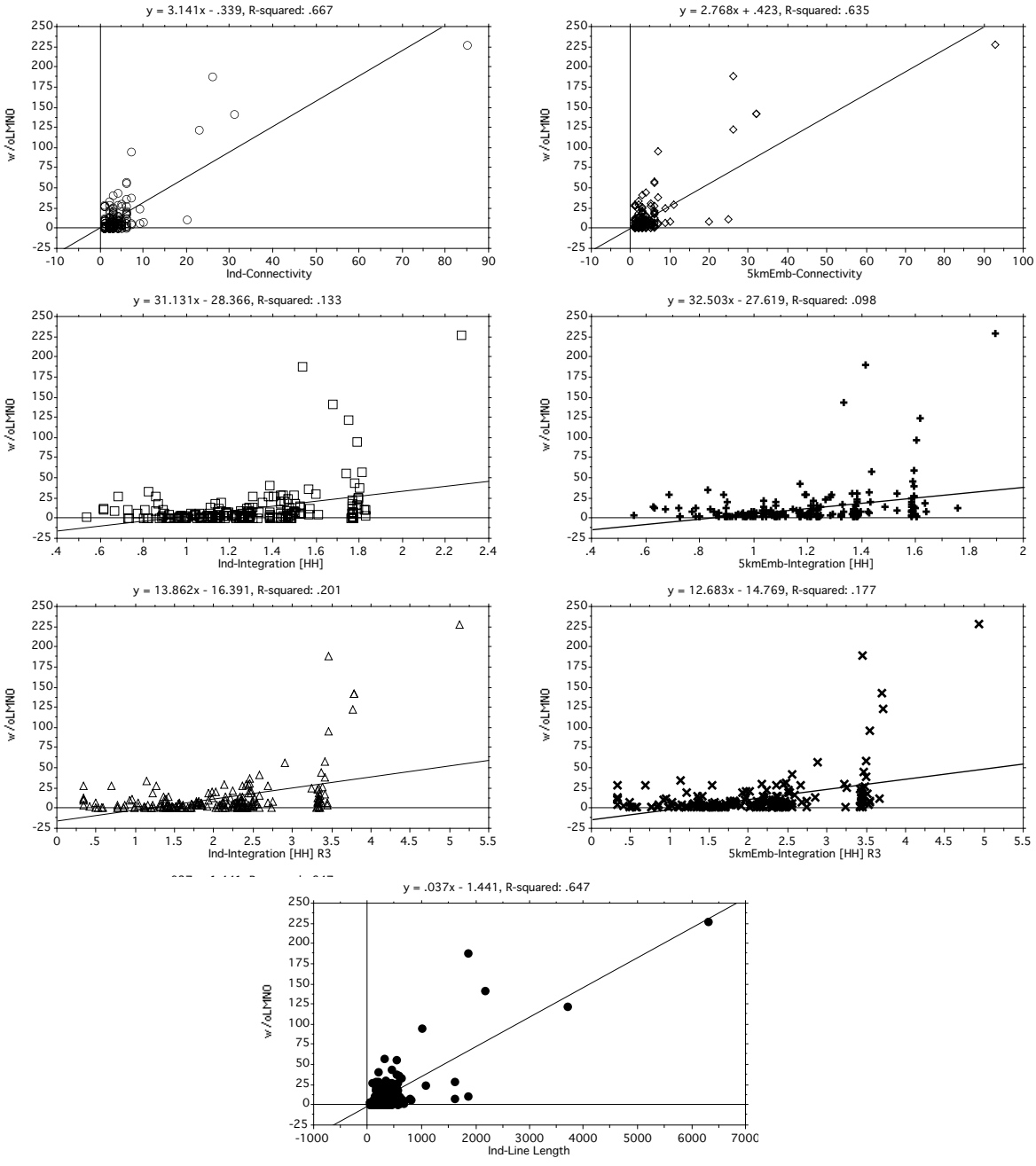
4.3 The spatial factor most associated with the micro-distribution of land uses (The multivariate analysis)

The findings from the last section indicate that the relationships between the spatial patterns and the micro-distribution of land uses can be established. In this section, the attempt is to try to pinpoint the spatial factor that is most associated with the land uses. The multivariate analysis then was carried out to try to find that spatial factor. The spatial variables were assigned as independent variables. There were seven of them and their values were obtained from the integration analyses of the embedded and the independent analysis. They are: embedded connectivity; embedded global integration; embedded local integration; independent connectivity; independent global integration; independent local integration; and, independent mean lengths. This means that the multivariate analysis was carried on the scale of the line.

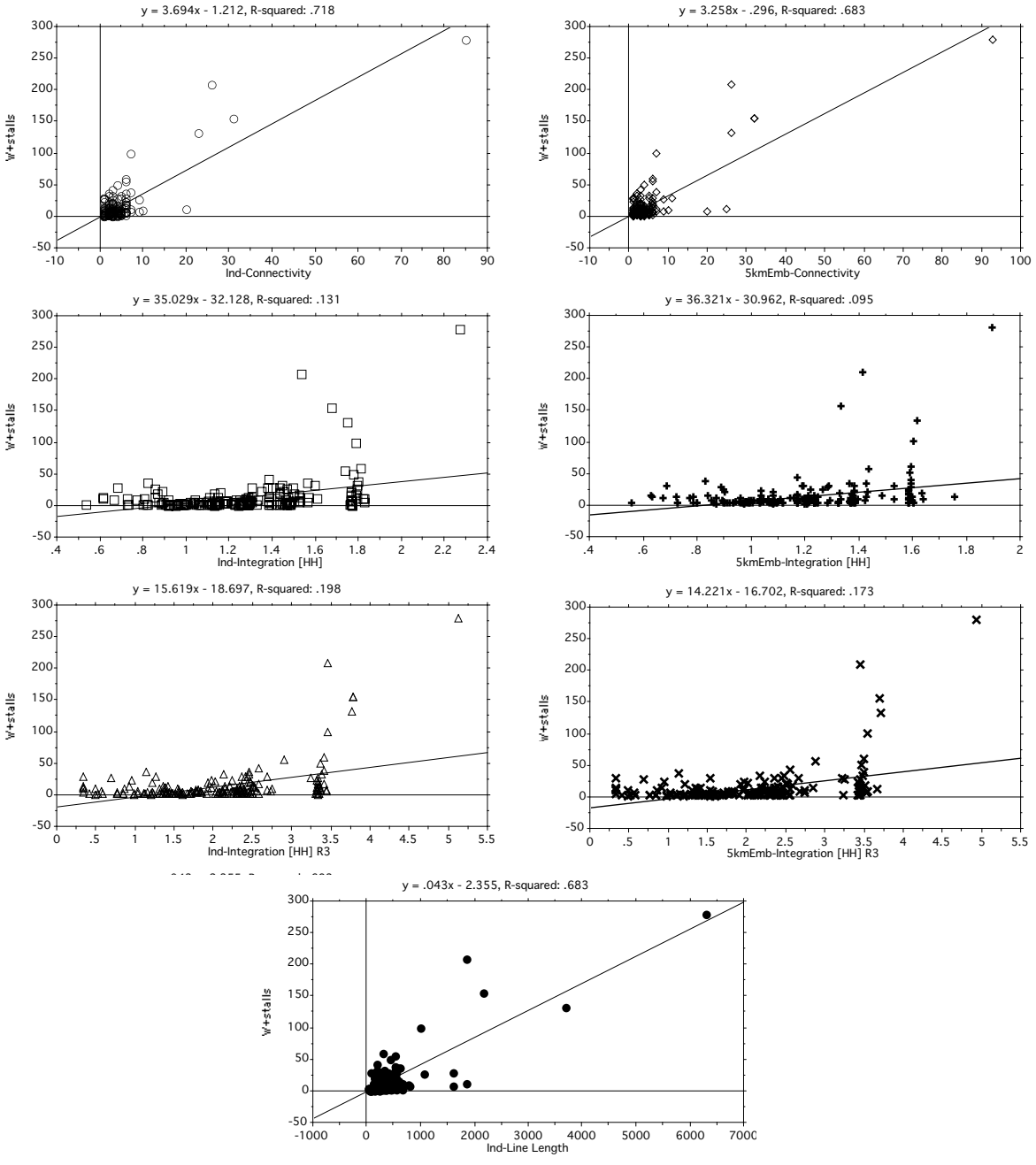
For the land-use variables, there were four of them: total premises, total premises and stalls, total floors of premises and total types of land use. The first three were designed to investigate the quantities of the land-use premises in relation to the spatial variable. The last one was designed to examine the variety of the land uses in order to establish the liveability indicator instigating by the spatial factor of the area. The values of each land-use variables, again, were summed as the values of the lines. The table showing all the spatial and the land-use values of the variables is included in the Appendix.

