

32

THE APPROACHES TO
URBAN ENERGY CONSERVATION ON TRANSPORTATION:
INTEGRATING URBAN DENSITY, TRANSPORTATION, AND OPEN SPACE
TO REBUILD A COMPACT URBAN AREA

by

HIA-SUE CHEN

B. Arch., Chung Yuan University
Taiwan, China 1979

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Approved by:


Major Professor

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Table of Contents

<u>INTRODUCTION</u>	-----	1
 <u>CHAPTER ONE:</u> <u>URBAN GROWTH, SIZE AND STRUCTURE</u>	 -----	 12
Growth of Urban Form		
Urban Growth Types		
Urban Size and Spatial Distribution		
Changing of Urban Form		
Urban Growth and Policy in the Selected Countries		
 <u>CHAPTER TWO:</u> <u>URBAN GROWTH AND URBAN DENSITY</u>	 -----	 25
Meaning of Population Density		
Factors Affecting Urban Densities		
High Density vs. Low Density		
Urban Density and Policy in the Selected Countries		
Density and Transportation System		
Density and Open Space Pattern		
Land Use and Housing Type with Density		
 <u>CHAPTER THREE:</u> <u>URBAN GROWTH AND TRANSPORTATION</u>	 -----	 39
Transportation in Urban Areas		
Transportation and Urban Form		
Transport Modes of Urban Transportation Systems		
Urban Transit and Urban Form		
Transportation System and Policy in the Selected Countries		

<u>CHAPTER FOUR:</u>	
<u>URBAN OPEN SPACE AND URBAN GROWTH</u>	60
Meaning and Function of Urban Open Space	
Urban Open Space and Urban Form	
Open Space Considering Density and Transportation	
Urban Open Space as Urban Amenities	
Urban Open Space and Land Policy in the Selected Countries	
 <u>CHAPTER FIVE:</u>	
<u>GUIDELINES FOR COMPACT URBAN APPROACHES</u>	74
Integrating the Approaches	
Compact Urban Energy Conserved on Transportation	
Review of the Concepts Relating to Compact Urban Form	
Guidelines	
 <u>CHAPTER SIX:</u>	
<u>EVALUATION AND CONCLUSION</u>	82
Perspective and Evaluation of Urban Planning	
Conclusion	
 <u>FOOTNOTES</u>	88
 <u>BIBLIOGRAPHY</u>	90

INTRODUCTION

After the energy shortage in 1973, one reaction has been a stated planning goal/objective to restructure the urban spatial system to be a more compact one on the assumption that the more compact form would, by its own nature, conserve energy.

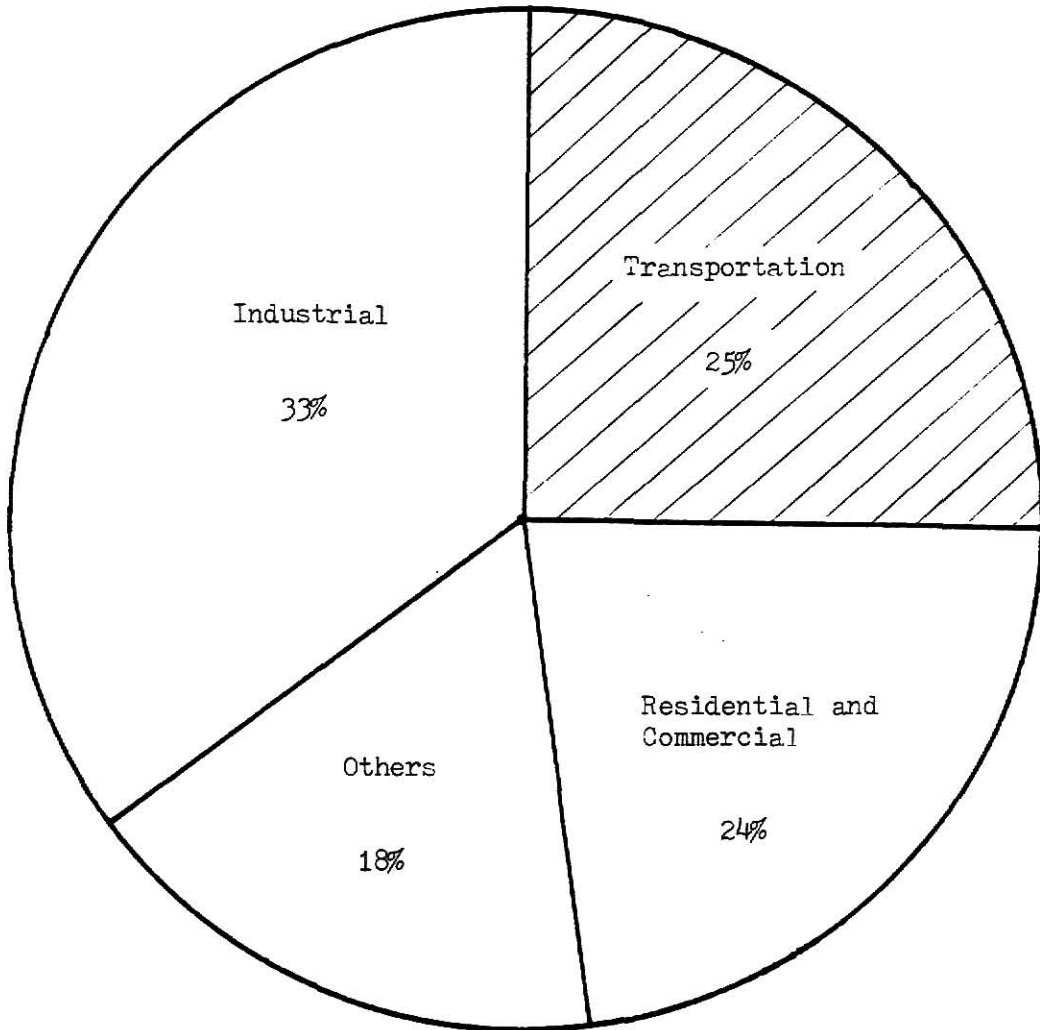
In general, shorter internal distances within compact cities require less travel by cars, buses, or trucks. These consumed annually approximate one-quarter of national energy in the U.S., since 1970 (see Table A). However, in order to reach urban compactness to meet energy conservation, many other unwanted urban problems might be encountered, such as conflicts of land uses. Without foreseeing those potential problems at the time of planning, the quality of urban settings may degrade to the point where the lifestyle and living standards of urban settlers may reach an undesirable low level.

Objectives of This Study

The objectives of this report are to discuss three main factors of the urban form system, i.e., density, transportation, and open space, to identify amenities within each of the factors which have important influences on the quality of urban context from non-compact urban structure to compact urban structure, and to suggest guidelines appropriate rebuilding more compact urban structures.

It is understood that the urban spatial structure formed before the use of gas-consuming automobiles, is more compact than those built after the use of automobiles as a transportation tool. Because the evolution of the auto has increased the capacity of traveling, it has also enlarged

Table A: Percentage of Energy Used by Purpose, in the U.S., 1974.



(Source: Margaret J. Tifft, Energy Consumption and Conservation in the United States, U.S. EPA, Aug. 1975, p.5).

the urban settlement size.

In the early stages of urbanization, the home or residence was the work place, or people had to walk to work and shopping places. In that time, living within a reasonable walking distance to those places became a highly dominant factor that resulted in dense settlement and a compact urban spatial structure.

With the change of increasing mechanization, road systems, and inexpensive gasoline, the increased capacity of traveling encouraged the growth of settlement size and the formation of less compact urban spatial distribution pattern. Along with the rapid population growth in those urban areas and the continuously increasing use of the automobiles, the energy consumption for transportation grew every year before 1973.

Population Growth Trend

The population trend in many countries showed an increase during the last decade (see Table B), a trend that will probably continue through this decade. Together with the attempt to rebuild an energy-conserving compact urban form, the urban planning required to deal with the size of urban settlement and the structure of urban space has become complicated.

In some countries where the urban area is not so compact, the problem of rebuilding urban areas to a more compact form is different from those countries where the urban area is already compact. Therefore, there is an explicit need to examine the population growth patterns in some urban areas, and to realize the energy consumption for transportation in these areas as it has occurred over the last few decades.

Population Growth Pattern

Since suburbanization patterns in the urban areas of many countries are similar to population distribution patterns, a trend of out-migration in the central cities is implied. For example, in the U.S. and the Canada, the population growth had significant increase in suburbs, exurbs, and non-metropolitan areas, and was stable or decreasing in the core city since the 1950s.¹ The result has been a reversed population growth pattern since the initiative of urbanization in these countries (for the U.S., see Figure A).

Energy Used for Transportation

Because most urban areas were primarily formed before 1970, and suburbanization in those areas had caused the transportation growth before 1973, there is a need to overview the typical pattern of energy used for transportation of those areas in the 1970s.

Transportation Growth Pattern

The evolution of transportation modes brought about the suburbanization which in turn did cause the shift of growth pattern of overall transportation system.² In the U.S., for instance, the transportation mileage of urban intercity highways grew by 31 percent during 1960 to 1970, which was much more than the growth of rural intercity roads during the same period (see Table C). During that time, the public transportation mileage of intercity railroad decreased, there was only a 1 percent growth of intercity mass transit bus; but there was a 60 percent growth of intercity airplane travel. In addition to a decline in intercity mass transportation, there was a 40

Table B: Number of Population and Population Growth of the Selected Countries, in 1960, 1970, 1980 by country.

	Number of Population (in thousand)			Growth Rate (%)	
	1960	1970	1980	1960-1970	1970-1980
The U.S.A.	180,698	206,985	223,186	14	8
Canada	17,909	21,673	24,033	21	11
The Netherlands	11,462	13,110	14,182	14	8
Japan	93,419	102,795	117,266	10	14
Taiwan	10,612	14,402	17,987	35	25

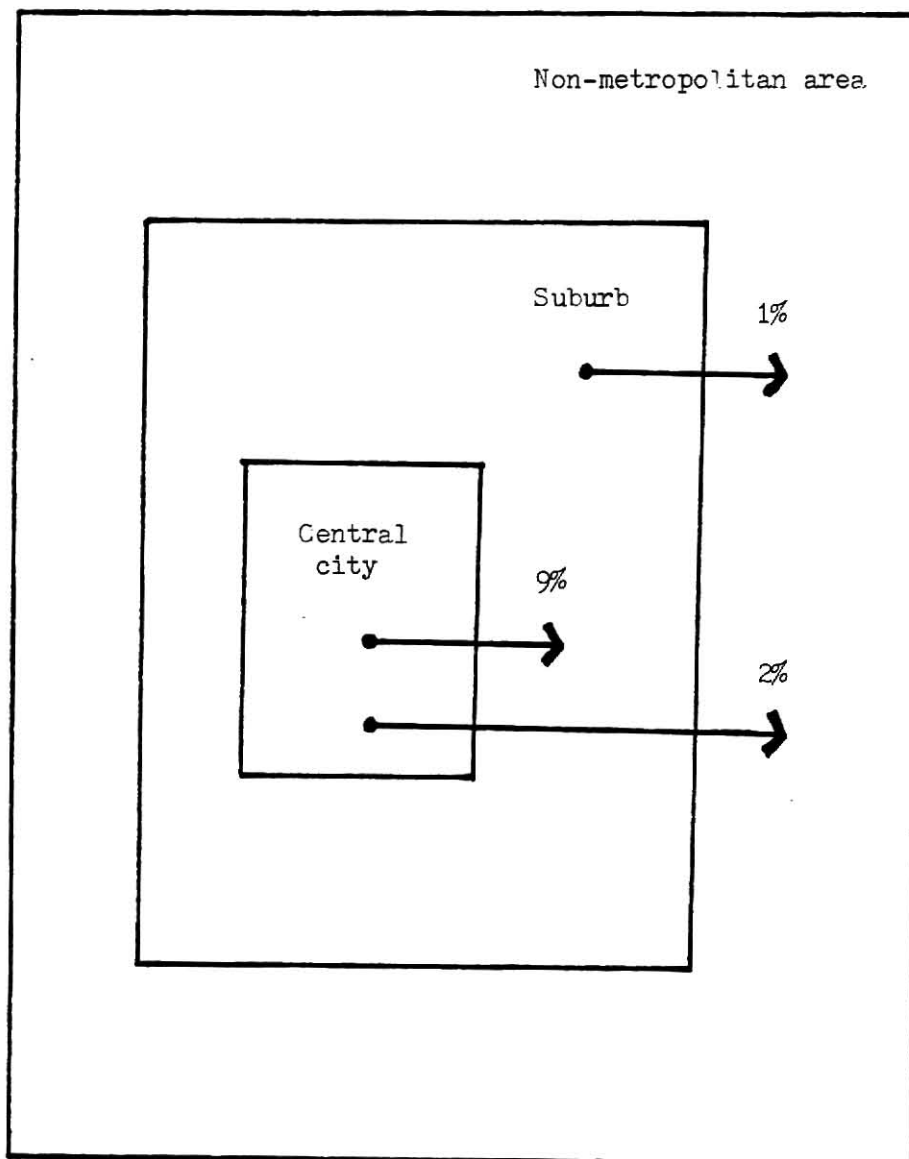
(Source: World Urbanization 1950-1970, Vol. I, Kingsley Davis, University of California, Berkeley, 1969. World Population: 1977, Bureau of the Census, U.S. Department of Commerce. The World Factbook - 1981, National Foreign Assessment Center).

Table C: Transportation mileage by roads used, in the U.S., in 1960 and 1970 (in thousands of miles).

	1960	1970	Growth Rate (%) 1960-1970
Rural intercity roads	3,116	3,170	2
Urban intracity highway	429	560	31

(Source: Washington Center for Metropolitan Studies from U.S. Department of Transportation, 1972 National Transportation Report, July 1972, and U.S. Bureau of the Census, Statistical Abstract of the U.S. 1972).

Figure A: The out-migration in the urban area of the U.S., 1970-1978.



(Source: U.S. Bureau of the Census, "Mobility of the population of the U.S.: March 1970 to March 1975" and "Geographic Mobility: March 1975 to March 1978", Current Population Reports, Series p. 20, No. 285 and 331, 1975 and 1978).

percent decrease of the intracity mass transit ridership, including railway, subway, and trolley, during the same period (see Table D).

It is also shown that in the same time period, the number of cars owned per household increased which also contributed to an increased number of car passenger miles per person (see Table E).

Energy Consumption of Transportation Modes

The total energy consumption by all transportation modes in the U.S. in 1970, for example, showed the portion used by the auto to be approximately 54 percent. Particularly, energy consumption by the urban intracity auto was approximately 34 percent of the total, and the intercity auto was about 20 percent of the total (see Table F).

Length of Trip by Auto

It has been shown that for most urban intracity trips by the auto in the U.S., the average mileage driven per trip was below 31 miles, which represents 64 percent of the total miles driven (see Table G). One-way commuting time within metropolitan areas average approximately 30 minutes.

Urban Auto Trip

Because the auto is the transportation mode consuming the largest portion of the energy consumption pie, and the auto used within the urban area has a higher percentage than that used in the intercity travel, it is clear that the current urban auto plays a significant role in energy used for transportation. It is also obvious that the urban auto is primarily

Table D: Transportation mileage by transportation mode in the U.S., 1960 and 1970 (Thousands of miles).