The analysis shows a number of interesting findings. First, the spatial values of the independent analysed system were better correlated with the land-use values in general. Second, all the spatial values were positively correlated with the values of the four land-use variables in general. Third, connectivity of the independent analysed system was found to be the spatial variable most correlated with all the four land-use variables shown by the linear regression analysis. It was also constantly selected from the stepwise regression analysis for the first step as well. The second and the third variable most selected from the stepwise analysis were line length and connectivity of the embedded analysed system, which were alternated of the selected step sometimes.

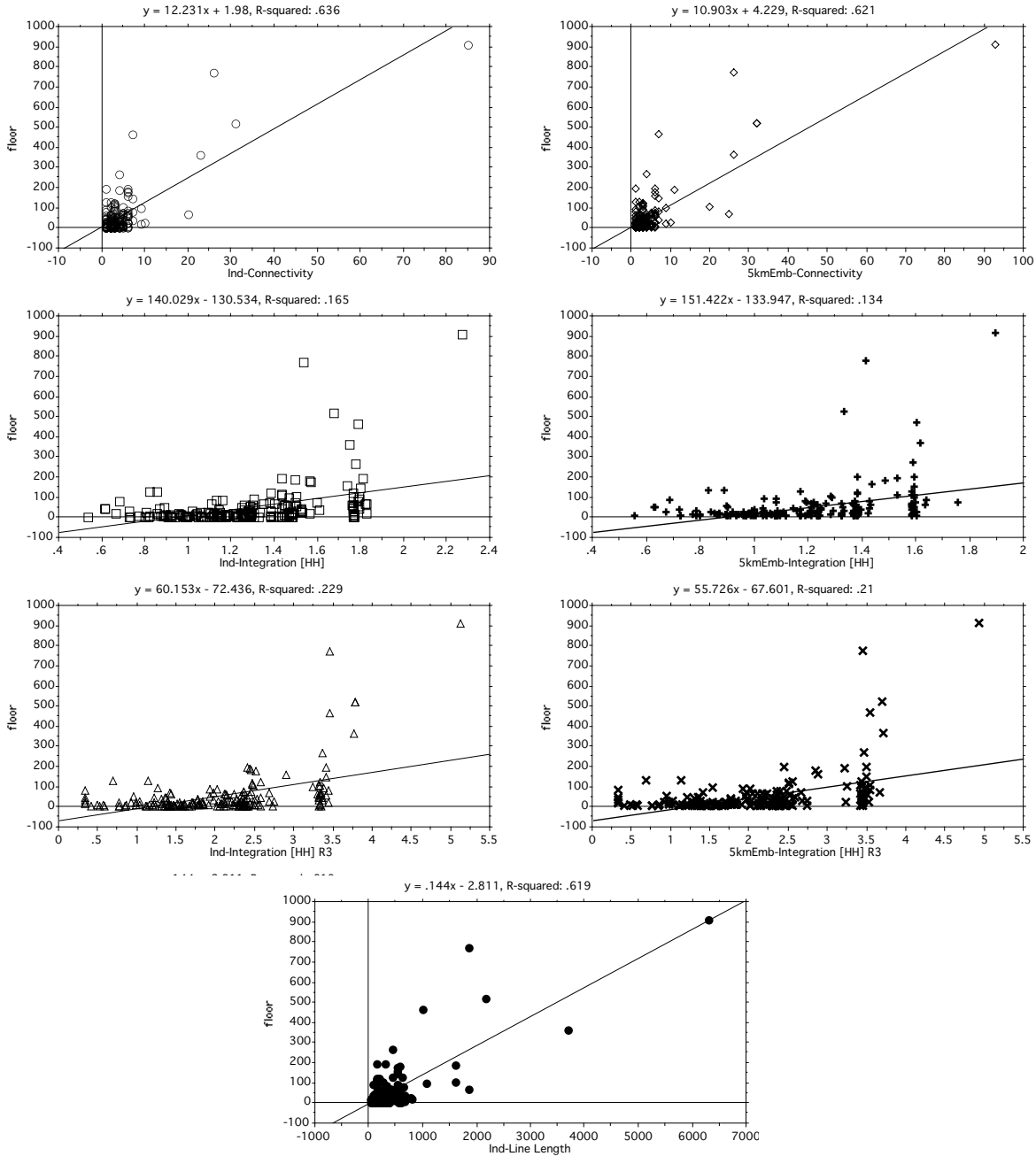
Fourth, as we divided the land-use variables into two groups, a quantity indicative and a quality indicative, the linear regression analyses pointed out that the associations between the spatial and land-use variables is stronger for the quantity indicative than that of the quality indicative. Figures 4.13-4.16 are scattergrams showing correlations between seven spatial variables and each land-use variable. For the quantity group, the scattergrams show that r-squared values are over .5, for example, r-squared value of independent connectivity and total number of premises of all land-use types is at .667 (Figure 4.13). As for the quality group, the r-squared values are much lower. The highest r-squared value given is from independent connectivity and number of land-use types found at .322 (Figure 4.16).



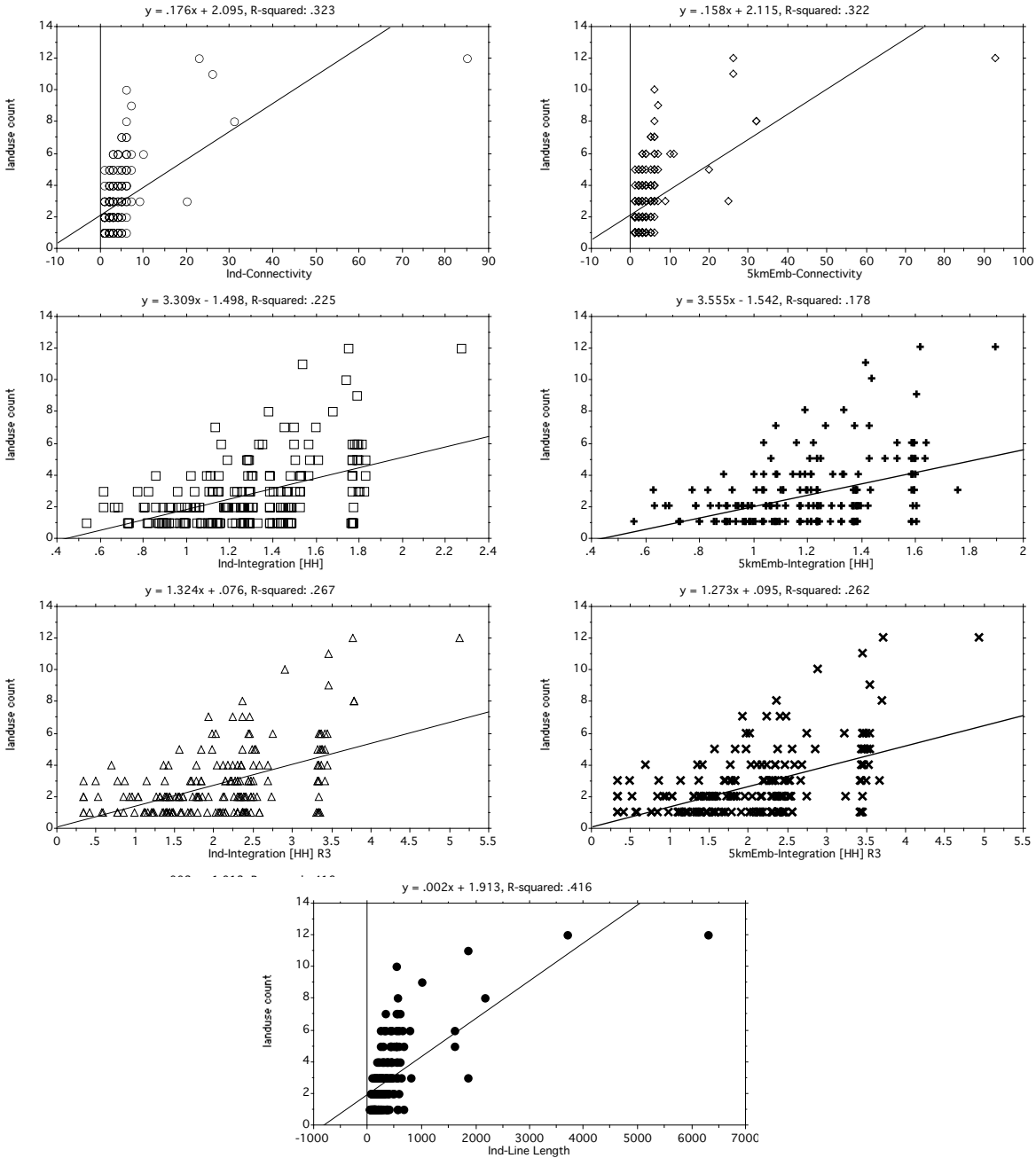
Figures 4.13: Scattergrams showing correlations between seven spatial variables and total number of premises of all land-use types, except vacant and under-construction