Transportation mode	1960	1970	Percent change
Intercity bus	265	268	1
Intercity railroad	94	50	-47
Intercity airplane	101	162	60
Intracity bus	109	113	4
Intracity railway, subway, and trolley	5	3	-40

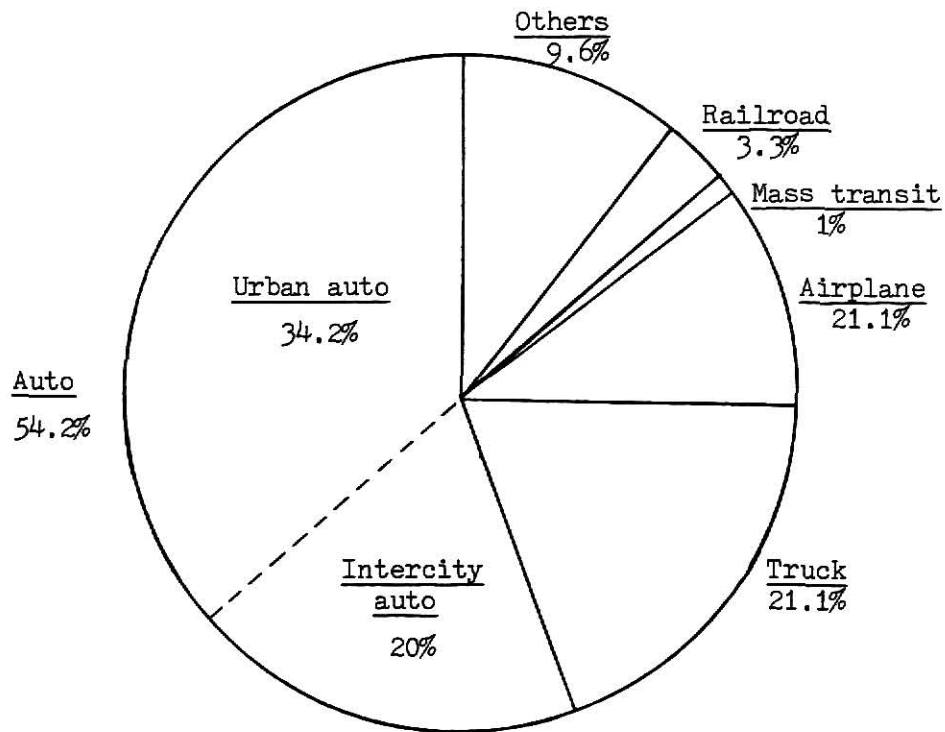
(Source: Washington Center for Metropolitan Studies from U.S. Department of Transportation, 1972 National Transportation Report, July 1972, and U.S. Bureau of the Census, Statistical Abstract of the U.S. 1972).

Table E: Distribution of Households by Number of Cars Owned, in the U.S., 1960 and 1970.

Number of Cars	1960	1970	Percent change
All households	100	100	-
none	25	20	-20
1 or more	75	80	7
2 or more	16	29	81

(Source: Washington Center for Metropolitan Studies from U.S. Bureau of the Census, Consumer Buying Indicators, Current Population Reports, Oct. 16, 1970 and May 1972).

Table F: Energy Consumption by Transport Mode, 1970, in the U.S.



(Source: Lutin, J.M., Comparison of Energy Savings for Work Trips, Princeton University Transportation Program, 1974).

Table G: Annual Car Miles Driven, by Length of the Trip, in the U.S., 1969-1970.

Length of Trip	Number (billions)	Percent
Total miles driven	777	100
Under 10 miles	241	31
11-30 miles	258	33
31-99 miles	145	19
Over 99 miles	133	17

(Source: Unpublished data from U.S. Department of Transportation, Federal Highway Administration, "Nationwide Personal Transportation Study", Washington D.C.).

used for commuting to and from work, and for social and recreational trips, which share a 75 percent portion of total urban vehicle-miles traveled (see Table H).

Due to the different percentage of energy consumed for transportation relative to national output in the different countries (see Table I), it can be concluded that once the urban settlement size and structure is formed, there is a long-term impact on the transportation cost and time which affect human behavior as well as the national economy. There is no doubt that energy use has a very strong relationship with the population distribution pattern, as well as to the transportation use pattern. In order to reduce the increasing needs of using private auto for transportation, study attempting to rebuild the urban area to be more compact should focus on the auto used in the intra-city urban area, rather than in intercity or rural areas. It should also focus on the trips related to urban commuting. This study will concentrate on the following: first, reviewing the existing urban growth patterns and urban transportation systems used in the suburb, exurb, core city, and downtown CBD; and second, looking for an effective guideline for rebuilding an energy-conservation compact urban settlement with reasonable transportation system and appropriate urban environmental quality, by integrating the approaches of urban density, transportation, and urban open space.

Table H: Urban auto trips and lengths by purpose, 1970, in U.S.

Trip purpose	Percent vehicle-miles	Number urban vehicle-miles (millions)
For work	42%	539
Social-recreation	33%	423
Family business, shopping	20%	257
Education, religious	5%	64
All purposes	100%	1283

(Source: Federal Highway Administration figures for 1969, and DOT Nationwide Personal Transportation Survey, 1969-1970).

Table I: Percentage of energy consumed for transportation relative to national output, selected countries, 1972.

U.S.A.	Canada	France	Germany	The Netherlands	Japan	U.K.
23%	20%	16%	13%	11%	13%	13%

(Source: Joel Darnstadter, Jay Dunderley, and Alterman, Resource for the Future).

CHAPTER ONE:

URBAN GROWTH, SIZE AND STRUCTURE

In this chapter, a review will be made into the process of urban growth before and after suburbanization as it relates to the transition of urban spatial structure and size of urban settlements, within which the need of transportation by private auto is changing. Reviews will also be made of the reaction of the selected countries which have faced rapid urban growth and the component problems of urban form changes.

Growth of Urban Form

Urban form is the physical outcome of urban growth. When it is being shaped, many urban factors will contribute to the process of its formation, and they arise both from the natural environment and from human society. The result of urban formation may be illustrated by two components: first, urban size; and second, urban spatial distribution pattern.³

Historically, the urban form generally was shaped under the consideration of social, political, ecological, economic, geographical, military, religious, and technological conditions. In the twentieth century, the technology of mechanization has been so significantly developed that it has changed the relative situation of the other factors. Consequently, this century's urban settlement has brought about an unprecedented urban growth along with a restructuring of urban form.

The size of urban form in modern urban area has been strongly determined by the agglomeration of economic scale, and the capacity of transportation within the urban area and connections to outside areas. The spatial distribution pattern of urban form is determined by the specific land use,

socioeconomic segregation, and the capacity of communication. Both the urban size and spatial distribution pattern have a direct relationship to the natural physical and geographical limitations of the urban area. Transportation is an important consideration within the economic factor in deciding the future urban form, due to energy conservation of urban needs.

Urban Growth Types

Once urbanized, the pattern of continued growth may be briefly categorized into two types by using the measure of suburbanization, i.e., pre-suburbanization period and post-suburbanization period. In the U.S., for example, the pre-suburbanization period was approximately prior to 1920, and the post-suburbanization period was after 1920.⁴

Pre-Suburbanization Period

The first type of urban growth pattern was shaped in the areas built in the pre-suburbanization period. It was characterized by being stable in size, and by being concentrated within the core city area. In this type of urban growth, the spatial structure was shaping less segregated land use, and had more mixed and highly clustered settlements. The encompassment of the core city was the primary component of the urban spatial structure. The suburban area outside the central city mainly consisted of rural open spaces used for agriculture or as natural scenery. Auto use as a transportation tool in the core city was helpful, but not required. The lengths of trips to work for most inhabitants were generally short that transportation might be easily resolved by walking, biking, or intracity

mass transit if it was available. The other daily trips were also few and the lengths were not long, so that walking or biking was not difficult because the localities were all close to the home. The new settlements were principally growing along or close to the few major streets, where the intracity bus or railway traveled to the central business district (CBD) or downtown.⁵

This type of urban growth was reinforced not only by the public transportation services and by the opportunities for economic development, but also by the availability of immigrants from outside the growing core urban area.

Post-Suburbanization Period

The second type of urban growth was found in the area where people continuously moved out of central city into suburban, exurban, even rural areas. The factors resulting in this type of urban growth were not attributable to increasing immigrants from outside the urban area, but resulted from many other reasons. In the U.S., for instance, the factors causing people to flee to the suburbs or exurbs are listed, but not limited to the following:

- a. rising real incomes
- b. broad availability of autos
- c. seeking for more privacy
- d. socio-economic, ethnic incompatibility in core city
- e. increased land cost in core city
- f. public funded highway system network
- g. loose national land policy

- h. federally insured home mortgage
- i. ample parking space for employees
- j. low tax of land in suburb
- k. ample flat land in suburb.⁶

The time of its beginning and the extent of the suburbanization was varied in the different countries or different regions because of their variant economic, social, climatic, and physical limitations.

In this type of urban growth pattern, the size of urban area grew rapidly, the region of urban settlement sprawled out which increased the distance of travel within the entire urban area. The spatial structure of this kind of urban area was primarily characterized as segregated land uses, that separated the commercial use from a residential neighborhood. Eventually, the dependency on the automobile for travel within the urban region was intensified to the exclusion of competing transportation modes. In turn, this has meant that auto energy consumption has come to dominate transportation energy use.

Urban Size and Spatial Distribution

Basically, the two types of urban growth pattern discussed above were heavily influenced by population growth trend, i.e., the ebb and flow of migrating population of urban area. First, the migrants drifted into the urban core area; then second, the migrants drifted into the outside area of the core city. The urban size and urban spatial distribution pattern are two major measures used to examine the variances of the urban form within the two different urban growth patterns.

Urban Size

The urban size illustrates the range and the invisible territory of an urban area within which most inhabitants act their daily activities. Urban size has a direct influence on deciding the efficient use of urban transport modes. In the suburbanized urban region, the size of urban area is much larger than in the pre-suburbanized period, even though the population size might remain the same. Basically, the size of an urban area has a direct relationship with the population size and the urban economy to support the population and their associated activities. It also has a functional relation with the capacity of the transport network within the urban area.

The urban size has more or less a direct influence on the length of the trips in the urban area, but it has no absolute effect on the need of travel, because some trips can be substituted by using telecommunication technology, or the distance may be shortened by the appropriate arrangement of correlated localities.

The urban size is also determined by the natural land form and topography which can in some sites and situations be the predominant factor in shaping urban form. In Japan, for instance, the size of an urban area is often restricted by the mountains which limit the city growth into urban fringe.⁷ However, in most parts of the U.S., the urban settlement freely grows into its periphery because there are rarely natural borders surrounding the core city.

Urban Spatial Distribution Pattern

The spatial distribution pattern expresses the functional correlated

localities of the urban sub-area on which urban activities are held individually. Since any sub-area has its unique location, the urban inhabitant has to travel to that specific place to pursue the specific activity every time.

Spatial structure is directly related with the land use pattern which is dominated by both natural factors and man-made factors. The natural factors include rivers, water, topography, and soil type, which restrict the use of land in some urban sub-areas that may increase the distance in traveling between two places. The man-made factors include land use regulations and land policy, which may separate the two correlated uses of land into two remotely-separated places.⁸

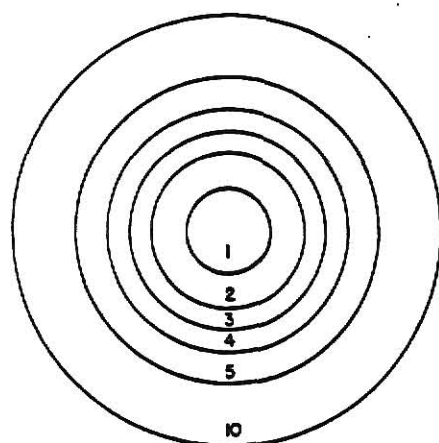
There are four generalized types of city growth form, i.e., concentric zone theory, sector theory, multiple nuclei, and linear theory (see Figure 1-1). They illustrate the possible formation of different spatial distribution patterns of urban land use pattern and its location tendency.

The form of spatial structure has great impact on the transportation behavior of the urban resident in choosing which transport mode to travel from one locality to another. Each mode of transportation has its own energy performance related to the utility of moving people and goods in the urban settling.

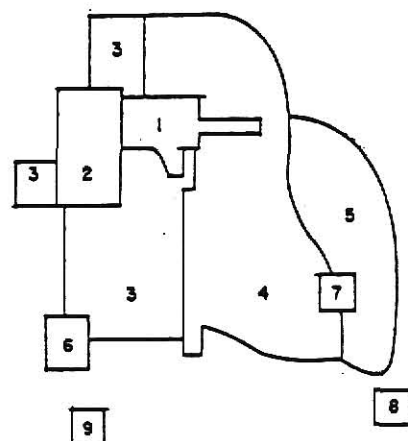
Changing of Urban Form

In the first type of urban growth pattern, the urban size generally grew very slowly, and the urban spatial distribution had better interactive relationships with individual locations. However, it often resulted in conflicts between the non-related, but close, lands and their uses of land

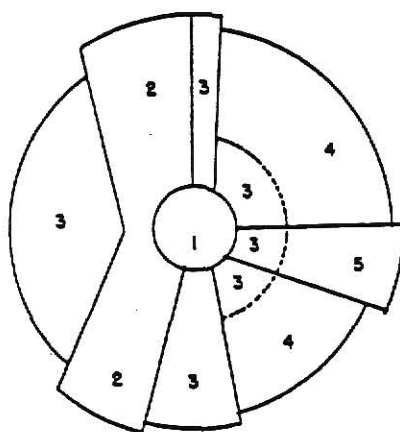
Figure 1-1: Schematic Diagram of Form of Urban Growth.



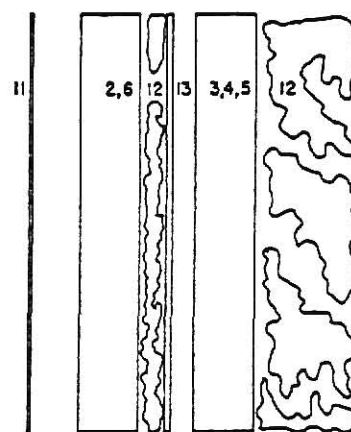
CONCENTRIC ZONE THEORY



MULTIPLE NUCLEI THEORY



SECTOR THEORY



LINEAR THEORY

DISTRICTS:

- 1. CENTRAL BUSINESS DISTRICT
- 2. WHOLESALE LIGHT MANUFACTURING
- 3. LOW-CLASS RESIDENTIAL
- 4. MEDIUM-CLASS RESIDENTIAL
- 5. HIGH-CLASS RESIDENTIAL
- 6. HEAVY MANUFACTURING
- 7. OUTLYING BUSINESS DISTRICT