Figures 4.14: Scattergrams showing correlations between seven spatial variables and total number of premises of all land-use types and stalls



Figures 4.15: Scattergrams showing correlations between seven spatial variables and total number of floor



Figures 4.16: Scattergrams showing correlations between seven spatial variables and total number of land-use types found

When the linear regression analysis was applied to examine the total number of premises of each land-use type in order to try to understand the detail of each land-use distribution, it was found that not all the land-uses' values are positively correlated with spatial values.

For some land uses, their all or almost all their spatial variables were negatively correlated with the total number of premises of all land uses, for example, cultural/religion, hospital, government office and storage. The others may have some spatial variables negatively correlated with the total number of premises such as hotel and appliances (Table 4.3).

Among the seven spatial variables, independent connectivity was most correlated with majority of the total premises of land uses. There were six types of them: convenience/grocery, office, service, school/university, under-construction and stall. All have a strong association, except school/university (Table 4.3).

The second most correlated spatial variable with total premises of land uses is global integration. Two land uses' total premises associated with embedded global integration, while the other two associated with independent global integration. Interestingly, three of them had negatively strong associations: cultural/religion, storage, government office (Table 4.3). The other one that had positive correlation is fabric/fashion.

The third most correlated spatial variable with total premises of land uses is local integration. It strongly and positively and associated with financial premises. In contrast, it strongly and negatively associated with government office (Table 4.3). In addition, vacant premises also positively correlated with local integration as well.

Land use	5kmEmb-Connectivity	5kmEmb-Integration [HH]	5kmEmb-Integration [HH] R3	Ind-Connectivity	Ind-Integration [HH]	Ind-Integration [HH] R3	Ind-Line Length
convenience/grocery	0.804	0.311	0.423	0.827	0.358	0.46	0.774
eatery	0.574	0.289	0.429	0.604	0.354	0.466	0.586
office	0.432	0.241	0.354	0.442	0.259	0.391	0.578
service	0.547	0.186	0.302	0.556	0.21	0.329	0.538
school/university	0.13	0.055	0.147	0.162	0.052	0.152	0.033
fabric fashion	0.262	0.243	0.367	0.272	0.4	0.378	0.2
financial	0.862	0.538	0.644	0.89	0.588	0.71	0.759
hotel	-0.18	0.199	0.155	-0.195	0.13	0.113	-0.093
appliances	0.243	-0.012	-0.099	0.235	-0.072	-0.081	0.273
cultural/religion	-0.272	-0.397	-0.326	-0.171	-0.34	-0.287	-0.297
hospital	-0.1	-0.162	-0.034	-0.095	-0.076	0.019	-0.103
office place/governme	-0.569	-0.645	-0.91	-0.591	-0.897	-0.876	-0.411
storage	-0.447	-0.746	-0.691	-0.447	-0.735	-0.686	0.869
vacant	0.257	0.274	0.295	0.241	0.248	0.309	0.477
under construction	0.913	0.434	0.581	0.925	0.557	0.66	0.926
taxi/motorcycle	0.498	0.335	0.399	0.441	0.209	0.264	0.556
stall	0.915	0.316	0.38	0.913	0.347	0.417	0.86

Table 4.3: A table showing r-values of the matrix correlation of spatial variables and total number of premises of all land-use types

To summarise, we can establish that land-use development and distribution have a tendency to associate with connectivity whether in terms of quantity of land-use premises or variety of land-use type. Second most associated spatial variable with land-use variable was line length. However, it should be noted that both connectivity and line length may affected by the global-scale characteristic of the lines, being the lines forming the major roads of the city. This means that the spatial values of these lines can be of significant different from the other lines in the studied area in general. When each the development of each land-use type was concerned, connectivity continued to be the spatial variable associated with most of each land-use development. However, global and local integrations began to show a strong association with some land uses' development.

Chapter 5
Discussion and Conclusion

Let us now discuss the findings from the analyses in relation to the research questions and objectives set out in the beginning.

How has the former peripheral area of Bangkok developed with a special reference to Sukhumwit area?

The peripheral area of Bangkok with regards to Sukhumwit area has spatially been developed with two cases. First is the construction of arterial roads. Some arterial roads were just added into the area; in the case of Sukhumwit area this is the construction of Petchaburi Road. The other arterial roads were the extension of the main roads within the area to connect with the arterial roads, normally the edges. In addition, when the internal main roads were extended, they were often enlarged. The second case is the construction of the internal roads. This can be the construction of the new roads and the extension of the existing roads to directly or sequentially connect to the internal main roads or the edges. Roads enlarged could also occur, but normally when the internal roads were extended to the edges.

Has the centrality process involved within the development?

With reference to Sukhumwit area, the spatial changes from the two cases were meant to create the accessibility. Most often, they were carried out to complete the block, i.e., creating the grid structure. In the first case, the road construction and extension produces the large-scale grid structure. In the second case, it makes the small-scale grid structure. These two-scale grid structures are the indication of the centrality process. The presence of the grid points out that the centrality process involves with the area development through creating the accessibility ‘to’ the area and ‘within’ the area. As a result, the movement economy can be generated for the through-movement through the area and the through-movement within the area.

However, as the twp-scale grid structures are of different patterns. One is of the orthogonal, and the other of the quasi orthogonal almost to the extent of broken-grid pattern. In the other words, the internal grid structure of the area will be weak. This suggests that the movement economy within the area would be weaker than that of the edges. Consequently, giving that grid structure

associates with land-use development and distribution, the spatial patterns and changes found in Sukhumwit area indicate that land-use development within the area should be weaker than the edge or the main roads composting the large-scale grid. This conjecture has been confirmed by the micro-distribution of the land-use types and their variety within the area.

And, has the navigational purpose been concerned when the area has developed?

As for navigational purpose, the two types of spatial changes do generate a more intelligible grid structure. We see evidence from the increase in intelligibility value of the spatial structure in 1987 from that of 1974. Nevertheless, as the value of the spatial structure in 2009 drops from that of 1987, it could be said that to some extents the small changes in spatial structure may have some limit to make the area more intelligible for the navigational purpose.