- 8. RESIDENTIAL SUBURB
- 9. INDUSTRIAL SUBURB
- 10. COMMUTERS ZONE
- 11. RAILROAD
- 12. GREENBELT
- 13. HIGHWAY

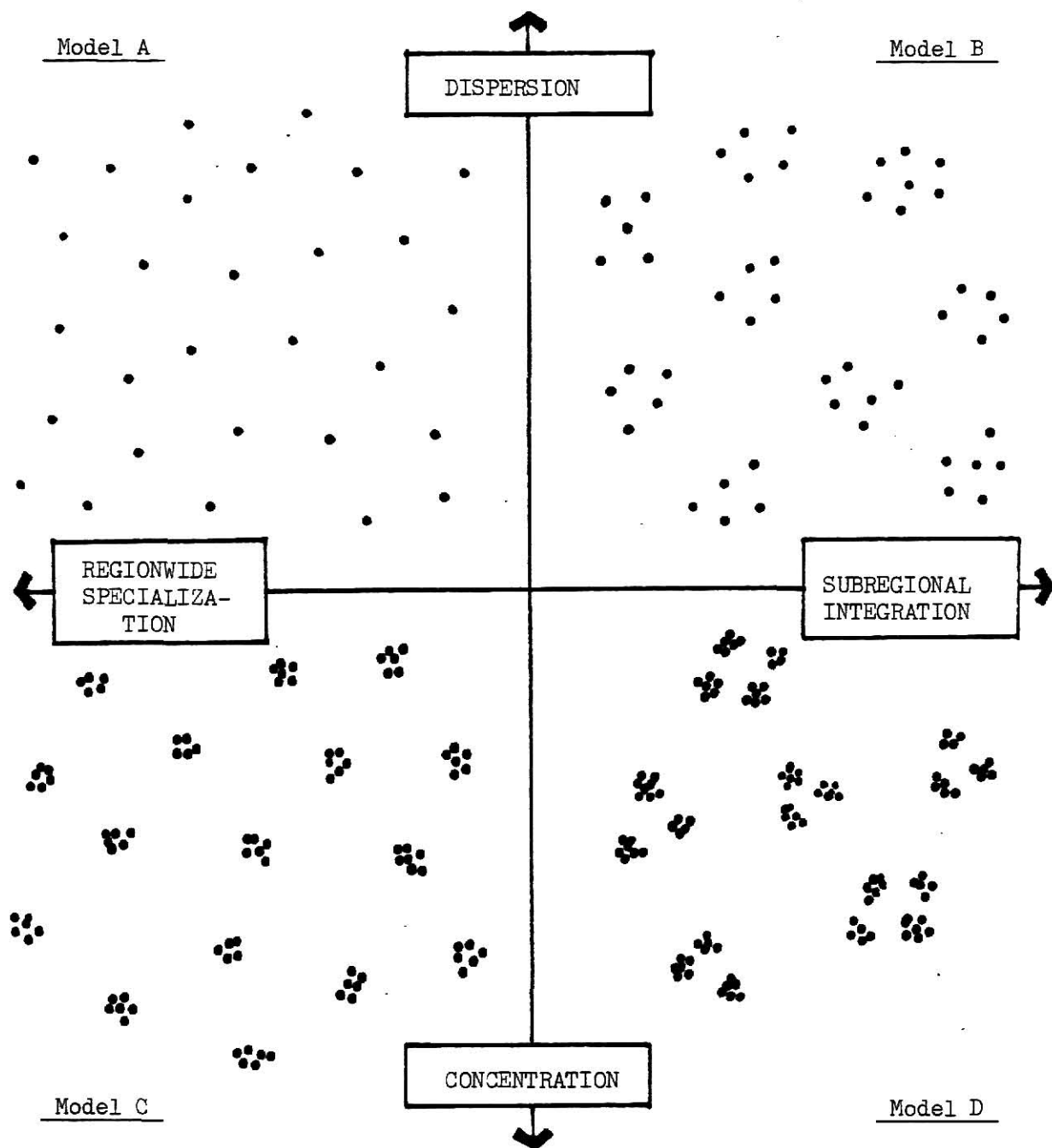
(Source: C.D. Harris and E.L. Ullman, The Nature of Cities, Annals of the American Academy of Political and Social Science, 242, 1945)..

that may bring about some unwanted impact on the neighborhood living quality and city harmony, but it did require fewer non-walking trips and had short-distanced trips to travel. In this type of urban city area, the sub-city areas were much correlatedly located in terms of function, that, in turn, reduced the lengths of trips within the city. In the "residential" neighborhood areas, the use of land was much more mixed and more clustered with many nearby services, this also alleviated the need of using an auto for shopping or to access recreational places within the neighborhood area.

In the second type of urban growth form, the urban size generally grew quickly and its region extended from the core city far into the suburb, exurb, and its rural areas. The spatial structure also changed in that the use of land of a sub-city area was unified and often any one sub-city area was segregated from the others. One result of this type of urban growth was an increasing amount of energy used for auto traveling within and among those sub-city areas. The main problem resulting from the change of the urban growth was the interrelated localities of work and shops to the residential location. In its spatial distribution aspect, these localities were not growing under the consideration of distance and function per se.

In the second type of urban growth, the urban form in a regional or a subregional scale may be found in four types of models (see Figure 1-2) by measuring the degree of concentration of the cities within the subregion, and by measuring the interrelated locations of the cities within the region or subregion. In the model A (dispersion and region-wide specialization), it shows that the distances among the cities are almost similar. The model B (dispersion and subregional integration) shows that the cities

Figure 1-2: Typical Models of Regional, Subregional, Core City's Spatial Structure.



(Source: APA Journal, July 1979, "Spatial form and structure in a possible future", Jon Van Til, p. 325).

clustered into couple of subregions, and the distances among the subregions are farther than those among the cities inside a subregion. In the model C (concentration and region-wide specialization), the clustered cities concentrate into a big core city, and the distances among these big core cities are generally similar. The model D (concentration and subregional integration) has both the big concentrated core cities, and the integration of these core cities as a clustered subregion.⁹ These four models of urban spatial form imply that the spatial distribution pattern has been a very critical factor in relating to the distance of traveling within a region, subregion, or core city.

Urban Growth and Policy in the Selected Countries

In response to rapid urban growth patterns, many countries formulated a variety of urban growth policies before 1970. In general, most policies did not consider energy and transportation as primary factors. During that time, the policies, especially those made by the developed countries in Europe, mainly focused on resolving the problem of the major urban metropolitan area, which had many social and urban environmental disadvantages resulting from ample immigration and over-agglomeration in those areas. The public services and facilities were over-used, land cost in those areas was increasing, and the traffic congestion in most streets was worsening; this contributed to the diseconomies of urban agglomeration in those major metropolitan areas.¹⁰

Due to their different economic conditions and political backgrounds, the strategies and objectives of each urban growth policy was varied. In France, the policy was intended to decentralize the population from

Paris to other larger cities by encouraging some non-industrial facilities and enterprises to move to other regional centers rather than the Paris regional.¹⁰

In the United Kingdom, the strategic policy was directed at concentrating industrial growth in a few old areas rather than in the London area, and preserving the prime agricultural land throughout the London region.¹⁰

In Sweden, the nation suffered from an internal migration that was draining population out of the north and west of the country into the metropolitan areas in the south and east. Like that of France, Sweden's policy was one of national dispersal, and regional concentration. The size of primary centers were cities having a population of 30,000 to 100,000 persons in its neighborhood units.¹⁰

In Hungary, the nation experienced a heavy internal migration from its agricultural region to the big cities in the industrial belt. A policy was adopted for balancing the nation's urban growth in the adopted hierachical system of communities which included major cities, minor cities, villages, and communities.¹⁰

Nationwide urban growth policy in the U.S. was weak and the regionwide urban growth policies were blurred. Due to the suburbanization in many urban areas since 1920 that was hurting the old central cities, downtown redevelopment and city renewal were the primary concerns of local and federal governments in the 1960s and 1970s, that were trying to slow down the speed of suburbanization. Another problem was the unbalanced population growth in the different regions: urban areas in the southern regions were growing and population in the northern regions were decreasing.¹¹

In Canada, urban growth resulted from foreign immigrants, who clustered

in the downtown core area of major cities rather than flowing to the farms of the rural area. The policy in Canada focused on the land-use review in urban areas, trying to acquire urban vacant lands to supply the increasing population. It also focused on the nationwide transportation system development to alleviate the pressure from the over-populated agglomeration occurring in a few major metropolitan regions.¹²

The rapid population growth of Japan in the Tokyo-Yokohama conurbation and the lack of adequate smooth lands outside core cities, placed constraints on urban growth. The urban growth policy of Japan therefore tried to alleviate both the increasing complex pressure due to congestion arising in the megalopolis, and to preserve a geographical balance within the country. Nationwide rapid mass transit was developed to extend to other cities of the country, to help decentralize the population in the few major cities.⁷

In Taiwan the rapid population growth in the few, better-developed urban areas was causing the diseconomies scale of over-agglomeration in these areas. The urban growth policy was made to redevelop some second major urban areas in order to balance the population growth. It also tried to improve the nationwide railway network and to build a highway system. Due to topography, urban growth was also focused on the redevelopment of urban core areas rather than on the suburbs of the urban fringe.

Conclusion

Conclusions on urban growth policy in the countries mentioned may be grouped into four sets of understandings. First, all the countries experienced the macro-location that the population were concentrated in

major cities, and their policies were made for micro-location that the population were dispersed to secondary cities. Second, the policies used to decentralize the urban immigrating population may be further categorized into two types: the region-oriented policy which focuses on the regional spread-out in the inner fringe of the original region, and the nation-oriented policy which considers the relocation of the population from one region to another region. Third, the policies generally suggested that mass transit or the transportation network should be included as part of the overall growth policy. Finally, the policies had few considerations of energy conservation regarding transportation at either national, regional, or subregional levels.

CHAPTER TWO:

URBAN GROWTH AND URBAN DENSITY

This chapter will discuss urban population density within urban growth patterns, and the relationships among urban size, urban spatial structure, and transportation. The two major factors, i.e., land use pattern and transportation system in urban area, have strong impacts on urban density which may be perceived as an indicator for rebuilding an energy saving urban form for transportation.

Meaning of Population Density

In an urban area, the population density is a crucial indicator illustrating the extent of "compactness" of the inhabitants in an area. Density is a measure of the intensity of land development or land occupation, and it is usually measured by the number of dwelling units per unit area or by the number of people residing per unit area. Equivalent measures exist for employment and other indicators of human activity.

Density is a result of clustered population residing in a certain defined area where these inhabitants have some action correlated with use of these lands. Different use of the land may result in a different density in the sub-city areas of a city. The density of a sub-city area may vary as to the hour of a day, or the season of a year. The greater the density of a sub-city varies in a day, the more the residents of the entire city may need transportation during the day.

However, density has no direct impact on the quality of an urban area, therefore, the density is not a required measurement to review the

quality of urban settlements. But, density may be used as a measure to understand the urban growth pattern and spatial distribution pattern, i.e., the population agglomeration trend and its distribution pattern. Also, it is used as an indicator of economy of scale for evaluating the economic development of mass transit or other services and facilities.¹³

Factors Affecting Urban Densities

Due to the advantages and specific limitations of an urban area, the degree of the compactness of an area is strongly affected by some important factors. In the historical urban growth process, if an urban area was infiltrated by immigrants, it would change its population size by either increasing its urban size, or increasing its urban density, or increasing both of them. The final primary approach to changing the urban form for the immigrants was always affected by specific factors.

The factors which influence the path of urban growth may be categorized into several major considerations. First, economic considerations generally play a crucial role in determining urban density: that the better the economic situation of an urban area is, the more residents often demand larger lot sizes and dwelling spaces. Second, a physical condition is also an important factor in affecting urban density. Topography, water, or other geographical limitations may physically reduce the size of usable urban land that generates higher densities. Third, technological conditions are also major determinants of urban density. Some technologies tend to make highly dense settlement possible, and other technologies reinforce low-density urban residence. Fourth, a

land policy promulgated by government may affect the variation of urban sub-area density. The prohibition or restriction of urban growth management in rural or suburban area may also generate increasing density in the urban area. Fifth, a cultural factor is also one of the determinants influencing the compactness of urban settlements, that religious beliefs, social philosophies, and some customs may maintain some traditional clusters of compact pattern.¹⁴

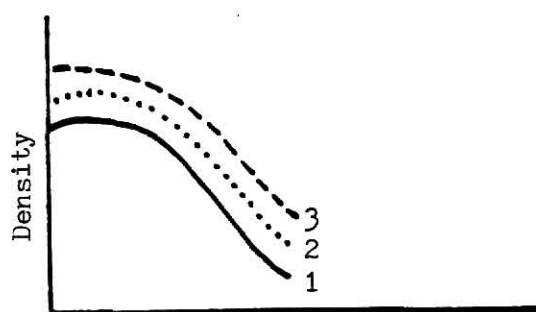
Generally, an appropriate urban density should be evaluated by all the considerations rather than just one, and it should be a long-term consideration rather than a short-term one. In the pre-suburbanization period, the urban density was much higher in the core city area (see Figure 2-1(a)), primarily because the economy of most societies was not strong, and centralization of functions was highly desirable. However, in the post-suburbanization period, most urban density became low in both the core city and the suburb (see Figure 2-1(b)), because the economic development of society could afford low density development if a less dense land use was not prohibited, and if suburban area was not restricted by physical limitations.

The population density in a suburbanized area may vary during a day in the central city and suburban area. Mostly, the central city has a higher density in the day-time than in the night-time and the suburban area has a lower density in the day-time than in the night-time (see Figure 2-1(a)). The variation of density during a day in a non-suburbanized urban is generally slight both in city core area and city ring area¹¹ (see Figure 2-2(b)). It is obvious that the more variation a sub-city area density has in a day, the more traveling generated within the urban area.

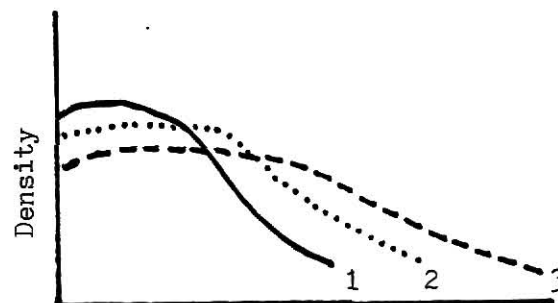
Figure 2-1: Schematic Diagram of Density Variations in Two Types of Urban Form

(a) Pre-suburbanization urban area

(b) Post-suburbanization urban area



Distance to CBD



Distance to CBD

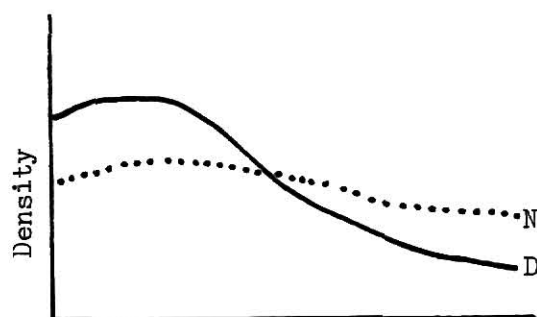
Note: 1,2,3 show different time periods

(Source: Edwin S. Mills, "The Nature of Urban Area", Urban Economics, 1972. Norman J. Glickman, "The Spatial Structure of Japanese Cities", Studies in Urban Economics, 1979.)

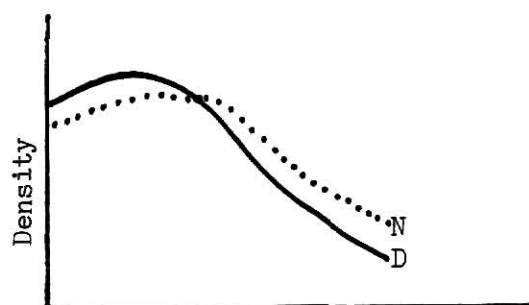
Figure 2-2: Schematic Diagram of Density Variation in a Day in Two Types of Urban Form

(a) Post-suburbanization urban area

(b) Pre-suburbanization urban area



Distance to CBD



Distance to CBD

Note: D is in day-time, N is in night-time

(Source: Same as in Figure 2-1).

High Density vs. Low Density

A low density urban area may accelerate the sprawl of urban size, that also facilitates the use of auto travel, and decreases the economy scale of mass transit services and other services. However, in a high density area, the cost of land is also generally high. It has been realized that there are some advantages and some disadvantages in a compact urban form, as well as in an expansive urban form.

In an expansive urban area, its advantages may be better traffic conditions, fewer conflicts in use of lands, lower cost for lands, and perhaps a lower crime rate. The disadvantage, on the other hand, may be the over-extension of urbanized area, isolation of daily life, exclusion of other classes of people, and poor economies in transportation and provisions for other services. Likewise, in a compact urban area, the advantage may be a lower cost of facilities, lower cost for transportation, more preservation of natural land, and more enjoyment in the clustering life. The disadvantage of high density is more traffic congestion, higher cost for land, higher crime rate, and more conflicts among uses of land.