Perhaps, this limited intelligible structure may be specific for Sukhumwit area. This is because the spatial structure of the whole area is very weak, as seen from the low integration values when compared with the other areas of Bangkok as discussed in Chapter 3. To create a more intelligible structure for Sukhumwit area would need a big change in the spatial system. The construction of the BTS into the area has no effect on the spatial system of the area, except for the traffic which would need to help from the spatial system of the road network, nonetheless, to assist or feed the BTS.

Does the micro distribution of land-use types associate with the internal grid structure?

The research's findings have clearly demonstrated the association between the grid structure and the micro-distribution of land-use types. Spatial factors more likely to associate with land-use variables can be identified, for the land-use premises and the number of types. They are: connectivity, line length and global integration respectively. Giving that connectivity and line length of the area are of the global properties, this reflects that the strong edge is dominant for Sukhumwit area. However, this is the effect of Sukhumwit Road being the arterial road, which has a significantly long length compared to all the other lines within the studied area.

The association between spatial and land-use variables was clearer when the integration and segment patterns and the micro-distribution of land-use types were examined. The findings from the visual inspection and comparison indicate details of the association. For the integration lines and the segments, the integrated one will have strong clustering of land uses and many land-

use types, whether the lines and segments were of the edge or the internal area. In contrast, the segregated one will have dispersed land uses' premises and few types. The segment pattern seems to be better in picking up the clustering of land uses, while the integration is better for indicating the variety of land-use types. This is the evidence of the association between the internal grid structure and the micro-distribution of land-use types in a fine detail.

If so, to what extent do the spatial structure and land uses help consolidate the urban areas, suggesting to the urban consolidation process?

It seems that the urban consolidation process work likes these. First, there occur the spatial changes within the area. Some of the changes may have the strong impact on the grid structure of the area as a whole; the other may have the impact on the internal grid and of the less degree. If both types of change shape the grid structure to have an orthogonal or quasi-orthogonal grid structure, then the centrality process will start. On the one hand, the quasi-orthogonal grid structure of the internal area initiates the spreading of land-use development from the strong and perhaps too dense edges into the internal area. When these spreading reach the internal core, they distribute and clustering around the integrated segment. On the other hand, the internal grid structure discriminate the types of land use which favour the degree of movement economy the grid generates. This results in the variety of land-use types within the internal area.

With the number of land-use premises and the variety of their types coupled with the accessibility provided by the grid, they both instigate some kinds of a social process to shape the area's characteristics. They make the area to be more accessible and usefulness. In short, together they help make the area liveability.