The values used to evaluate these advantages and disadvantages are under the considerations mentioned above, i.e., economic, physical, technological, policy, and cultural conditions. Due to the increasing cost for transportation, to damage of natural environment, and to air pollution, the values have changed and the priority of these considerations has varied, too. Some disadvantages in a fairly compact urban area may be eliminated by application of explicit planning processes and proper management. In fact, the denseness of an entire urban area is not the major focusing point of urban energy for transportation, however, the

daily density variation of an urban sub-area is the primary focus. There are two models to approach the point; first, maintaining the expansive area as the same in the built urban size; second, shifting the density of the built urban area from low to high.⁹

Low Density Model

In this model, the urban density will be low, however, the size and major spatial pattern of urban area may be kept as the same. The only difference is that the land use pattern within the sub-city areas will be more mix-use. For example, a neighborhood may have some walking distance stores, and a residential area may have some commercial or office land use. But, there are some problems in this model. In a low density neighborhood, the economy and scale for maintenance of some stores in the walking distance market area is not possible. The residential and commercial mix-used area may reduce the length of journey to work and assumes that if one changes jobs, one moves to be near that job. Providing an adequate mass transit system may be difficult, if not impossible.

Increasing Density Model

In this model, the urban density is gradually becoming greater, the size of urban area may shrink back, and its spatial distribution pattern may be restructured. The land use may be planned and become more mix-use both in the entire city and in a neighborhood area. Due to compactness, urban size may be stabilized, restructuring of urban sub-city areas may be needed and the cost and time for transportation may be reduced to a

targeted and acceptable level. But, the approach of this model is more difficult than the first model, because the cost for land may rise, and the process may cause stress to existing residents.

After reviewing these two models, it is evident that the second model has as many difficulties as the first model. Again, the values used to evaluate the process of the two models are based on various considerations and the priorities of the urban residents.

Urban Density and Policy in the Selected Countries

The population density of the selected countries implies a very different pattern (see Table 2-1). The urban population density in largest and most dense core city of the countries illustrates a similar compactness in central city areas but different in metropolitan regions (see Table 2-2).

The trend of urban density variation in a core city may also be implied by the migration pattern of the core city, that a positive net migration shows a growing density in the core city, and a negative net migration expresses a decreasing density in the core city (see Figure 2-3). Among them, Japan and Taiwan imply increasing compactness in the core city areas, and the U.S., Canada, and the Netherlands have decreasing densities in the core city areas.

Since the urban form and density pattern have a significant relationship with the amount of energy used for transportation, energy as one of nation's resources, has been managed under some urban policies in some countries. In the past, urban density was just used for preventing urban agglomeration from becoming too compact to maintain the urban quality.

Table 2-1: Nation's Density of the Selected Countries, 1960, 1970, and 1980.
(Unit: Person per square mile)

	<u>1960</u>	<u>1970</u>	<u>1980</u>
The U.S.A.	60	70	74
Canada	9	11	13
The Netherlands	890	950	1000
Japan	650	730	810
Taiwan	760	1050	1295

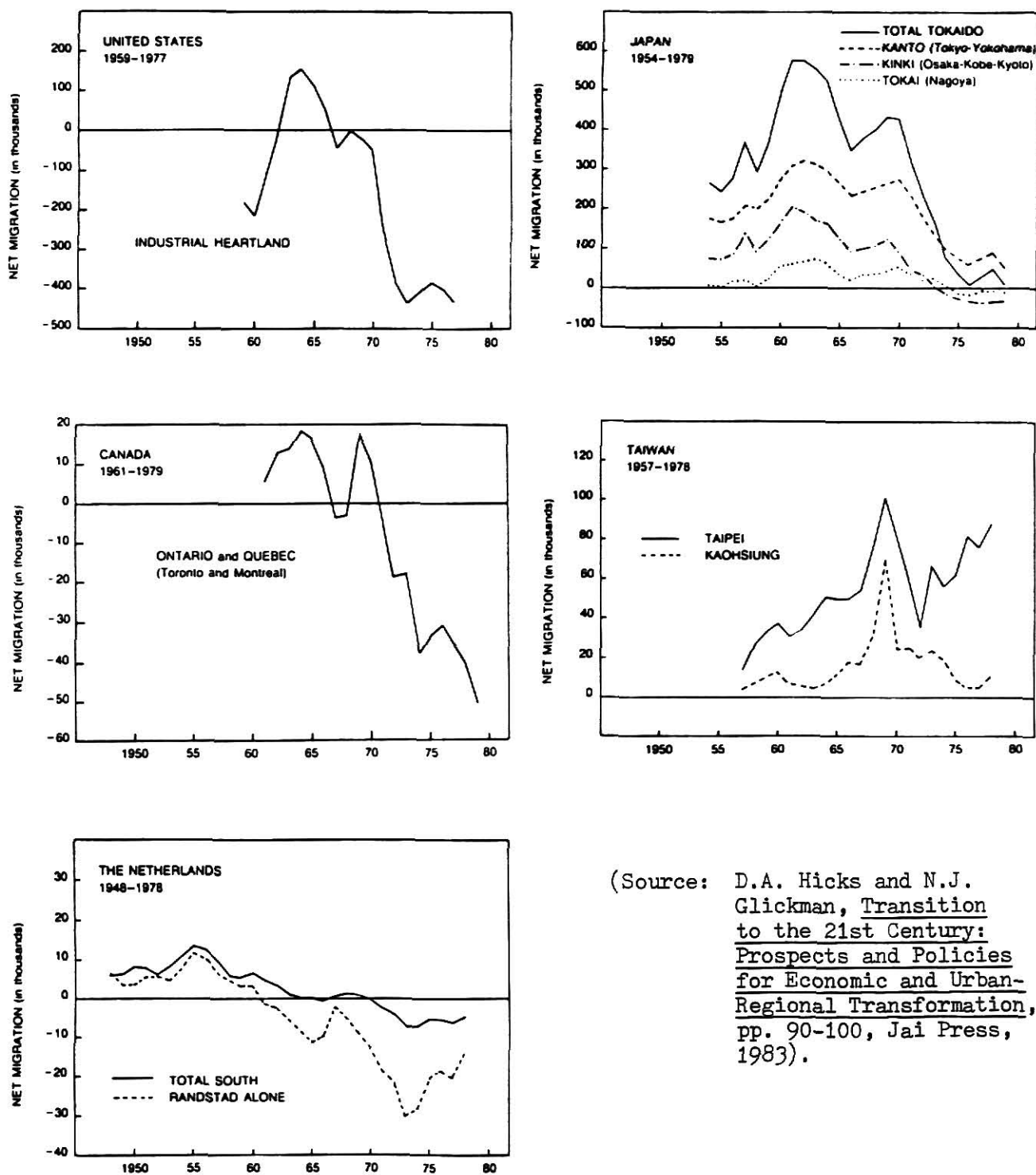
(Source: World Population: 1977, Bureau of the Census, U.S. Department of Commerce. The World Factbook - 1981, National Foreign Assessment Center).

Table 2-2: Population Density in the Largest and Most Dense Urban Area in the Selected Countries, 1980.
(Unit: Person per square mile)

New York	Toronto	Amsterdam	Tokyo	Taipei
<u>Central City Area</u>				
23,650	12,500	13,800	38,600	21,900
<u>Metropolitan Area</u>				
2,700	11,500	10,900	9,800	15,600

(Source: Variety of data)

Figure 2-3: Annual Net Internal Migration to Core Urban Area in the Selected Countries.



(Source: D.A. Hicks and N.J. Glickman, Transition to the 21st Century: Prospects and Policies for Economic and Urban-Regional Transformation, pp. 90-100, Jai Press, 1983).

Currently, the density may be an indicator for a governing body to evaluate the economy of scale of providing services, and the possible extension of the urban size.¹³ Although it has two different approaches concerning the urban density, an appropriate urban density may be found between high density-oriented urban growth and low density-oriented urban growth.

Density and Transportation System

In an urban growth process, the changing of urban densities is greatly affected by the variation of urban transportation systems. In short, at first, intercity mass transit transported immigrants moving into urban central cities, that made the population density rise in those core areas. Then, private auto and intra-urban highway systems encouraged people to migrate outward from central cities to the suburbs. This reduced the population density in the core city areas and increased the density in the edge area of those core cities. As a whole, overall density in these urban areas decreased.

With only few exceptions, most urban areas experiencing the variation of urban density had to change or reduce its mass transit system entirely or partially. This in turn accelerated more urban commuters shifting to use more gas-consuming transport modes. In the U.S., for instance, mass transit before 1940 shared an important part of the transportations service in urban areas. But after 1950, because it lost the competition against private cars, many intra-urban mass transit systems had to stop operation. More people were then forced to use private cars, and more low density communities had to be developed in the suburbs. After 1970,

when the cost for transportation in private cars was increasing, the mass transportation system failed to immediately substitute for the private car, in part because of the lack of economy of scale within the low density communities spreading in suburban areas.

The poor economies of providing mass transit in low density areas may disappear, either when the cost for private cars rises to reach the economy of scale to maintain mass transit, or by changing densities in those areas to meet the minimum economy of scale. However, the consideration of these two approaches may be quite different. (Further discussion in Chapter Three.)

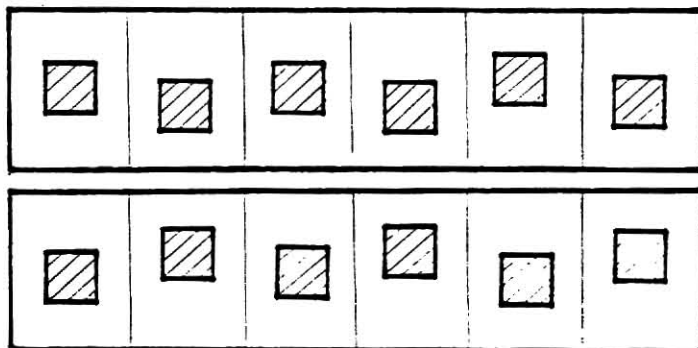
Density and Open Space Pattern

Both dwelling unit density and open space pattern have some relationships with housing clustering patterns which play a crucial role in creating urban characteristics and structuring sub-city spatial distribution pattern. For example, in a typical residential block in a core city in the U.S. having 12 single-family units, the density in this block may remain the same, but the changing of housing clustering patterns may create different open spaces in terms of quantity and quality (see Figure 2-4).

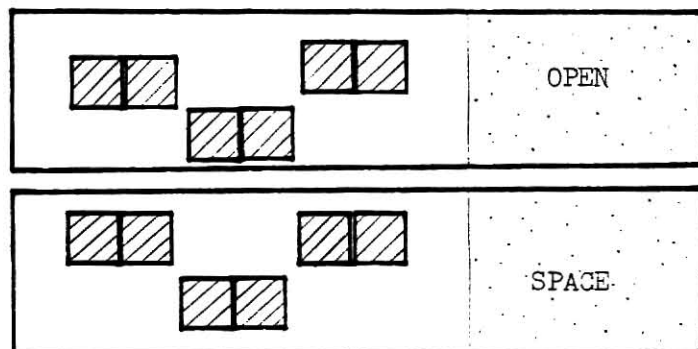
It is evident that a low density area does not imply better quantity of the urban open space if the open space is broken into several small individual open spaces having fewer functions of use for the residents in the block. Therefore, in a compact area if the housing clustering was planned in a particular pattern, the residents may have another chance to enjoy the urban amenities of an open space as in low density areas.

Figure 2-4: Schematic Diagram of Changing Clustering Pattern Without Changing Density in a Residential Block.

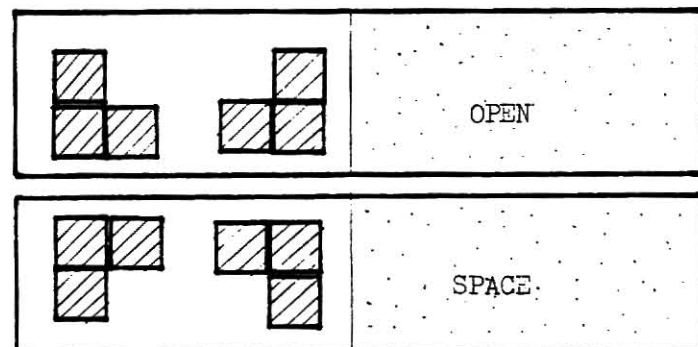
(a) Single Detached



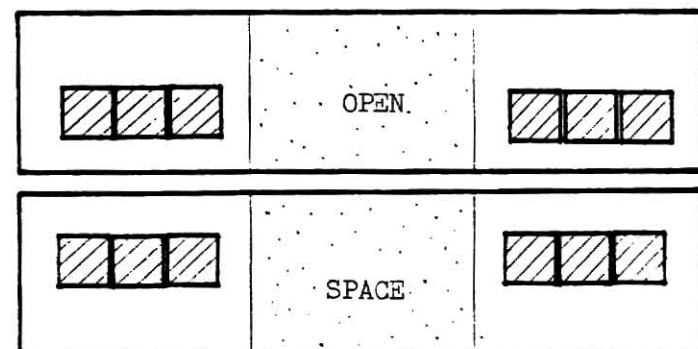
(b) Duplex Townhouse



(c) Cluster



(d) Row House



Basically, the compactness of urban settlement and size of urban space do not greatly influence urban quality, unless urban landscape in the open space relating to housing clustering patterns is integrally considered.¹⁵ There is a need to search for a proper approach to consider open space in a compact urban area. (Further discussion in Chapter Four.)

Land Uses and Housing Type with Density

Land use regulations may greatly affect the relative density of an urban area; zoning restrictions are made principally to manage use of lands relating to urban spatial quantity and quality. Without appropriate land-use zoning planning, the use of land may damage the neighborhood quality of an urban area.

In general, commercial land use has the highest density in an urban area during day-time. In residential area, single-family land use has the lowest density, and multi-family land use has medium density. Recreational land use also has very low density in an urban area.

Two similar land uses in different countries may show a different density, because of their nation's culture and experience with densities and urban forms. For example, the land use of multi-family row houses in the U.S. may be considered as a dense area, but in the Japanese standard, that land use is considered as a low density area. For the same reasons, in a relative high density country, a very low density land use in an urban area is generally not appropriate; but from the U.S. viewpoint it is reasonable because of the different supplies of available land for urban land use.

In the approach to rebuild a compact city, urban density standards may need to make rearrangements both in land use planning and in some social values of an entire society. One of the approaches to rebuild a compact city may focus on residential areas, because residential land use usually has the largest percentage in the total urban land. If most residential land uses become more compact, the whole urban size might eventually be reduced by a significant amount, that would decrease the average trip length and the total urban auto travel.

The housing types in a residential area may illustrate the densities of those sub-city areas in urban forms, because different types of housing structures have different capacities to accomodate different numbers of families and family sizes. The urban quality of residential area is generally affected by the land use densities as well as housing types.

Due to urban zoning ordinances, a housing type permitted to be built in a residential area is restricted. In general, a residential area with detached single-family houses zone has the density of 1-10 dwelling units/acre, semi-detached single-family houses zone has the density of 12-16 dwelling units/acre, a row-house single-family zone has the density of 18-35 dwelling units/acre, a garden (walk-up) apartment zone has the density of 25-40 dwelling units/acre, an elevator (intermediate high-rise) apartment zone has 50-100 dwelling units/acre, and a high rise (more than seven-story building) apartment zone has potential densities of 100-200 dwelling units/acre.¹⁶ In a more compact urban area, housing types consist of multi-unit and high-rise structures, and probably more mix-used structures as well.

CHAPTER THREE:

URBAN GROWTH AND TRANSPORTATION

Historically, transportation played a principal role in deciding urban spatial patterning and urban size. The evolution of transportation modes were certainly a major factor. Because the rapid growth of using private autos accelerated the sprawl of urban size, which in turn increased commuting distance, urban transportation consumes increasingly more energy. There is a need to look at the relationship of urban transportation and different urban forms, in terms of developing appropriate urban transportation systems relating to rebuilding compact and energy saving urban areas.

Transportation in Urban Areas

Since urbanization, the development of an urban transportation system has become as a primary factor affecting urban growth. Due to changes and "advances" in transportation technology, which varied the use of transportation modes, an urban area has had to change its transportation system accordingly. Before the private auto period, primary transportation influences in determining the location and range of human urban activities were waterways, availability of rails (including trolleys) and roads for wagons, trucks, coaches, and buses. In even earlier times, railways and waterways were the only competent modes transporting both passengers and freight. In the passenger transportation system, bus, rail, and waterways were often public transits and operated under fixed routes and schedules. Since economy of scale was one of the considerations of operation,

the location and size of urban settlement was definitely restricted. Therefore, energy used for transportation in that time was not as great as today.

In the post-private auto period, railway and waterway travel were gradually replaced by the automobile travel in urban transportation. In fact, the railroad and waterway were mostly used as inter-city transport modes, and the bus and truck were mainly used as intra-urban transport modes. In the U.S. and the Netherlands, for example, the use of railroads has been discontinued for inter-city passenger transportation for many locations. Only a few cities still used trains for passengers transportation within urban regions. Obviously, the private auto became the primary intra-urban passenger transportation mode that changed the characteristics of entire urban form.¹⁷

In most urban areas of the post-motor period, the use of different transportation modes were dependent upon different sizes of the urban area. Due to the characteristic of post-motor period as an auto-oriented urban form, automobiles for transporting passengers have become a predominant mode. The private auto shares a significant part and is still incrementally increasing. In general, a small city with population below 20,000, and without having economy of agglomeration scale to provide public transit, private auto or other private transportation modes may become the major urban transportation mode in the area. The larger the population size and higher the density of a city, the more possible an economy scale may be to provide public transportation with a reasonable service and operation cost.

The strength of economy of an urban area may also influence the formation of urban transportation systems. In the U.S., for example, the higher the income level of a family, the more privately owned cars are used. Due to the convenience of using private auto as a transportation

mode in urban areas, the extent of using it has become extreme. The trend of urban transportation which shifted from public transportation modes to private auto has caused many serious problems. For example, in a medium or large size city, the streets and parking facilities in the downtown were generally inadequate. Balanced use of public transportation and private autos in an entire urban area had been the major subject of many urban transportation system studies before the energy shortage.

Transportation and Urban Form

Basically the change in size of urban areas and urban spatial distribution pattern showed a great connection with the development of urban transportation systems. In the pre-private auto period, urban growth patterns generally followed the existing public transportation ways, i.e., railroads or waterways or other mass transit routes. In short, the period of pre-private auto was about the same time as the pre-suburbanization period. Therefore, the growth of the urban area in the pre-private auto period was limited around the locations of stations, interchanges, and terminal of public transportation ways. These areas were evidence of convergent nodes. Those mass transit systems transported both passengers and freight. The urban spatial pattern reflected the pattern of mass transit systems.² For example, in some areas, the urban spatial growth followed the railroad system or bus line system that contributed a linear urban form, or reinforced a sector urban form. This kind of model of urban growth was illustrated in chapter one (see Figure 1-1, (b)(d)). In such a model of spatial distribution pattern, a highly dense urban settlement along the transport lines was inevitable, and mix-use urban land was also prevailed. Because most non-walking

urban trips were served by the mass transit systems, the majority of the urban area was growing under a stable size and compact urban structure. The energy used by private autos was not significant, and walking and other non-auto modes were still optimal. In short, the mass transit systems were largely used for both intra-urban and inter-city transportation modes.

In the post-private auto period, the private auto has greatly increased its share of transportation systems. Due to specific passenger space and convenience of private autos, the urban settlement spread out rapidly. Areas previously not served by mass transit systems might be easily accessible by private auto, resulting in the change of urban settlement pattern. The growth of urban spatial pattern was free from the usually linear pattern of mass transit systems, and the growing range of urban size was much larger and faster than it was before. This type of urban growth model is illustrated by the multiple nuclei and concentric zone theories discussed in chapter one (see Figure 1-1 (a)(c)).

Because increased numbers of private autos were used to commute to and within urban areas, the gross residential density within urban area was lowered. It is obvious that enlarged urban size has increased the length of intra-urban journeys, and more and more residents resort to use private autos as the major transportation mode, resulting in reduced ridership and increased length of mass transit trips. After high maintenance costs forced the discontinuation of many mass transit systems, residents living along transit routes moved to outlying areas and used the private auto for commuting.

The increased use of private autos also accelerated the request for more urban land used for streets, highways, and parking lots that also

changed the urban land use pattern. Generally, the ratio of land used for street per person in a high density urban area is smaller than in a low density urban area.¹⁸ In a low density area, the street acreage per inhabitant is about 1.5 - 2 times than in a high density area (see Figure 3-1). The intensity of need of land for streets is also allied to the urban spatial distribution pattern of urban area. Highly mix-use urban land needs less street land than a non-mix-use urban area.

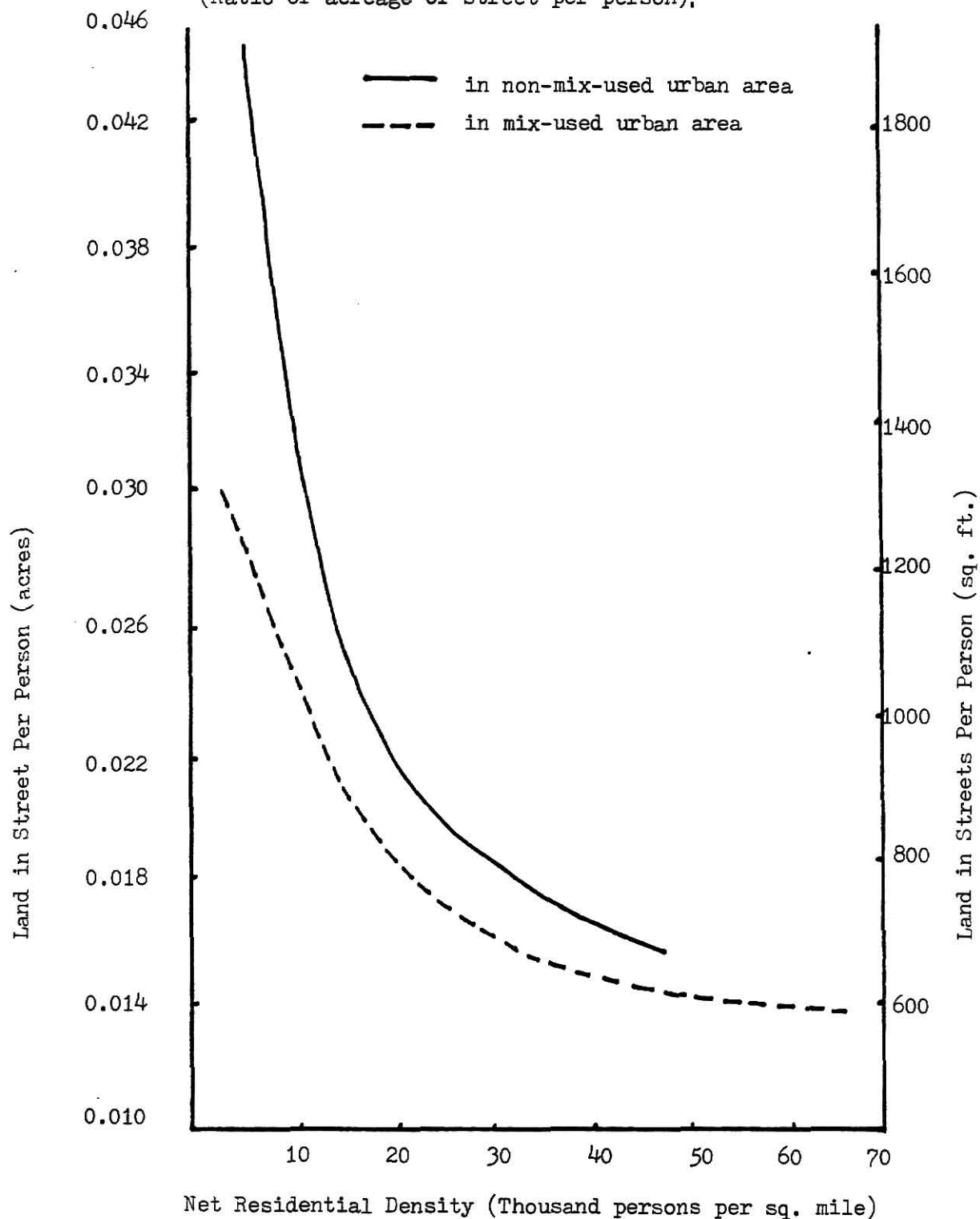
Transport Modes of Urban Transportation Systems

Since transport modes are many, and their characteristics are different, the use of these modes in a variety of urban areas implies some variation. Basically, the transportation modes used for commuting to and from work are categorized into private transportation, public transportation, and non-motor biking or walking. In the U.S., for instance, the highest ratio of modes used for to and from work has been private transportation modes since 1973 (see Table 3-1). Due to the predominance of private auto-oriented urban settlement in the post-private auto period, the auto almost supplanted all the other commuting modes in many urban areas. It is a need to compare the appropriate use of those modes within an urban area and urban sub-areas as in Table 3-2.

Private Cars

Small, medium, and large size private cars are used for commuting to and from work. Because it is used mostly during a specific period of the day, the land for streets and parking lots has become a large part of

Figure 3-1: Relationship Between Compactness and Street Land Required
(Ratio of acreage of street per person),



(Source: "Urban Form and the Allocation of Land to Streets" Research Report, V.P. Goldberg and K.M. Kriesel, 1971).

Table 3-1: Means of Transportation to Work of Employed Heads of Households, 1973.

Transportation Modes	Percent
<u>Private Transportation Modes</u>	86
Car	76
Truck	9
Motorcycle	1
Taxi	0
<u>Public Transit Modes</u>	9
Bus or Streetcar	5
Subway, Exclusive Train	2
Commuter Train	2
<u>Walking or Bike</u>	5

(Source: "Energy Use on the Road", The American Energy Consumer, D.K. Norman and D. Day, p. 79, 1975).

Table 3-2: Speed, Passenger Capacity, and Energy Efficiency of Mode of Passenger Transport.

Modes	Average Speed (mph)	Passenger Capacity (no.)	Transportation Efficiency (Passenger mile per gal.)
Private Car	30-50	4	16-32
Taxi	30-50	4	16-32
Large Bus	20	40	125
Streetcar	20	40	125
Commuter Train	35	1000	100
Subway Train	20	1000	75
Motorcycle	30-50	2	70
Biking	10-12	1	-
Walking	3-4	-	-

(Source: "Energy Use in Transportation", D.P. Grimmer and K. Luszczynski, Energy and Human Welfare - A Critical Analysis, p. 32, 1975).

the urban area. In many CBDs, land used for streets and parking lots becomes uneconomic, and also hurts the continuity of commercial activities in the CBD. In short, private cars are not a proper transport mode used in a compact urban core area.

Large Bus and Streetcar

Public buses may be provided in a compact urban area because of economic agglomeration. In compact core city areas, public bus service may maintain adequate quality and quantity, but in non-compact suburbs, public buses are not economical to operate over extensive routes and frequent schedules necessary to displace private cars. Public bus needs no urban land dedicated to parking that is required in core city areas. Consequently, preserved land in CBD can be used for commercial needs. The time spent waiting for public buses is often a reason that keeps people from using public bus as main commuter mode. Buses may be operated for short intra-city trips, long-trip commuting, or as an inter-city express. Streetcars are generally operated within a core city area, and other highly dense populated areas. Both of them may be operated to provide a feeder system for higher capacity transit systems, such as subway or railway, within urban areas.¹⁹

Railway

Railways, once served as an important transportation mode in non-private auto-oriented urban areas, but its wide-spread use no longer prevails in the private auto-oriented urban areas. In the pre-suburbanization

period, it similarly provided both passengers and freight transportation. In the post-suburbanization period, due to its inconvenience compared to the private auto, rail has only maintained freight transportation within most regional areas. The exceptions of intra-urban rail for passengers are only in the older metropolitan areas, such as New York City and Chicago of the U.S. Seating capacity and economical operation are two primary factors that intensify the rail used for commuter train in peak hours in the urban area served.

Subway

The advantage of using subway mode includes, first, reduction of CBD traffic congestion, and second, elimination of traffic pollution and noise. One of its drawbacks is the cost of construction that asks for not only a more compact urban settlement, but also a large population size to patronize the operation. The population size of an urban area to economically operate a subway system should be over 700,000 inhabitants. However, subways as an underground transportation mode need less urban surface land, thereby preserving more land in the CBD for commercial use or urban amenities. Its locations of routes and stations are directly allied to urban spatial patterning, since their service capacity and system speeds are a function of station spacing and route coverage just as in commuter rail operations.

Taxi (cab)

Taxi cabs, even though convenient, are not an energy efficient urban transport mode, especially used in a compact central city rather than in

suburbs. However, they are more capital efficient than their look-alikes, the private auto, since they, unlike autos, have higher passenger service rates and are not merely parked for long periods in a day. The economy of maintaining a reasonably sized taxi fleet in an urban area is greatly affected by urban population size and the compactness of urban spatial distribution pattern. Taxi cabs may not become a dominant public commuting mode, because of high service costs. Nevertheless, cabs are really needed to supplement the time inefficiency of a mass transit oriented urban area. Because of its net operation cost to the user, a compact urban area may attract adequate taxi users and maintain a large taxi supply.

Motorcycle

From both energy conservation and time efficiency viewpoints, the motorcycle is the best mode used for urban transportation. In addition to driver performance limits, the only drawback is that using motorcycles is greatly restricted by weather and climate. In warm areas or areas of light snow or infrequent thunderstorms, the motorcycle has a better opportunity to become the primary commuting mode. It also needs very limited land for street and parking, which preserves more land of core city for commercial use or urban amenities.

Bike

Use of the bicycle is greatly limited by natural weather and human physical endurance. The speed of a bicycle is not appropriate in an auto-oriented urban area. Therefore, bicycle use in nice weather is restricted to small urban size areas or residential neighborhoods. However, due to

rapid urban growth in the last two decades, the use of bikes has been discouraged by the lack of facilities and the prevalence of private autos. Sprawling urban areas are usually not planned for safe bicycle use.

On-foot Walking

Walking once was the primary way of transportation, especially in small villages before urbanization. After urbanization development over large lands, foot travel became too time consuming and physically impractical. After suburbanization, walking became almost totally impossible as a mode for commuting. In addition to large urban size, highway and parking lots were also intensifying the barriers to walking. Although walking requires no fossil fuel directly, its speed is not an economic scale in this auto-oriented urban size and spatial structure. Besides, many streets in suburban areas are not designed for pedestrians. However, in highly dense CBDs, walking may be the best transport mode if the street facilities were properly planned.

Other Modes

There are some other urban transportation modes, but due to their few numbers and small influence on the entire urban transportation system, it is not appropriate to discuss them in this report.

Urban Transit and Urban Form

In order to meet urban energy conservation, reducing use of private autos and increasing mass transit systems are two interrelated approaches.

Today, mass transit modes generally include public bus, streetcar, subway, commuter trains (in some metropolitan areas), and excluded-express trains. All these modes have one thing in common, i.e., they need an appropriate urban form and economies of agglomeration scale.

Yet, the U.S., there are some major reasons that urban inhabitants are not using public transit. Among them, public transit is not readily available (see Table 3-3). But at the same time, most people use public transit, not because they have no car or no driver's license, but because that mode has some advantages over private autos. It is found that mass transit is still viable in some urban areas. It also illustrates that mass transit has two critical disadvantages, i.e., that the time spent by using transit would be longer than by using private auto at some times, and that the cost for using public transit may be the same or higher than using private autos. In fact, the time needed is related to the urban size and the correlative locality of working and residential areas, likewise, the cost is related to the economic agglomeration of urban settlement size and urban density.

The capacity of providing a reasonable urban mass transportation system may be estimated by urban spatial characteristic as well as urban inhabitant settlement pattern. There are basically three indicators, i.e., urban size, urban density, and urban nucleation which are used to evaluate the appropriateness of operating a possible mass transit with reasonable cost and time efficiency.²⁰

Urban Size

The urban area served by mass transit is related to urban inhabitants' daily commuting activity size within which certain trips are needed. If the

Table 3-3: Percent of Employed Heads of Households, by Main Reasons for Not Using Public Transit, 1973.