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Appendix A

Research Appendix

I. Table of Spatial and Land-use Variables' Values

II. Maps of Land Use Pattern in Sukhumwit Area

Table of Spatial and Land-use Variables' Values

Ind-line-no.	5kmEmb--line-no.	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	Total-Premises	Total-Premises + Under-construction	Total-Premises +stalls	Total-Premises + Under-construction +stalls	landuse-count	floor	Ind-Connectivity	Ind-Integration [HH]	Ind-Integration [HH] R3	Ind-Line-Length	Ind-Mean-Depth	5kmEmb-Connectivity	5kmEmb-Integration-[HH]	5kmEmb-Integration [HH] R3	5kmEmb-Line-Length	5kmEmb-Mean-Depth
0	0	57	6	14			53					1		13	11		1			3		142	142	155	155	8	519	31	1.675065	3.791959	2162.835	5.691251	32	1.337802	3.705498	2162.835	8.31569
6	6	98	25	2		4	33					1		20	21			2	4	3		185	185	205	205	11	769	26	1.536522	3.465273	1853.349	6.114244	26	1.420616	3.460512	1853.349	7.889225
7	7	2					1											1				4	4	4	4	3	3	1	1.285372	2.298792	115.1265	7.113521	1	1.240576	2.315761	115.1265	8.889036
10	10	1										3		5	1				1			2	2	7	7	4	5	6	1.381093	2.343064	593.4259	6.689805	6	1.19568	2.351867	593.4259	9.185255
11	11		2				5								1	1						9	9	9	9	4	39	4	1.284157	2.345715	346.1114	7.119306	4	1.148723	2.354864	346.1114	9.519849
12	12	3	1		2		10						3	2	9				1			25	28	27	30		97	9	1.467038	3.251507	1069.373	6.356472	9	1.290838	3.265991	1069.373	8.581853
16	16													4	1							1	1	5	5	2	2	6	1.385495	2.737086	373.1423	6.671728	6	1.177648	2.751825	373.1423	9.310586
23	23													2								0	0	2	2	1	0	2	1.287809	2.365681	284.7703	7.101952	2	1.241052	2.379922	284.7703	8.886011
29	29		1														4					5	5	5	5	2	6	2	1.382323	2.550174	273.3382	6.684743	2	1.177166	2.53356	273.3382	9.313989
30	30	9					18							2								27	27	29	29	3	69	5	1.400131	2.690074	391.9954	6.612437	5	1.200087	2.676756	391.9954	9.155198
31	31	-				1									1	1						3	3	3	3	3	17	5	1.11671	1.844359	128.242	8.036877	5	1.103501	1.844359	128.242	9.868999
33	33	1				1									2							4	4	4	4	3	13	2	1.290562	2.439448	202.9738	7.088937	2	1.241587	2.451545	202.9738	8.882608
40	40	5					5															10	10	10	10	2	22	1	1.285372	2.298792	254.7596	7.113521	1	1.240576	2.315761	254.7596	8.889036
41	41														1							1	1	1	1	1	4	2	0.9873554	1.119194	134.1078	8.958785	2	0.9937416	1.119194	134.1078	10.84858
42	42	1					1							2					1	1		2	2	4	4	5	18	2	1.287809	2.362191	289.7633	7.101952	2	1.241052	2.376325	289.7633	8.886011
45	45				14																	14	14	14	14	1	56	2	1.287809	2.362191	231.8224	7.101952	2	1.241052	2.376325	231.8224	8.886011
46	46														2							2	2	2	2	1	8	2	1.112936	1.464872	357.7065	8.060738	2	1.102725	1.464872	357.7065	9.875237
56	56														1							1	1	1	1	1	2	2	0.8168837	0.8491229	107.6432	10.61967	2	0.8039027	0.8491229	107.6432	13.17429
62	62		1				2															3	3	3	3	2	10	5	1.037204	1.728888	118.4809	8.576283	5	0.9630026	1.728888	118.4809	11.16295
63	63						2					1				1						3	3	3	3	2	12	2	1.179362	1.609216	268.0172	7.663051	2	1.065462	1.609216	268.0172	10.18563
64	64	10	6	2	1		5							1	3				1			27	27	28	28	8	74	6	1.37899	2.369202	546.1978	6.698482	6	1.194273	2.369202	546.1978	9.194896
66	66	1																				1	1	1	1	1	2	1	1.285372	2.298792	119.8503	7.113521	1	1.240576	2.315761	119.8503	8.889036
67	67													2								0	0	2	2	1		1	1.285372	2.298792	121.9811	7.113521	1	1.240576	2.315761	121.9811	8.889036
68	68	2																				2	2	2	2	1	6	1	1.285372	2.298792	184.1783	7.113521	1	1.240576	2.315761	184.1783	8.889036
70	70														3							3	3	3	3	1	12	5	1.152595	2.067832	277.3906	7.817788	5	1.041521	2.067832	277.3906	10.39679
74	74	1										1										1	1	1	1	1	18	2	1.137753	1.710445	191.6938	7.906724	2	1.03895	1.710445	191.6938	10.42004
76	76						2									2		4				8	8	8	8	3	40	2	1.14026	1.770222	253.7915	7.89154	2	1.039388	1.770222	253.7915	10.41607
77	77		2			1	1								1							5	5	5	5	4	8	5	1.147969	2.240151	518.2645	7.845264	5	1.040725	2.240151	518.2645	10.40397
79	79	1	1																			2	2	2	2	2	8	1	1.056873	1.040526	94.3642	8.435286	1	0.9993619	1.040526	94.3642	10.79319
83	83													1		1						1	1	2	2	2	2	1	0.7988695	0.5279905	59.18358	10.83659	1	0.7891616	0.5279905	59.18358	13.4017
85	85	3	1				1							1	3				1			8	8	9	9	6	24	10	1.329885	2.756728	764.9313	6.908894	10	1.162262	2.756728	764.9313	9.420605
86	86	14	1	2			3	1				2							1			21	21	23	23	7	61	6	1.451947	2.242224	526.309	6.412148	6	1.271407	2.242224	526.309	8.697732
87	87	1														1						2	2	2	2	2	5	1	1.225648	1.30688	143.5731	7.411425	1	1.125254	1.30688	143.5731	9.697542
90	90											1										0	0	0	0		2	4	1.132065	1.60081	226.4269	7.941432	4	1.086206	1.60081	226.4269	10.01021
91	91	1																				1	1	1	1	1	2	2	1.065577	1.198155	100.24	8.374548	2	1.010224	1.198155	100.24	10.6879
92	92	1																				1	1	1	1	1	5	2	1.22828	1.485036	82.89999	7.397686	2	1.125719	1.485036	82.89999	9.693951