Reasons	Percent
Not Readily Available	74
not available at all	57
not convenient to work	10
not convenient to home	7
Take Too Long	9
Cost as much or more than private auto	5
Uncomfortable	4
Need Auto for work	6
Other	2

(Source: "Energy Use on the Road", The American Energy Consumer, D.K. Norman and D. Day, p. 80, 1975).

urban settlement size is relatively large, and every sub-area is separated from each other, the time spent for transportation may become longer. Inevitably, using public transit may "waste" more time if there is no system for connecting and transfers. Urban size, therefore, has been considered the most critical factor in selecting a reasonable mode of mass transit for urban areas.

Urban Density

The cost for maintaining a certain quality and quantity of mass transit is directly correlated to the population density of urban areas. Economically, there is a certain requirement of minimum residential density to maintain a public transit service. For example, the minimum density for providing a local bus with frequent services per day is 15 dwelling units/acre, and for providing a light train with frequent services per day is 9 dwelling units/acre. Basically, urban size and urban density together affect the choice of time efficient transit mode with the possibility of economic operation.

Urban Nucleation

The concentration of clustering of urban settlement is also an important factor in determining an economic and efficient transit mode operation. For a core city bus or other commuter transit modes, higher nucleation of a core city area helps the frequency and economy of transit service. In fact, in a highly nucleated urban area, the use of private auto may demand more streets and parking lots in core area, that may also result in less economic land use and more traffic problems. Basically,

urban public transit may help to relieve the peak hour traffic congestion caused by private auto used in such nucleated urban area.

Since each mass transit mode has its own specific carrying capacity, speed, construction cost, and operation cost, a reasonable use of mass transit system within a variety of urban sizes and urban densities may be different (see Table 3-4). In a highly integrated and concentrated conurbational region, rapid transit may be an economic and efficient mode of transportation between linear-located cities within the region. In a fairly compact and large-sized metropolitan area, subways may be an appropriate public transit system serving the entire area if the urban economy is strong enough to support the construction cost. Likewise, in a highly dense and populated core city area, streetcars and a local bus system may be the appropriate modes for the inhabitants of this area. In a non-compact and non-populated urban area, almost no transit system may be operated at reasonable cost and adequate quality of service, even though some specialized services, such as dial-a-ride, may at least exist.

Transit and Land Use Pattern

In an urban area served by transit buses, the place adjacent to the bus route may present a linear land use pattern, because many activities may be concentrated along both sides of the bus route. Sometimes, without private autos, a bus system may attract inhabitants residing along the bus route, bus station, and bus network. For rail systems, if the distance between two stations is long, its influence on land use pattern is presented as nodes along the railway. Rails themselves act as a barrier to urban growth and can have an adverse impact on land use patterning. However, a bus system generally stimulates free patterning of urban land use because of its

Table 3-4: Preferential Employment of Transportation System in Urban Areas.

(a) in Regional Conurbation

Degree of integration/concentration		
High	Moderate	Low
<ul style="list-style-type: none"> • Rapid transit • Light rail • Express bus 	<ul style="list-style-type: none"> • Light rail • Express bus 	<ul style="list-style-type: none"> • Commuter rail • Commuter bus

(b) in Metropolitan areas

Size of urban population \ Density (du/a)	High density (Over 11)	Moderate density (5 - 11)	Low density (below 5)
Over 700,000	<ul style="list-style-type: none"> • Subway • Metro Bus (L) • Express Bus 	<ul style="list-style-type: none"> • Metro Bus • Express Bus 	<ul style="list-style-type: none"> • Metro Bus (S)* • Express Bus • Commuter Bus
700,000 - 350,000	<ul style="list-style-type: none"> • Metro Bus (L) • Express Bus 	<ul style="list-style-type: none"> • Metro Bus (S) • Express Bus 	<ul style="list-style-type: none"> • Metro Bus (S)* • Commuter Bus
350,000 - 150,000	<ul style="list-style-type: none"> • Metro Bus (S) • Commuter Bus 	<ul style="list-style-type: none"> • Metro Bus (S) • Commuter Bus 	<ul style="list-style-type: none"> • Commuter Bus

(continued next page)

Table 3-4: Preferential Employment of Transportation System in Urban Areas (continued)

(c) in Central City area

Size of city population \ Density (du/a)	High density (Over 14)	Moderate density (7 - 14)	Low density (below 7)
Over 90,000	<ul style="list-style-type: none"> • Local Bus (L) • Express Bus • Street Car 	<ul style="list-style-type: none"> • Local Bus (L) • Streetcar 	<ul style="list-style-type: none"> • Local Bus (S)* • Commuter Bus
90,000 - 30,000	<ul style="list-style-type: none"> • Local Bus (S) • Commuter Bus 	<ul style="list-style-type: none"> • Commuter Bus 	-
Below 30,000	<ul style="list-style-type: none"> • Commuter Bus 	-	-

Note: Metro Bus is served in 3-5 minute period.

Express Bus is served in 15-30 minute period.

Commuter Bus is served in only peak hour period.

* Means it is serving for heavy traffic demand.

(L): Large size.

(S): Small size.

(Source: City Traffic, Horst R. Weigelt et al., p. 153, Van Nostrand Reinhold Company, New York, 1973. Regional Plan Association).

inexpensive construction and flexible network. A subway system, because it is underground, does not affect urban land use pattern, except that the subway station may impact on the location as a nodal land use pattern.²

Basically, the spatial relations between the four basic land uses, i.e., residential areas, industrial districts, central area; and open areas (primarily recreational areas) determine the needs for intra-urban transportation, while the location of the mass transit and the mode of mass transit system in turn may determine the land use pattern as well as spatial distribution.

Transportation System and Policy in the Selected Countries

Due to the different economic and urban context in different countries, urbanization has resulted in various transportation systems in those urban areas.

In the U.S., the significant development of highway systems since the 1940's has created a suburbanized urban form. In turn, suburbanization demanded a more extensive highway network that discouraged the development of other transportation systems in the urban area. In fact, due to the increasing highway system and private auto-oriented urban form, public transit systems have been reduced, and public transit-oriented urban form has been changed. About 10-15 percent of urban commuters use public transit in some major urban areas. Private autos, however, are still the main commuting mode in most areas. The federal government long ignored transit and even after some highway trust fund monies were allocated to transit, there have been recent attempts to cut the subsidies for local mass transit services. The commuter bus and rail systems may therefore become more difficult to

maintain within those urban areas of medium or small size. Only in some big cities and urban areas, where the local government provides large financial subsidies, can mass transit continue to operate. Even then, transit subsidies nowhere match those for automobiles, trucks, and airplanes.

In Canada, railway and waterway networks have been, and continue to be, essential transportation systems -- especially for the movement of freight. Like the U.S., most passenger transportation is by road. The activity of intercity buses has recently held steady, and urban transit activity -- comprised of local bus services, subway system, and commuter rail services -- tends to be increasing slightly. However, about 80 percent of Canadians use private autos, and about 20 percent use public transport facilities. Policy for transportation systems is measured by the energy cost for greater energy efficiency.²¹

In the Netherlands, due to its historical development of transportation system and population growth trend, the use of the waterway and railroad as transportation systems remain at a stable level, but the growth of road network is increasing. In major urban areas, it is estimated that about 30 percent of urban commuters use mass transit to and from work, and the rest use private autos as the primary commuting mode. However, one of the urban transportation policies calls for the urban transportation system of residential precincts, the motor vehicles has been subordinated to the pedestrian and biking requirement.²²

In Japan, the transportation system has been greatly planned and the mass transit modes have become a very significant transportation system in the major conurbation areas. Both state-run and privately-owned railways provide service for approximately 50 percent of commuters to and from work. Along with other public transit modes, i.e., subway, streetcar, and

local bus, they carry total about 80-90 percent of commuters daily. The cabs in the Japanese city are also as a major transportation system. The policy of the Japanese transportation system is that public transit systems have to be developed closely with urban and newtown planning, and rail, subway, and other mass transit networks should be integrated to reduce unwanted traffic in major cities.²²

In Taiwan, the number of commuters using private autos to get to work has increased rapidly, and providing sufficient mass transit system in order to alleviate this trend is underway. Highway and railway are mainly utilized as intercity networks for both passengers and freight. In big cities, intracity bus, and cab are all serving as major transportation modes. Due to year-round mild temperatures, motorcycles are also a primary urban transportation mode, but it has been decreasing recently. Basically, the delay of policy for subway development has accelerated the use of private autos in many metropolitan areas, and has also resulted in traffic problems in many core cities. About 80 percent of commuters use transit and the rest use private autos, motorcycles, or cabs to and from work in urban areas.²²

CHAPTER FOUR:

URBAN OPEN SPACE AND URBAN GROWTH

In a compact urban area, the very compactness of the urban settlement does intensify the possibility of economic operation of mass transit which may help to slow down the growing number of urban private autos and decrease urban trips using private auto. Generally in a compact urban area, however, the increase of urban land used for buildings is rather significant; this, as a result, may decrease the vacant lands and open spaces within an urban area. The impact of inadequate open space or open land for outdoor recreation and facilities is that these disadvantages of a compact urban may become significant, and the quality of urban context may certainly change. There is a need to examine the open space in an urban area relating both to urban density and to urban transportation systems.

Meaning and Function of Urban Open Space

In short, open space is defined as an outdoor area devoted to public recreation, or to a visual scene, or to other needs, or it may be just abandoned as unused vacant land. In general, open space may be characterized into either positive or negative; it may be natural or man-made.

Examples of natural open space are wilderness areas, rivers, bays, lakes, oceans, hills, mountains, valleys, cliffs, deserts, and combinations of these. Examples of man-made open space are reservoirs, quarries, farms, orchards, parks, pedestrian ways, sidewalks, streets, parkways, gardens, artificial ponds, golf courses, urban vacant lands, cemeteries, etc.

Most man-made open spaces are created for certain functions, and many are located in urban areas. Positive open space means any open land used with reasonable purpose or active function. Negative open space means any open land unused or abandoned for a period of time.²³

Open space may be categorized into two additional classes. The first is urban open space, which includes all kinds of open land within an urban area, the second is rural open space, which includes those open spaces outside an urban area. In particular, urban open spaces such as parks, open squares, parkways, streets, publicly owned open space, etc., are considered as amenity resources or local public goods and incorporated into neo-classical urban land-use theory. Moreover, urban open space basically provides light and air to buildings, provides perspective and vistas of the urban scene, provides recreation and ecological protection, serves as a city-shaping device, and reserves presently vacant areas for more active public use at some future date. Accordingly, urban open space is a major land-use sector which significantly affects the overall quality of urban environment.

There are four fundamental functions of urban open space, i.e., for well-being, for public safety, for corridors, and for urban expansion. Even a compact urban area, open space has to meet these basic functions if it is to provide these qualities to an urban settlement. In fact, the size and the location of an open space may directly affect the urban form of urban growth, and indirectly affect the transportation system, that together would influence the total auto-linked journeys within an urban area daily.²³

Because streets, pedestrian ways, and parks are the three major components of urban open spaces, the urban density and urban size of urban areas are affected by them. An urban park, for instance, provides a

recreational place for the urban residents, and it also increases the size and reduces the density of the whole urban area. Streets and pedestrian ways as transportation ways may increase urban size, and also reduce the urban density. Due to the significant size of open space in an urban area, the management of the urban open space as urban landscapes and urban amenities become critical in terms of urban environmental quality.

Practically, the function of urban open space serves physical and psychological needs. In physical terms, it plays a principal role in structuring some significant urban spatial patterns, e.g., park area or hill districts pattern, and in shaping the transportation patterns, e.g., streets and riverway patterns. In psychological terms, urban open space provides openness or a sense of wilderness which is an important sense required by human. Therefore, from urban transportation system and urban density aspects, the urban open space pattern is really an important factor dealing with the consideration for rebuilding a compact urban area.

Urban Open Space and Urban Form

In the pre-suburbanized urban area, the ratio of total size of urban open space in urban area is generally smaller than in the post-suburbanized non-compact urban area. In the pre-suburbanized compact urban area, the components of streets, hills, and some unusable lands were the typical and primary urban open spaces. When park land is lacking, as particular recreational open land, the streets became not only used for transportation, but also as an open space for recreation by the residents and as the place of their daily social activities. In addition, some private small open spaces, such as front yards, parking lots, and sideyards, were not required

by the urban development codes in that time, and this helped to shape the compact clustering of the urban settlement.

In the post-suburbanized urban area, the urban spatial pattern has changed, that previous compact settlement has not prevailed in most suburbs. In this time, vacant or unused open lands were increasing among adjacent neighborhoods, or among single-family housing, and between core city and urban ring area. Besides, the need for many different functions of open space for various activities or requirements also increased the size and total number of open spaces within an urban area.

In short, urban open space shows a significant transition relating to the urban form change. In the beginning, the streets and pedestrian ways were the predominant urban open space, then a street provided for multi-purposed functions, i.e., for transportation, recreation, markets, social activities, car parking, people watching, clothes drying, etc. Afterward, urban open space became as more single-purpose function, a street tended to be considered only for transportation, parks for recreation, neighborhood parks for social activities and children's playground, parking lot for car parking, frontyard plaza for people watching, housing frontyard for flowers, backyard for clothes drying or barbecue, sideyard for fire protection, etc. Eventually, the need for more open spaces has greatly changed the urban size, and urban spatial structure.²⁴

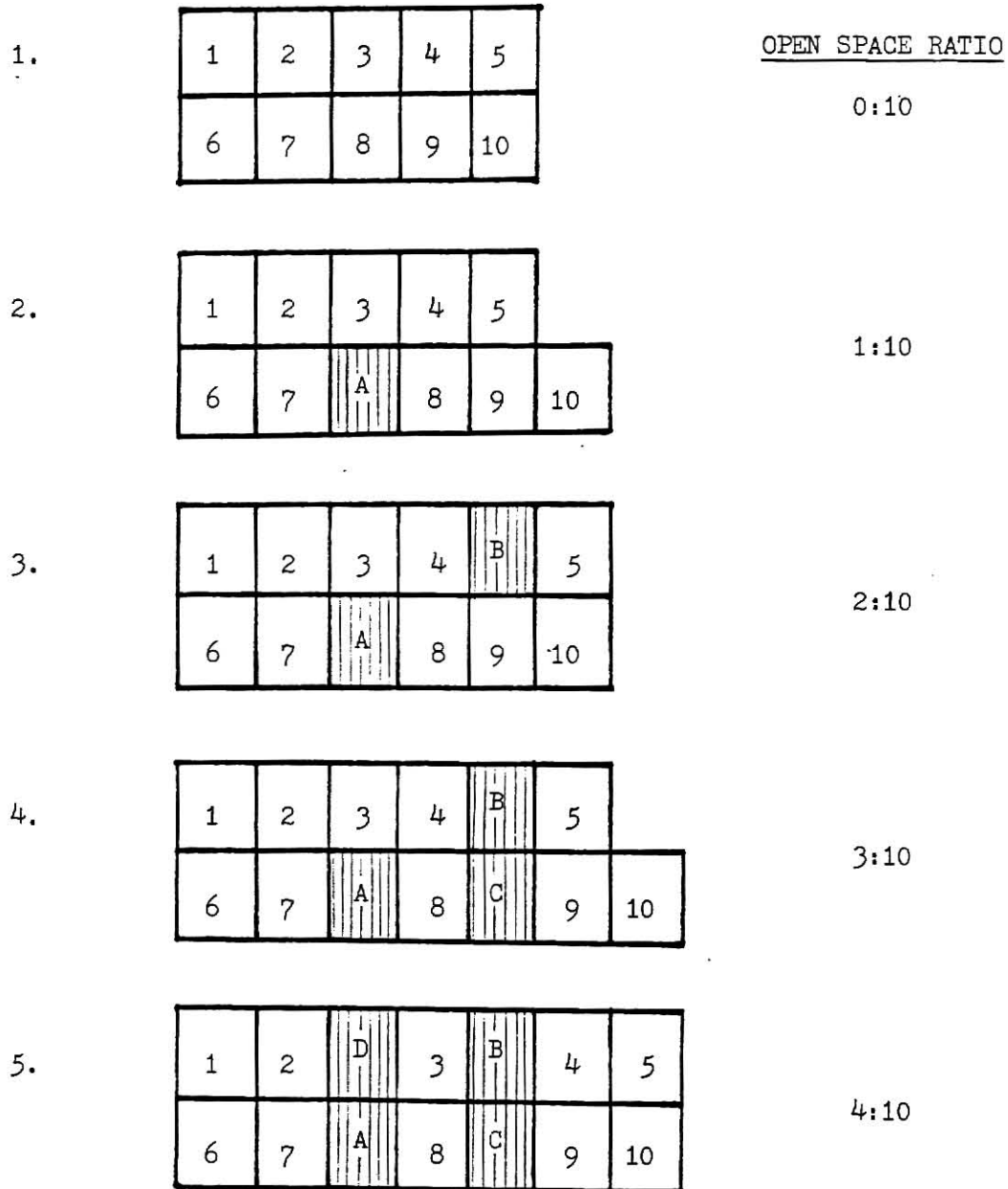
The expansion of urban size in the suburbanization period was mainly because the unprecedented increase of both urban positive and negative open spaces. In a suburban area, the positive urban open spaces are highways, neighborhood streets, sideyards, green belts, parking yards, neighborhood parks, outdoor sport courts, etc.; the urban negative open spaces are undeveloped vacant lands, dumping areas, unused waterfront areas, haphazard

areas, etc. Likewise, in core city area, the positive urban open spaces are local street systems, public parks, plazas, squares, front courts, parking lots, etc.; the negative urban open spaces are vacant undeveloped lots, abandoned lots, demolished blocks, and other unused open lands.