96	96		2																			2	2	2	2	1	4	3	1.121434	1.398851	115.2499	8.007231	3	1.084137	1.398851	115.2499	10.02741
97	97																1					1	1	1	1	1	5	3	1.142778	1.486466	339.4796	7.876356	3	1.088261	1.486466	339.4796	9.993195
98	98														1							1	1	1	1	1	3	3	1.286285	2.397404	311.6471	7.109183	3	1.240754	2.409255	311.6471	8.887901
100	100	7	3	4			5					2		1				1				20	20	21	21	6	86	3	1.157752	2.025026	329.3184	7.787419	3	1.042401	2.025026	329.3184	10.38885
105	105	154	14	6	12	5	27	1				4	7	52	7			1	4	1		227	234	279	286	12	907	85	2.271227	5.135136	6313.413	4.45987	93	1.901949	4.944037	6313.413	6.145747
213	577													2								0	0	2	2	1		1	1.380918	2.464949	104.3403	6.690528	1	1.176952	2.433604	104.3403	9.315501
219	583	1													1							2	2	2	2	2	7	1	1.380918	2.464949	191.0628	6.690528	1	1.176952	2.433604	191.0628	9.315501
220	584						1															1	1	1	1	1	2	2	1.396354	2.585907	353.9863	6.627621	2	1.179499	2.566579	353.9863	9.297543
260	635	18	5	16	1	1	10	1							2	2				1		56	56	56	56	10	160	6	1.736906	2.89843	519.5901	5.524223	6	1.442103	2.893638	519.5901	7.786579
268	643	1													2							3	3	3	3	1	12	2	1.444613	2.085733	559.2953	6.439624	2	1.370634	2.138898	559.2953	8.140453
269	644	1					2							1	2							5	5	6	6	4	20	3	1.56349	2.304273	284.9193	6.026031	3	1.391708	2.343979	284.9193	8.032325
271	646	9					4					1			1							14	14	14	14	3	24	3	1.522317	2.142849	346.9062	6.161967	3	1.384711	2.192221	346.9062	8.067863
272	647	20	1				2						1	2	1				1			24	25	26	27	6	104	3	1.794554	3.341131	236.8022	5.378887	3	1.59798	3.453851	236.8022	7.124575
274	649	7	1				4															12	12	12	12	3	44	2	1.793962	3.327577	258.3047	5.380332	2	1.597881	3.443273	258.3047	7.124953
275	650														1							1	1	1	1	1	1	1	1.484269	2.054763	63.402	6.294288	1	1.377966	2.109903	63.402	8.102457
276	651	6													1							7	7	7	7	2	32	4	1.524666	2.38561	336.8562	6.154013	4	1.401086	2.420812	336.8562	7.985255
278	653	1																				1	1	1	1	1	2	1	1.32826	1.125785	208.7658	6.916124	1	1.249257	1.125785	208.7658	8.834215
282	657															1						1	1	1	1	1	3	3	1.28598	2.374785	159.0758	7.110629	3	1.240695	2.387568	159.0758	8.88828
287	662	1		2			2							6					1			5	5	11	11	5	36	7	1.607904	2.532727	674	5.887202	7	1.433637	2.561271	674	7.826654
288	663			1			1					9		2		2						4	4	6	6	4	18	5	1.824991	3.440953	366.8072	5.305857	5	1.602977	3.536074	366.8072	7.105482
289	664	14	3			1	10							1	2			1				31	31	32	32	7	77	5	1.598209	2.458542	330.7538	5.916847	5	1.432011	2.490544	330.7538	7.834404
290	665	1					2						2	2		1						4	6	6	8	4	26	3	1.478213	2.045368	361.5513	6.31598	3	1.30024	2.045368	361.5513	8.527032
294	669		1				3					1			1	1		1				7	7	7	7	5	49	2	1.763684	3.328374	433.4562	5.455532	2	1.592769	3.444079	433.4562	7.144612
300	680	5	1			1	3					1			3	2						15	15	15	15	6	55	4	1.76483	3.355489	527.0786	5.452639	4	1.592965	3.46524	527.0786	7.143857
301	681		1				1							3	5				1			7	7	10	10	5	46	5	1.764543	3.361009	472.1409	5.453362	5	1.592916	3.469113	472.1409	7.144045
304	684	29												4								29	29	33	33	2	64	2	1.442886	2.135604	180.2405	6.446132	2	1.370307	2.185555	180.2405	8.142155
305	685		4				14							3								18	18	21	21	-	125	3	1.763398	3.333572	151.6082	5.456254	3	1.59272	3.447764	151.6082	7.144802
306	686													2								0	0	2	2	1		2	1.465456	2.142045	71.40659	6.362256	2	1.374527	2.191556	71.40659	8.120227
401	1158	6					4					1	1	3	3							13	14	16	17	4	56	3	1.76483	3.341877	341.709	5.452639	3	1.592965	3.454627	341.709	7.143857
495	1331	32					21							2		1		3	1			57	57	59	59	6	195	6	1.807688	3.406618	295.2172	5.347072	6	1.600153	3.506116	295.2172	7.116257
748	2079	1												1								1	1	2	2	2	3	1	0.9223306	0.8461539	111.21	9.519884	1	0.9100056	0.8461539	111.21	11.75482
749	2080		1				1		1							2		1				6	6	6	6	5	29	6	1.281583	1.832828	424.9469	7.131598	6	1.214273	1.832828	424.9469	9.059924
750	2081																	1				1	1	1	1	1	2	2	1.480831	2.255641	128.7478	6.30658	2	1.377343	2.298093	128.7478	8.105671
751	2082														1							1	1	1	1	1	2	4	1.044882	1.578518	237.7065	8.520607	4	1.003274	1.578518	237.7065	10.75501
752	2083															1						1	1	1	1	1	4	4	0.9077699	1.471094	364.2216	9.656544	4	0.9015907	1.471094	364.2216	11.8552
757	2088							1				-										1	1	1	1	1	5	3	0.9860117	1.384559	324.7875	8.969631	3	0.9769771	1.384559	324.7875	11.01758
758	2089				1																	1	1	1	1	1	4	2	0.9881634	1.238816	123.1657	8.952277	2	0.9774197	1.238816	123.1657	11.01304

*note: a=convenience/grocery, b= service, c= fabric fashion, d= appliances, e= financial, f= eatery, g= hotel, h= cultural/religion, i= storage, j= residential, k= vacant, l= under construction, m= stall, n=office, o= school/university, p=government office, q= hospital, r= taxi/ motorcycle, s= bus stop, t= police check point

Table of Spatial and Land-use Variables' Values (Cont.)

Ind-line-no.	5kmEmb--line-no.	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	Total-Premises	Total-Premises + Under-construction	Total-Premises +stalls	Total-Premises + Under-construction +stalls	landuse-count	floor	Ind-Connectivity	Ind-Integration [HH]	Ind-Integration [HH] R3	Ind-Line-Length	Ind-Mean-Depth	5kmEmb-Connectivity	5kmEmb-Integration-[HH]	5kmEmb-Integration [HH] R3	5kmEmb-Line-Length	5kmEmb-Mean-Depth
760	2091	5	1				1								1							8	8	8	8	4	61	5	1.300134	2.11039	406.8088	7.044107	5	1.217728	2.11039	406.8088	9.037051
761	2092	-													1							1	1	1	1	1	2	3	1.153207	1.571762	140.9496	7.814172	3	1.090232	1.571762	140.9496	9.976937
762	2093	2					2															4	4	4	4	2	8	3	1.169589	1.559824	220.017	7.718728	3	1.093271	1.559824	220.017	9.951984
765	2096	12		3			2							2	3				1			20	20	22	22	6	71	6	1.348867	1.980574	419.9105	6.825741	6	1.22644	1.980574	419.9105	8.979962
766	2097	3	1		1																	5	5	5	5	3	17	5	1.220966	1.839104	411.8949	7.436008	5	1.11299	1.839104	411.8949	9.793384
767	2098	4	2																			6	6	6	6	2	24	1	1.056873	1.040526	95.32072	8.435286	1	0.9993619	1.040526	95.32072	10.79319
769	2100	4	2				5								3							14	14	14	14	4	42	2	1.304504	1.359221	247.9401	7.023861	2	1.218531	1.359221	247.9401	9.031758
770	2101	4	1				1															6	6	6	6	3	37	2	1.52488	2.277181	154.7777	6.15329	2	1.385155	2.31841	154.7777	8.065596
771	2102	1																				1	1	1	1	1	2	1	1.465061	2.117978	112.6471	6.363702	1	1.374454	2.168962	112.6471	8.120605
772	2103	4	2																			6	6	6	6	2	24	1	1.465061	2.117978	99.37048	6.363702	1	1.374454	2.168962	99.37048	8.120605
774	2105						3															3	3	3	3	1	15	2	1.486706	2.112819	269.014	6.285611	2	1.378406	2.164041	269.014	8.100189
775	2106	5	3												1							9	9	9	9	3	59	3	1.462891	2.154754	154.7006	6.371656	3	1.374053	2.203406	154.7006	8.122684
776	2107	1												6	2							3	3	9	9	3	7	2	1.233718	0.8619656	213.5	7.369487	2	1.204975	0.8619656	213.5	9.122117
778	2109	8	10				5															23	23	23	23	3	105	2	1.762826	3.320021	248.6265	5.457701	2	1.592622	3.437188	248.6265	7.14518
784	2115	30	3				10	1				2		6					1			44	44	50	50	6	268	4	1.778985	3.365049	440.1835	5.417209	4	1.59537	3.473506	440.1835	7.134593
785	2116	4		1								1										5	5	5	5	2	21	3	1.479622	2.254295	272.688	6.310918	3	1.377123	2.296843	272.688	8.106805
790	2121													2	1	1						2	2	4	4	3	8	4	1.465851	2.226342	145.0097	6.36081	4	1.3746	2.270552	145.0097	8.119849
793	2124	1					4	1						1								6	6	7	7	4	31	4	1.7677	3.363009	306.8047	5.445408	4	1.593455	3.471303	306.8047	7.141966
795	2126	10					13	2						6	1							26	26	32	32	5	95	3	1.795444	3.391108	533.1177	5.376717	3	1.598128	3.495693	533.1177	7.124008
796	2127	2			1		4	2				1		5	1				1			10	10	15	15	7	75	5	1.492833	2.369534	594.6852	6.263919	5	1.379508	2.405615	594.6852	8.094518
798	2129	-					2					1	1									2	3	2	3	1		3	1.069246	1.108778	245.3214	8.349241	3	1.073504	1.108778	245.3214	10.11682
799	2130	1																				1	1	1	1	1	3	1	0.9412628	0.5817041	76.47115	9.348517	1	0.9674112	0.5817041	76.47115	11.11664
800	2131	-										1										0	0	0	0		20	1	1.241327	0.9909774	73.14228	7.330441	1	1.213305	0.9909774	73.14228	9.066352
801	2132	3					11															14	14	14	14	2	57	4	1.474002	2.330626	280.2145	6.331164	4	1.38497	2.368896	280.2145	8.066541
804	2135	-										2	1		1							1	2	1	2	1	63	1	1.762254	3.306579	243.8258	5.459147	1	1.592524	3.426677	243.8258	7.145558
806	2137	5					1								1	1						8	8	8	8	4	30	2	1.763398	3.327577	185.8123	5.456254	2	1.59272	3.443273	185.8123	7.144802
807	2138	18	9				11															38	38	38	38	3	148	7	1.8005	3.409353	523.5983	5.364425	7	1.598967	3.509372	523.5983	7.120794
809	2140	6													2							8	8	8	8	2	15	3	1.772602	3.341877	575.7319	5.433116	3	1.594289	3.454627	575.7319	7.138752
811	2142		2																			2	2	2	2	1	4	2	1.762826	3.320021	108.9031	5.457701	2	1.592622	3.437188	108.9031	7.14518
828	2159														1							1	1	1	1	1	1	3	1.771735	3.353072	110.8387	5.435286	3	1.610857	3.464514	110.8387	7.075614
830	2161	2					1	2				1			1			1		1		7	7	7	7	6	78	7	1.786295	3.44666	639.4346	5.399132	7	1.644473	3.549211	639.4346	6.951418
832	2163	49	8	1		1	27		1			23		9	32	1	2		2			122	122	131	131	12	360	23	1.749207	3.763841	3703.021	5.492408	26	1.621045	3.719234	3703.021	7.037429
833	2228								1													1	1	1	1	1	2	2	1.431295	2.428397	140.2641	6.490239	2	1.390811	2.474049	140.2641	8.036862
835	2230	15													4							19	19	19	19	2	119	3	1.432049	2.4703	146.085	6.487346	3	1.390961	2.516104	146.085	8.036106
836	2231	9	3												9							21	21	21	21	3	112	3	1.432049	2.4703	144.1273	6.487346	3	1.390961	2.516104	144.1273	8.036106
840	2235	24	5																			29	29	29	29	2	194	1	1.430918	2.403617	152.4023	6.491685	1	1.390736	2.448932	152.4023	8.03724
845	2240														6							6	6	6	6	1	42	1	1.430918	2.403617	108.3001	6.491685	1	1.390736	2.448932	108.3001	8.03724
847	2242														3							3	3	3	3	1	21	1	1.210899	1.227736	37.00933	7.489516	1	1.217786	1.294392	37.00933	9.036673
848	2243						1															1	1	1	1	1	3	1	1.430918	2.403617	136.0881	6.491685	1	1.390736	2.448932	136.0881	8.03724
881	2276		2																			2	2	2	2	1	10	2	1.28598	2.358737	125.25	7.110629	2	1.240695	2.372751	125.25	8.88828
882	2277		3																			3	3	3	3	1	12	2	1.28598	2.358737	102.8311	7.110629	2	1.240695	2.372751	102.8311	8.88828
883	2278		4																			4	4	4	4	1	16	1	0.9692162	0.3333333	43.09572	9.107737	1	0.9898279	0.3333333	43.09572	10.88752
884	2279					1																1	1	1	1	1	4	2	1.105464	1.366819	53.24749	8.108459	2	1.101177	1.366819	53.24749	9.887712
885	2280											1		6								0	0	6	6	1	9	1	0.8698432	0.5660819	353.9573	10.03398	1	0.9005087	0.5660819	353.9573	11.86824
887	-						2								1							3	3	3	3	2	11	1	1.188519	1.559014	204.1283	7.611714	1	1.069026	1.573531	204.1283	10.15501
892	2287	11												12								11	11	23	23	2	49	1	0.8897839	0.9571087	489.9854	9.831526	1	0.9049158	0.9571087	489.9854	11.81531
893	2288														3							3	3	3	3	1	11	2	0.8900754	1.15614	397.223	9.828633	2	0.9049791	1.15614	397.223	11.81456
895	2290	2								4				4								6	6	10	10	3	11	1	0.7696212	0.4986036	324.4002	11.21041	1	0.7794783	0.4986036	324.4002	13.55577
896	2291	10												3								10	10	13	13	2	23	1	0.8529802	0.9216888	230.4745	10.21258	1	0.8468903	0.9216888	230.4745	12.55633
897	2292													1	1				1			1	1	2	2	3	21	4	0.9567586	1.692666	447.3111	9.213305	4	0.9270995	1.692666	447.3111	11.55652
915	2310	4	6				3															13	13	13	13	3	43	1	0.6142441	0.3333333	200.7705	13.7932	1	0.6359141	0.3333333	200.7705	16.39036
916	2311	11																				11	11	11	11	1	33	1	0.7250531	0.3333333	112.6333	11.83803	1	0.7302558	0.3333333	112.6333	14.40208
917	2312	1		1																		2	2	2	2	2	8	2	1.001735	1.438096	59.114	8.844541	2	0.9407105	1.438096	59.114	11.40378
920	2315	4	7				2															13	13	13	13	3	26	6	1.147242	2.215306	543.6621	7.849602	6	1.040599	2.215306	543.6621	10.4051
921	2316	26					2															28	28	28	28	2	78	1	0.6798761	0.3333333	155.7305	12.55821	1	0.6921147	0.3333333	155.7305	15.14064
923	2318	1																				1	1	1	1	1	10	2	0.8218877	0.9855802	87.3364	10.5611	2	0.8060806	0.9855802	87.3364	13.1414
924	2319	5												5								5	5	10	10	2	12	3	0.9175028	1.305726	135.2896	9.564714	3	0.8783561	1.305726	135.2896	12.14234
925	2320								5					5								5	5	10	10	2	22	4	1.037897	1.540548	131.4608	8.571222	4	0.9647971	1.540548	131.4608	11.14405
926	2321												1									0	1	0	1		7	3	0.9173479	1.206386	144.8926	9.56616	3	0.8783263	1.206386	144.8926	12.14272
928	2323	6					2															8	8	8	8	2	7	3	1.190994	1.8097	366.5757	7.597975	3	1.069446	1.819367	366.5757	10.15142
929	2324	2								2				1	1	1						6	6	7	7	5	8	1	1.188519	1.559014	226.5779	7.611714	1	1.069026	1.573531	226.5779	10.15501
930	2325														1							1	1	1	1	1	2	5	1.141098	2.025748	196.5793	7.886479	5	1.039534	2.025748	196.5793	10.41474
931	2326														1							1	1	1	1	1	3	2	0.9981467	1.345503	62.57813	8.872741	2	0.9400444	1.345503	62.57813	11.41115
945	2340	6																				6	6	6	6	1	14	4	0.89425	1.785223	165.8811	9.787418	4	0.8593448	1.785223	165.8811	12.38885
946	2341	7					3															10	10	10	10	2	22	1	0.6668193	0.3333333	304.682	12.78453	1	0.6802116	0.3333333	304.682	15.38809
949	2344	1																				1	1	1	1	1	4	2	0.7286016	0.7661917	60.69714	11.78525	2	0.7310085	0.7661917	60.69714	14.38828
954	2349	8					3															11	11	11	11	2	25	4	0.8032982	1.387368	252.1258	10.78236	4	0.7900648	1.387368	252.1258	13.38752
957	2352								1													1	1	1	1	1	2	1	0.7288458	0.7661917	36.08472	11.78163	1	0.7310601	0.7661917	36.08472	14.38733
958	2353						2															2	2	2	2	1	4	1	0.532658	0.4223924	65.3306	15.75271	1	0.5631228	0.4223924	65.3306	18.37977
959	2354	9					2															11	11	11	11	2	42	3	0.6160547	1.379145	159.8633	13.7556	3	0.6363205	1.379145	159.8633	16.38053
979	2375	1													1							2	2	2	2	2	7	2	1.453695	2.507261	312.5754	6.40564	2	1.395196	2.549754	312.5754	8.014745
980	2376	1																				1	1	1	1	1	2	4	0.9183556	1.666667	156.9771	9.556761	4	0.9151691	1.666667	156.9771	11.69414
981	2377	8					2					1										10	10	10	10	2	49	4	1.248744	1.93548	395.9028	7.292841	4	1.225627	1.958725	395.9028	8.985255