In general, a low-density urban area has a higher open space ratio than that of a high-density urban area. That is, a core city area the open space ratio is lower than in suburban areas. Moreover, the largest percentage of all the urban open space, in a core city area may be transportation ways, in suburban areas it may be green belts and undeveloped natural lands. Apparently, the increase of roads for private auto, and sideyards for residential housing have physically enlarged the urban size (see Figure 4-1), and have complicated the urban spatial structure.

The variation of urban spatial distribution patterning in the post-suburbanization has been obvious, because of the increase of many large-sized urban open space land uses within an urban area, such as city parks, parkways, campuses, parking lots, building frontyards, station plazas, urban green belts, etc. In the earlier urbanization period, less urban land was used for those urban open spaces, many were small-scaled holdings. Open spaces did not play a crucial role in urban spatial distribution formation. There are notable exceptions, such as Central Park in New York city or the parks and gardens in London, or the traditional village commons. However, due to the evolution of urban life, more and more specialized open spaces were created, and more and more urban land was used for those open spaces. Furthermore, the rapid urban growth in the suburbanization period was made possible in part because the unplanned distribution and improper size of those urban open spaces. For instance, in an urban area, if the total size of urban open space is significant

Figure 4-1: Schematic Diagram of Urban Size Growing With the Increasing Open Space Ratio.



Note: 1,2,3....10 imply urban non-open space land uses.

A,B,C,D imply urban open space land uses.

compared to total urban size, and these open spaces are located and distributed to separate CBD and residential areas, the length of commuting trip within the urban area will inevitably be longer than if there is not as much land devoted to open space¹⁸ (see Figure 4-2).

In the suburbanization period, generally the primary factors affecting the urban size growing rapidly were: first, the overall size of total urban open spaces and low use of those open spaces, and second, the lack of adequate open space in old downtown areas that encouraged residents to move out to suburbs for more open space. Therefore, urban form is directly affected by the land use of open spaces and their sizes and spatial distribution relating to other urban land uses.

Open Space Considering Density and Transportation

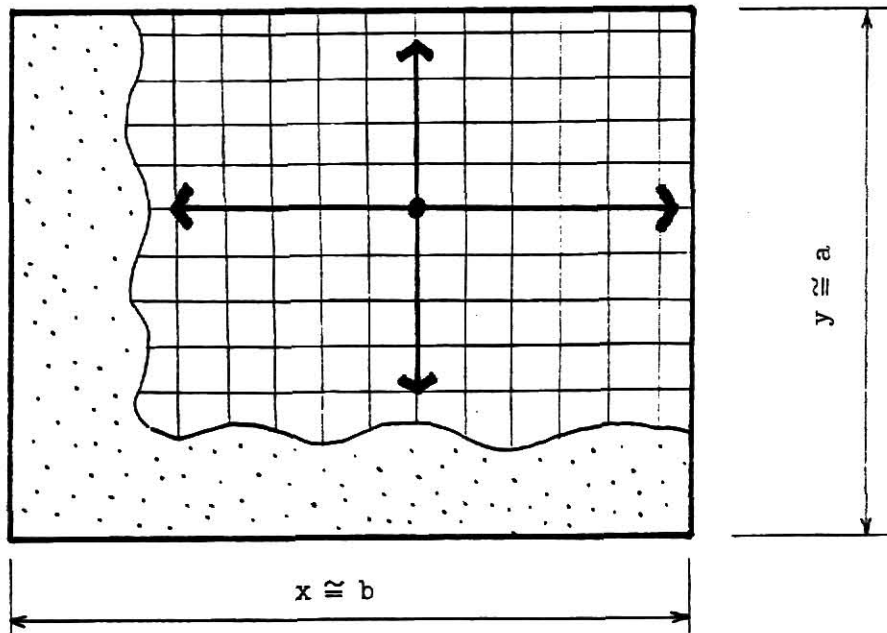
Basically, the major components of urban open space are parks, streets, and the natural land forms and features such as hillside and waterfront areas. All of them may influence the densities of urban settlement, so that urban space may be as a reference in managing the urban density in the rebuilding of a compact urban area.

Parks

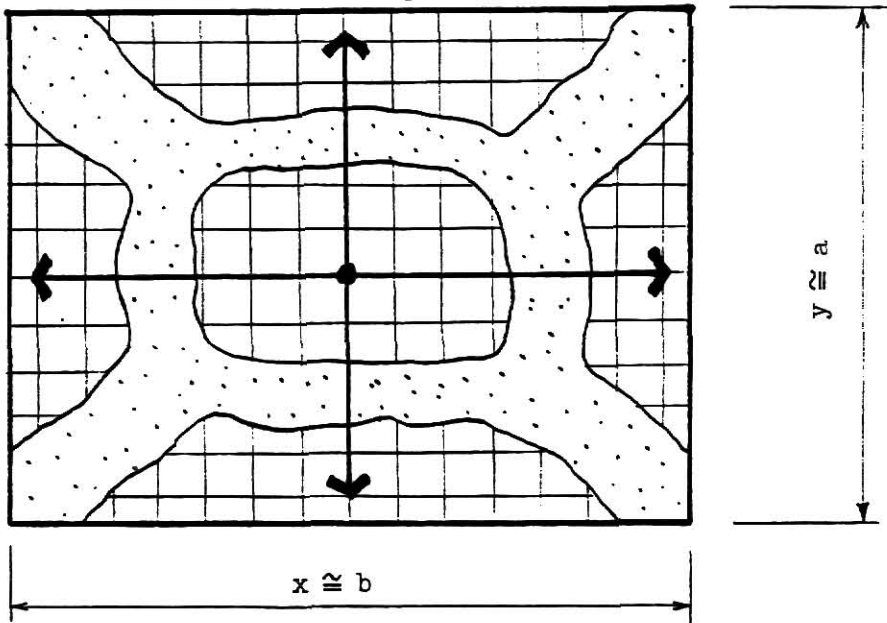
The basic function of urban parks is to provide an open area of recreation and landscape, or as gardening for urban resident's needs. Due to the relatively large size of total parks in many urban areas, the influence of urban parks on urban environmental quality is also significant. In particular within a compact urban area, preserving more land for park use and building more compact moderate- and high-rise structures may alleviate

Figure 4-2: Schematic Diagram of Two Different Patterns of Urban Open Space Distribution with Similar Density and Size.

Type A - Linear open space



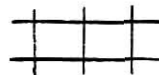
Type B - Dispersed open space



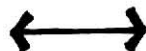
Note: a and b are any given constants.



Open space.



Built urban area.



Length of urban transportation line.

the sense of crowdedness, and reduce the need of the trip to a rural area for the rewards of open space. Besides, due to various needs, the location, the size, and the specific function of a park may vary. For instance, in a residential area, a neighborhood park with appropriate size, and within a walking distance is more appropriate, and in a compact CBD, small plazas and landscaped sidewalks are probably more appropriate. It is also a proper need that a large-scale park outside a core city area provides large green space and recreation facilities for the residents from core areas. Consequently, a proper scale and location of an urban park may decrease the total densities of the areas surrounding the park. Therefore, two different urban areas with similar densities, the one with more appropriate parks within it may provide more amenities than the other does.

Streets

In an urban setting, the total area of urban streets generally occupies 15-35 percent of the urban surface area, that makes the street a very important urban open space with which to deal. The street system in an urban area includes roads for automobiles, sidewalks, pedestrian paths, railways, and other transportation ways. In an auto-oriented urban area, the open space of the streets for automobiles is closely packed and the total area presents a high proportion in the urban land use, that also affects the overall urban densities. Obviously, the management of those street systems is also meaningful.²⁵ The basic function of streets in urban areas is to provide an exclusive space for transport modes to travel efficiently. However, due to its specific location and time period of use, the land of streets also may provide other tentative uses than transportation without having conflict with the transport uses, that may reduce

the need of additional urban land for some activities and uses. Therefore, a compact urban area may still possess the amenities as in non-compact urban areas, by increasing the multi-purposed functions of urban street spaces. For example, the streets in the CBD of a central city may become a pedestrian mall without any auto traffic after the office rush, or the streets in an urban core area may become a night-time parking space for special meetings in that area, or the streets in a residential area may become a holiday sport court for residents' recreation.

Natural Topography

Due to specific variations of urban terrain and landform, natural hills and waterfront areas may become particular urban open spaces in an urban area, either preserved as natural landscape or developed into as an urban park for recreation, or both. Basically, in an urban area having specific landforms with many natural landscapes, the urban open space development may directly use these existing natural characteristics as part of urban amenities. Therefore, the size and location of the open space of those natural topography patterns may be an important part of urban spatial patterns, that may also directly influence the densities of the urban area. However, in many urban areas, natural topography and the waterfront areas are still undeveloped such that those areas are treated as negative open spaces rather than positive open spaces. Physically, those unused natural areas are not as part of urban area for urban activities, so that they have less relation with management of urban densities.

The character of urban open space may be classified into two types. The first is single-functioned open space, i.e., golf course only for golf-playing, highway only for auto-driving, swimming pool only for swimming, etc.

The second is multi-functioned open space, i.e., a shopping mall for shopping activities, but also as a pedestrian way, sidewalk cafe, service parking, people watching, and urban landscaping, or a frontyard plaza for an entrance, but also for taxi parking, urban landscaping, and people watching, or a neighborhood court yard for a neighborhood entrance, but also as a social activities center, a children's playground, family outdoor recreation yard, and landscaped garden.

It is an alternative to create more multi-functioned urban open spaces to increase more purposes of urban land use in a compact urban.²⁶ The open space of transportation ways is the largest portion of urban open space that really needs more considerations of urban landscape and multi-use according to different time periods and different urban spatial structures.

Urban Open Space As Urban Amenities

Any open space in urban areas, either man-made open space or natural open space, may affect the urban visual quality in that the landscaping of the open space is directly related to the psychological needs of urban residents. With appropriate urban planning and urban design, even a small urban open space may become a significant amenity for some compact core areas. In fact, it is often the case that it is the visual qualities that attracts people to those areas.

In a compact urban area, due to its high land-use intensity and highly mixed land-use, the sense of crowdedness and orderlessness of the urban environment may become unavoidable. This also greatly affects the preference of urban inhabitants living in such a compact place. Generally, a landscaped park in CBD may provide a relief of visual sense, in a neighborhood it may provide a perspective view, and in the suburbs, it

may provide a sense of openness and wilderness. The different scale and location of each urban sub-area needs different kinds of parks as amenities. Therefore, a landscaped transportation corridor in CBD with some combination of pedestrian ways and street furniture may not only provide urban visual amenities, but also physically meet residents' needs. Besides, by integrating the nodular open spaces (plaza, park) and linear open spaces (transportation line, waterfront) in a compact urban area may eliminate the sense of urban orderlessness. Also, the proper connection with those man-made open spaces and natural open spaces, i.e., lakefront, riverfront, hillside, etc., may intensify the urban amenities and decrease the sense of crowdedness of an urban area.²⁶

The size of urban open space may be enlarged by preserving more land from building uses, that in turn may require the building of more moderate- and high-rise buildings rather than detached single family housing in most parts of an urban area. It is also necessary to emphasize the multi-functioned use of urban open space, and to provide mass transit to reduce the scattered open spaces dominated by parked automobiles. The visual quality of those urban open spaces, however, requires more careful landscaping to integrate these urban open spaces than has been the typical situation.

Urban Open Space and Land Policy in the Selected Countries

Due to the increasing attention to environmental preservation in many countries, urban open space has been an important issue and a critical component of urban spatial structure. In addition, the function of urban open space has been identified as an urban amenity for refreshing urban living. However, most urban areas with rapid growth in their urbanization

periods usually paid little attention to its positive open space patterning of their urban areas. During that time, without sufficient size of urban open spaces and appropriate urban open space distribution pattern, the over-agglomeration of urban population generally deteriorated the living quality of the urban areas, that later on encouraged the growth of extremely low-density and dispersed settlement in suburban areas in many high economy countries. In turn, the over-sized suburbanized urban growth has badly hurt many natural open spaces and their original, often stable, ecological environments.

In the U.S., for instance, the value of open space outside metropolitan area has incrementally been identified and preserved by local authorities, and the policy for doing so will continue in the near future. Open space such as sideyards, road right-of-ways, and neighborhood parks in residential areas has been regulated through land use zoning codes. But, there are still many vacant lands in many suburban areas, because the leapfrogging of urban growth in the suburbanization period. Many large core cities have sufficient open space, as parks, but there are also many unused vacant lands in some deteriorated downtown area. Basically, there has been no particular nation-wide land policy to deal with open space.

In Canada, like the U.S. counterpart, the preservation of rural open space is of immense concern. Furthermore, in many urban areas, the urban open space in core city areas has been relatively well integrated into urban land use pattern and urban amenity system. Basically, either in the U.S. or Canada urban area, residents share larger urban open space for recreation than possible in more densely settled countries.

In the Netherlands, due to high density of nation population and scarcity of suitable land for both urban and agricultural use, the

preservation of natural open land outside urban settlements is highly motivated. In order to reduce urban sprawl, careful restriction has been enforced at both the national level and local levels. Because their already compact urban growth, the landscape of urban open space in urban development process has been an important part of urban land use planning schemes.²⁷

In Japan, because the plain lands for urban and for agricultural use are few, and most of them are concentrated on the coast line, the percentage of public open spaces for recreation within urban core areas is certainly smaller than in the U.S. However, the mountain areas around those urban areas provide the place for recreation and visual amenity for the urban residents. The current policy for urban land recommends a decrease in core area population as well as traffic, and then convert some transportation ways into multi-functioned open spaces as urban amenities. Many new towns in suburbs are designed with careful integrating of natural topography which provides both man-made and natural open spaces for neighborhoods.

In Taiwan, there are few existing urban open spaces for recreation in most core cities; the few that exist are over-used by the residents. Except for the mountain areas, the main component of open space outside urban area is agricultural land, which is carefully restricted by the national land policy from being converted to urban use. Due to the high cost for acquiring urban open spaces for parks in most compact core cities, the local policy for preserving urban open space for recreation and urban amenity is made as a long-term scheme.