*note: a=convenience/grocery, b= service, c= fabric fashion, d= appliances, e= financial, f= eatery, g= hotel, h= cultural/religion, i= storage, j= residential, k= vacant, l= under construction, m= stall, n=office, o= school/university, p=government office, q= hospital, r= taxi/ motorcycle, s= bus stop, t= police check point

Table of Spatial and Land-use Variables' Values (Cont.)

Ind-line-no.	5kmEmb--line-no.	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	Total-Premises	Total-Premises + Under-construction	Total-Premises +stalls	Total-Premises + Under-construction +stalls	landuse-count	floor	Ind-Connectivity	Ind-Integration [HH]	Ind-Integration [HH] R3	Ind-Line-Length	Ind-Mean-Depth	5kmEmb-Connectivity	5kmEmb-Integration-[HH]	5kmEmb-Integration [HH] R3	5kmEmb-Line-Length	5kmEmb-Mean-Depth
983	-																					0	0	0	0			1	0.9479128	0.4986036	59.14062	9.289949	1	0.9802141	0.4986036	59.14062	10.9845
984	2380		1		22		2	2														27	27	27	27	4	129	1	0.8558013	0.6895725	445.4745	10.18221	1	0.8932684	0.6895725	445.4745	11.95633
987	2383	1	2																			3	3	3	3	2	8	5	0.9718162	1.790909	251.0855	9.086045	5	0.9854756	1.790909	251.0855	10.93119
990	2386														2							2	2	2	2	1	7	3	0.8848576	1.41359	211.6716	9.880694	3	0.8667249	1.41359	211.6716	12.29187
991	2387				2		2															4	4	4	4	2	10	4	0.990144	1.84898	172.9789	8.93637	4	0.9495964	1.84898	172.9789	11.30643
1000	2396	1													1							2	2	2	2	2	17	3	0.9626059	1.51108	460.474	9.163413	3	0.9834725	1.51108	460.474	10.95142
1001	2397	2		2			2												1			6	6	6	6	4	35	4	1.015494	1.782198	557.0507	8.73825	4	1.004656	1.782198	557.0507	10.74159
1006	2402	1		1										3	1							3	3	6	6	4	25	6	1.091914	2.178528	439.7776	8.196674	6	1.092279	2.178528	439.7776	9.960114
1018	2414														1							1	1	1	1	1	4	4	1.09887	1.588708	556.261	8.151121	4	1.085091	1.588708	556.261	10.01947
1025	2421	3		1											1							5	5	5	5	3	17	5	1.037501	1.721789	314.1122	8.574114	5	1.015156	1.721789	314.1122	10.64083
1033	2429	2													1							3	3	3	3	2	10	3	1.256686	1.402843	164.1336	7.253073	3	1.209507	1.402843	164.1336	9.091682
1037	2433		2	2	1		3	1							8			2				19	19	19	19	7	89	6	1.129946	1.932924	559.4254	7.954447	6	1.085796	1.932924	559.4254	10.01361
1040	2436	5					7								1	1						14	14	14	14	4	67	2	1.108057	1.425533	160.0373	8.091829	2	1.086959	1.425533	160.0373	10.00397
1042	2438	5	1				2	1							3							12	12	12	12	5	33	3	1.273921	1.97875	415.7574	7.168474	3	1.255771	1.97875	415.7574	8.793572
1049	2445	3	2				1															6	6	6	6	3	16	3	1.255235	1.374621	452.138	7.260303	3	1.21607	1.374621	452.138	9.048016
1050	2446														2			1				3	3	3	3	2	15	2	1.267828	1.600986	192.3626	7.19812	2	1.331095	2.377281	192.3626	8.352552
1057	2453														1							1	1	1	1	1	5	5	1.25451	2.145622	375.7009	7.263919	5	1.215927	2.145622	375.7009	9.048961
1058	2454	3													1	3						7	7	7	7	3	21	9	1.105015	2.296286	796.3153	8.111352	9	1.114859	2.296286	796.3153	9.778639
1061	2457	8	1				10								1							19	19	19	19	3	58	6	1.501495	2.441556	339.2339	6.23355	6	1.43702	2.531067	339.2339	7.810586
1066	2462	5					4						1		2							11	12	11	12	3	71	20	1.822237	3.335529	1844.035	5.312365	25	1.760925	3.673461	1844.035	6.557845
1075	2472	63	1				24	3				1		4	2	1	1		1			95	95	99	99	9	467	7	1.789531	3.466545	996.7208	5.391179	7	1.609105	3.555409	996.7208	7.082231
1077	2474	19					9															28	28	28	28	2	95	1	1.305915	1.263957	77.29883	7.017354	1	1.293903	1.537567	77.29883	8.563894
1078	2475					1									1							2	2	2	2	2	36	2	1.261061	1.308879	82.97079	7.231381	2	1.253127	1.308879	82.97079	8.810019
1079	2476	7	1			1	2					1			2							13	13	13	13	5	176	6	1.565968	2.51063	538.1294	6.018076	6	1.490984	2.860744	538.1294	7.564083
1122	2839	2				1	1		1						3							8	8	8	8	5	103	5	1.50378	2.488496	1596.115	6.225596	20	1.538892	3.56075	1596.115	7.359735
1123	2870																	1				1	1	1	1	1	8	1	1.262379	1.430414	115.6913	7.224874	1	1.32983	2.305038	115.6913	8.359547
1124	2871					1																1	1	1	1	1	5	1	1.262379	1.430414	81.58671	7.224874	1	1.32983	2.305038	81.58671	8.359547
1125	2881	14	4				6	2				3			3				7	0	0	29	29	29	29	6	190	4	1.497151	2.442425	1615.224	6.248734	11	1.536654	3.224882	1615.224	7.368998
1138	3306							1							1							2	2	2	2	2	61	2	1.257995	1.440218	160.9226	7.246565	2	1.328227	2.053858	160.9226	8.368431
1140	3308	1																				1	1	1	1	1	5	1	1.257704	1.38587	105.1439	7.248012	1	1.328158	2.022739	105.1439	8.368809
1150	3501	22	1				10								3				1		1	36	36	36	36	6	185	6	1.560124	2.455043	564.015	6.036876	-	-	-	-	-
1151	3502	11					1								5				1	1		17	17	17	17	5	58	6	1.789826	3.41721	523.2804	5.390456	6	1.641605	3.520497	523.2804	6.961815
1152	3503		1				1								1							3	3	3	3	3	20	2	1.117399	0.7661917	88.95421	8.032538	2	1.38216	1.799693	83.96487	8.080908
1162	3515														1				1			1	1	1	1	2	20	2	1.484269	2.322376	201.8678	6.294288	5	1.611158	3.240849	430.1478	7.07448
1163	3514																		1			0	0	0	0	1		3	1.772891	3.344138	89.76025	5.432394	3	1.203714	1.551724	165.1963	9.130624
1273	4003	4					2															6	6	6	6	2	14	3	1.484878	2.350824	224.1441	6.292119	3	1.431022	2.418707	224.1441	7.83913
1329	5228	3	4				2							1				2				11	11	12	12	5	71	4	1.829599	3.358306	570.6451	5.295011	4	1.603722	3.468235	570.6451	7.102646
1332	5231	3					4								1							8	8	8	8	3	28	2	1.285676	2.336171	135.3537	7.112075	2	1.240635	2.351116	135.3537	8.888658
1334	5233							2														2	2	2	2	1	10	3	1.763398	3.333572	140.5601	5.456254	3	1.59272	3.447764	140.5601	7.144802
1335	5234	13				1	2					1							1			16	16	16	16	4	46	4	1.52317	2.585705	270.7308	6.159074	4	1.337008	2.593331	270.7308	8.320038
1337	5236															1						1	1	1	1	1	4	3	1.281129	1.702803	256.5383	7.133767	3	1.177246	1.702803	256.5383	9.313421
1338	5237	3	1		1		2															7	7	7	7	4	26	6	1.529602	2.693324	436.1423	6.137383	6	1.338044	2.692718	436.1423	8.314366
1352	5252						1							5								1	1	6	6	2	2	2	1.304504	2.394192	314.3155	7.023861	2	1.244273	2.407781	314.3155	8.865596
1358	5258	19										1										19	19	19	19	1	47	2	0.8641028	1.2196	186.5228	10.094	2	0.908377	1.2196	186.5228	11.7741
1361	5261	26	8									3		2								34	34	36	36	3	129	2	0.8225719	1.136567	611.2665	10.55315	2	0.836978	1.136567	611.2665	12.69319
1365	5265		2				1			1				11								4	4	15	15	4	9	2	1.381269	2.495381	208.2405	6.689082	2	1.177006	2.470759	208.2405	9.315123
1366	5266						5			3		1		6								8	8	14	14	3	30	2	1.381269	2.495381	230.0687	6.689082	2	1.177006	2.470759	230.0687	9.315123
1367	5267						1							2								1	1	3	3	2	3	2	1.175154	1.440044	90.64471	7.686913	2	1.050715	1.457192	90.64471	10.31456
1368	5268	41																				41	41	41	41	1	123	3	1.382674	2.581464	181.2155	6.683297	3	1.17722	2.571948	181.2155	9.313611
1369	5269	7													1							8	8	8	8	2	10	3	1.179362	1.815166	209.1905	7.663051	3	1.051419	1.825023	209.1905	10.30832
1379	5293	2													1							3	3	3	3	2	11	2	1.280526	1.771489	220.424	7.13666	2	1.177139	1.771489	220.424	9.314178
1380	5294														2							2	2	2	2	1	7	6	1.41748	1.909035	668.7935	6.543746	6	1.289231	1.909035	668.7935	8.591305

*note: a=convenience/grocery, b= service, c= fabric fashion, d= appliances, e= financial, f= eatery, g= hotel, h= cultural/religion, i= storage, j= residential, k= vacant, l= under construction, m= stall, n=office, o= school/university, p=government office, q= hospital, r= taxi/ motorcycle, s= bus stop, t= police check point

Maps of Land Use Pattern in Sukhumwit Area

Convenience / Grocery

Service

Fabric Fashion

Appliances

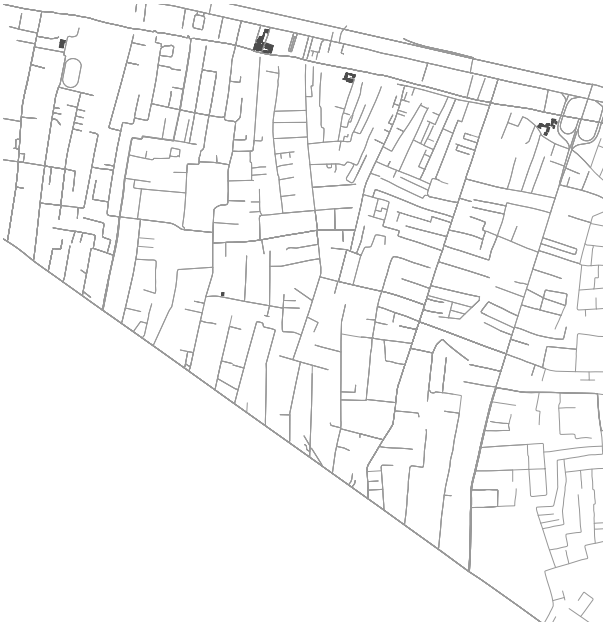
Maps of Land Use Pattern in Sukhumwit Area (Cont.)

Financial

Eatery

Hotel

Cultural / Religion



Maps of Land Use Pattern in Sukhumwit Area (Cont.)

Storage

Vacant

Under Constuction

Stall

Maps of Land Use Pattern in Sukhumwit Area (Cont.)

Office

School and University

Official Place / Government

Hospital