CHAPTER FIVE:

GUIDELINES FOR COMPACT URBAN APPROACHES

To most suburbanized urban areas, the shifts of urban form from low density and extreme sprawl to high density and relative concentration is not easy and cannot be achieved immediately. Therefore, the process of rebuilding a compact urban form has to follow some basic guidelines which provide the principles for rebuilding. Basically, the guidelines for structuring a new compact urban area are different from those for rebuilding an existing non-compact urban form into compact urban form. Since most urban areas during the past two decades have not been built in an energy conservation form, the integrating of the closely related topics of this paper become one of primary tasks in urban planning process.

Integrating the Approaches

It is obvious that urban energy conservation within transportation cannot be achieved without the integrative considerations of other primary approaches, such as urban density, urban form, urban mass transit, urban open space, etc. Due to the relatively complicated interrelations of urbanization processes, the consideration of any urban related factor and its influence on urbanization should not be simplified and isolated from other urban factors.

Since almost all urban forms were shaped and will be shaped with the influences of social, economic, physical, and then political factors, which are highly interactive with each other, urban energy conservation as one of dominant considerations has greatly affected those factors on

structuring the urban form and urban settlement patterning. Most urban forms during the suburbanization were growing outward, because the increased capacity of transportation modes, which were relatively dependent on the economical energy supplied. Moreover, the transportation system directly influences the land use patterns and population patterns of urban areas. Together, the interrelations among transportation system, land use, and population distribution pattern have become clearly significant. The land use and the population distribution in a built urban area work tightly with the function changing of urban form responding to the consideration of energy conservation on urban transportation. For instance, an urban transportation system providing reasonable and economical mass transit (either rapid transit or general commuter transit) is greatly interrelated with the population and the urban spatial distribution pattern. For maintaining the quality and well-being of the urban context, the land use pattern has to be considered with urban open space size and distribution within the urban spatial structure, that in turn indirectly affects the trend of distributing urban population and shaping urban densities.

In short, the process of changing urban form to meet the energy conservation on urban transportation is interrelated and interacted with urban transportation systems themselves, urban densities, and urban open space patterns.

Compact Urban Energy Conserved on Transportation

By integrating urban density, urban transportation, and urban open space into urban growth process, the urban size of a rebuilt compact urban area may be reduced roughly proportionally with its density, and the energy conservation on urban transportation may thus be calculated because the

urban energy conserved on transportation is implied primarily by reducing the total length of total urban commuting trips.

Theoretically, if urban area increases its density from low (5 dwelling units/acre) to moderate (10 dwelling units/acre), then the urban size may be reduced about 50 percent (which includes fewer open spaces for streets, parking lots, and sideyards in residential neighborhoods, but more neighborhood recreation parks). The total length of urban commuting trips may be reduced about 50 percent. If there is a 25 percent shift of urban commuters to the mass transit (which may become economic to operate because of higher density), and 75 percent of commuters still use private cars, (supposedly there is no commuter shifting to walking or biking to and from work), the total energy consumed by urban commuting trips may be reduced approximately 55 percent. It is also implied that total urban trips in the urban area may conserve at least 55 percent of the energy otherwise utilized in transportation. On the other hand, if there is a 50 percent shift of commuters to use mass transit with 50 percent of commuters still using private autos (no commuter walking or biking to work), then the total energy consumed for urban commuting and other trips may be reduced by 60 percent compared to the non-compact private-auto-oriented urban area.

Furthermore, if an urban area increases density from low (5 dwelling units/acre) to high (15 dwelling units/acre), then the urban size may be reduced about 65 percent (which includes more moderate- and high-rise residential housings and more open spaces for gardening and recreation). The total length of urban commuting trips may be reduced about 65 percent. In this case, if 25 percent of commuters use mass transit, and 75 percent use private cars (still supposing there is no commuter walking and biking to work), then the total energy consumed by urban commuting trips may be

reduced approximately 70 percent. That also means that total energy consumed by total urban trips may be reduced at least by 70 percent. Or if as many as 50 percent of commuters shift to mass transit, and 50 percent still use private autos, and no commuter walking or biking to work is considered, then the total energy consumed by total urban transportation may be reduced by as much as 80 percent.

With more mixed land use and correlated allocation of residential areas with the CBD, the energy consumed on the urban transportation may be reduced more than 50 percent or 60 percent in moderately dense urban areas, and more than 70 percent or 80 percent in highly dense urban areas. Besides, with large scale recreational open spaces allocated outside core city and highly correlated with some major residential areas, and with small scale open spaces in neighborhood areas and CBD and mix-used areas, the length of journeys using private autos to these open spaces may also be reduced. In general, biking and walking are still not primary commuting modes in moderate and large urban areas, but they may largely be used on the trips to recreation if those urban open spaces are reasonably distributed within an appropriate distance.

Review of the Concepts Relating to Compact Urban

Some concepts for an urban area's compactness have been developed and practiced in some urban areas. Due to their segmentations and single-functioned considerations, or lack of considering energy on urban transportation, the achievements of those concepts on energy conservation on transportation are generally low, and have brought about some minor conflicts within an urban area.

Planned Unit Development (PUD) is one such concept. It makes possible, among other reasons, the structuring of a sub-urban settlement into a compact clustering pattern, thus leaving more open spaces within the sub-area for recreation or urban amenity. In addition, it may provide more mixed land use within the sub-area. Due to its small scale, often one parcel of urban land, the effect on a whole neighborhood may be minor. In addition to the relative small scale, the magnitude of compactness and mixture of land use is generally not certain. It often lacks of direct connection with any whole urban transportation system. It has less significant effort to reduce most intra-urban trips of urban commuters.

Another concept is Auto Restricted Zone (ARZ), which provides some urban open spaces for pedestrian-dominated use in CBD or residential neighborhood area by restricting auto access into the zone. In this situation, less land needed for streets and parking lots inside highly compact CBD or sub-area become possible and safe. However, the ARZ should work with a mass transit system, that will encourage people not to use private auto but to use available urban mass transportation modes. Besides, within an ARZ, more open spaces may be preserved and landscaped as urban amenity for urban residents.

The utility corridor is a large urban scale concept for a compact urban settlement. It encourages urban growth following an utility corridor where all the utility and primary transportation ways are provided within a planned urban corridor. Considering the utility corridor as a linear urban spatial pattern, urban growth in the corridor area will become more compact and also may have more mixed land use. This concept is advantageous for the development of mass transit rather than private autos with a resulting increase in the importance of planned mass transportation

systems. In fact, the utility corridor concept has been largely developed in many areas where physical limitations restrict the four-direction urban growth into their suburbs.

An industrial park is also a concept which concentrates activities, in this case industrial working places and, more rarely, industrial workers' residential places within a landscaped park area. Within this park, the workers need no private auto for commuting, and the open space within the park provides places and urban amenities for recreation, this reduces the trip to other places for recreation. Possibly, the industrial park may also have infant daycare facilities, a school for children, a local shopping center for daily needs, and so forth. Therefore, it is a mixed land use and likely a compact clustered urban spatial pattern. However, the industrial park concept may not have a significant impact on rebuilding a compact urban because the scale of urban industry is often small. Certainly those industries should be limited to non-polluted types.

The urban infill concept is also an approach to rebuilding a compact urban by reducing the vacant unused land of an urban area. It is typically important for the urban area with extremely low density. By increasing the density, the infill concept contributes the possibility of economical operation of mass transit. However, the infill concept should work with urban transportation system and urban open space system, otherwise it may fail to maintain urban well-being and quality.

Since the technology of telecommunication has been improved in the past decades, using more telecommunication instead of auto trip has become one of concepts of urban energy conservation on transportation. It usually emphasizes the concentration of local settlement in core city and the dispersion in a regional area which telecommunication technology provides the information exchanges among these core areas. Most journeys needed

are only within local areas which reduces the uneconomies of urban transportation system resulting from urban over-agglomeration. Due to inter-related functions of many urban service industries, the distribution of those industries into a couple of separated core areas is only partially possible. Because of human nature, face-to-face contact of urban activities is still a critical requirement for many service industries. It is not possible that commuting trips may be greatly reduced because of using telecommunications. However, transportation among core areas and within every core area will still be a major opportunity for urban energy conservation.

There are perhaps other concepts dealing with rebuilding compact urban settlement, these just presented are simply the most likely to be utilized.

Guidelines

By going through the approaches of urban density, urban transportation, and urban open space, it is understood that rebuilding a compact urban cannot be worked out without an appropriate urban planning process and urban growth policy. Moreover, no urban planning or urban growth policy can be made without regarding the limitations and situations of natural resources and human capacity. Urban planning and urban growth policy should be done early before any urban problem becomes significant. Because any urban planning or urban policy, once made, will greatly affect thousands and thousands of people over a long time, it cannot have any inappropriate step, or be formulated too late to respond to the urban needs during the urban planning process.

These approaches in response to the urban energy conservation on transportation are basically concentrated on managing certain urban planning

elements, such as urban land use, urban zoning, urban subdivision regulations, urban infrastructure, and urban services. Therefore, the approach regarding urban density is to examine those planning elements in order to provide an appropriate urban density for urban growth, and the approach of urban transportation is to review those planning elements in order to realize a reasonable urban size for transit service to meet energy conservation consideration, and the approach of urban open space is to correlate with urban density and urban transportation to review those planning elements. Thus it is possible to provide sound urban amenities in compact urban areas.

Fortunately, the guidelines for developing these approaches do not conflict with the guidances for preserving natural ecological environments and for reducing urban pollution on natural environments. However, after industrialization and urbanization, as well as suburbanization, the area devoted to urban settlements has been much more complicated than it was before, in terms of urban structure, urban pattern, urban size, urban ecology, and urban economy. Any approach to rebuilding a compact urban area from a built non-compact urban area will connect to existing urban economic, social, physical, and political factors while dealing with these urban planning elements. In fact, already there are some communities in the world working on rebuilding into a compact form; they provide the opportunities for developing guidelines for compact urban approaches by learning from their planning processes.

CHAPTER SIX:

EVALUATION AND CONCLUSION

Although a compact urban form is an attempt to reducing the length of trips using autos, particularly private autos, and increasing mass transit, the willingness of urban inhabitants to accept the urban planning process to rebuild a compact urban is unpredictable. The capacity of technology and the growth of urban population are not so exactly expressed in the next decade; this has somehow blurred the intensity and necessity of rebuilding energy conservation's compact urban form from the non-compact urban form. There is a need to review the compatibility between this study and future trends of urban settlement growth.

Perspective and Evaluation of Urban Planning

Because in most urban areas the trend of population growth has shown a continuing increase in the past decades, there is an implication that there will be a continuous increasing trend in the near future. The numbers of the urban population also will imperatively increase; this will definitely increase urban population size and enlarge the urban acreage. Without changing current urban growth process of low density and highly private auto-oriented urban form, the future trend of urban growth may intensify the problem of urban energy conservation regarding transportation.

There are some certain basic human needs, for example, that people prefer to have face-to-face activities, many prefer to travel to separate shopping areas (because, among other reasons, some items of daily needs are not electric-transportable). Human nature suggests that many like

to live or to act in groups, this emphasizes the clustering in a particular locality. In addition to human nature, economic consideration also emphasizes the need of clustering that also has stimulated settlements to become urbanized. Under these situations, the growth of urban population and urban size becomes inevitable, urban settlements will certainly increase and consume more energy, including energy for urban transportation, in order to acquire an increased sense of well-being for additional population.

However, due to various human values on urban life, judging urban well-being is extremely difficult. Urban growth is not only a phenomenon of human settlement, but also an effort to achieve a "better" lifestyle according to urban residents' values. Consequently, it is one of beliefs that urban planning is an efficient and effective tool for dealing with these urban settlements to meet the future situations and human values (which are changeable sometimes) by using all the planning methods, techniques, and guidelines.

The feasibility of rebuilding urban settlements into compact urban forms is not a question theoretically, but in practical terms, the settlement may end up with complicated social situations, priorities, and conflicting interests of various human values. Therefore, the further study of detailed planning process for rebuilding compact urban forms may be required. It is implied that a compact urban area is substantially one serving energy conservation, but many other urban non-transportation activities may become inefficient and may be forced to change human values to some extent. It needs an in-depth inspection of efficiencies of overall urban interrelated activities. The rationality of rebuilding a compact urban area is also a major consideration for dealing with the urban planning process because many efforts beyond urban planning may also provide some significant opportunities to maintain or to improve the urban settlement

to be more energy conserving regarding transportation without becoming a compact urban form. Also; the comprehensiveness of these planning processes and efforts relating to urban energy conservation should be examined because of the complications inherent in urban settlement patterns and urban planning elements with which the urban planning is dealing.

It should be understood that any approach to rebuilding compact urban areas under the existing urban conditions may belately affect and change the urban economic, or social, or physical, and even political structure and situations more or less.²⁸ Those approaches are providing a chance to predict and evaluate some possible changes in the future that could be a very significant reference for planning process to deal with energy conservation within urban transportation and urban growth.

By integrating approaches relating to rebuilding a compact urban form, the importance of the planning process in managing the trend of urban growth will be intensified. Since energy conservation regarding urban transportation can be effectively achieved by restructuring urban spatial distribution pattern and reforming urban transportation system, public planning agencies and planning institutions have to involve the development and stimulation of rebuilding compact urban area actively and comprehensively. They should particularly aim at urban spatial patterning (i.e., urban form growth planning, mixed land use planning, and open space planning), and at urban transportation system planning (i.e., urban mass transit planning). By developing appropriate and integrative these urban plannings, an energy-conserving urban area may be implemented along with human-scaled and landscaped amenities.

Because of lack of precise relationships between compact urban form and the efficiency of its energy conservation, the process of rebuilding to a compact urban form in order to meet energy conservation does not

work in a simple straight fashion. Moreover, failure to consider energy conservation with urban growth process has eliminated the attention and understanding of these approaches in the urban planning process. Basically, the three approaches studies mainly deal with certain long-term urban factors affecting urban growth. Thus, the process and objectives of urban planning and the specific urban situations and urban growth processes themselves should be carefully evaluated.

Currently, most public or private planning agencies managing urban land use planning process do not relate energy evaluation of urban transportation system to urban land use patterning and mass transit development. A long-term and integrative land use planning for any urban community development should include the evaluation process. A general criterion and a basic standard for the evaluation process should be systematically and considerably developed into a land use planning of overall urban growth process. The result of an evaluation of any land use development may become a reference for planning agencies to make a judge of efficient and appropriate land use development process.

Conclusion

Any urban growth process is a long-term affair with significant impact. Any attempt to reverse the growth trend of urban form from non-compact to compact pattern will inevitably change land use patterns and affect the human urban behaviors immensely. The further examinations of these changes of urban land use patterns and human urban behaviors and their impacts on urban living and lifestyle are desirable because these changes will certainly influence the growth process of urban settlement.

This study basically is to realize the past and possible urban form transition by overviewing urban density, the urban transportation system, and urban open space system, all of which affect the trips using private auto within various urban growth patterns. Thus, this study is characterized as more comprehensive and integrated discussion of urban growth and energy on urban transportation. Since in different urban situations and urban forms, the process to manage those approaches may be quite different, and the planning process to deal with those approaches may also vary. There is an implication that there are some particular topics that require further study following this report.

One of the important considerations has to be discussed when dealing with these approaches is the extent of compactness that an urban area has to be achieved in order to meet the objective of urban energy conservation on transportation. It seems that the compactness of urban area is not simply to be figured out unanimously and built at once. There are many other considerations and limitations impeding on the way toward becoming compact. Since many Utopian urban forms such as Le Corbusier's highly technological, compact, and populated urban structures are not possible to be built from many present viewpoints, some realistic approaches to rebuilding compact urban are more valuable as well advantageous to the perspective urban planning and urban settlement.

It has been understood that only a few natural resources in the world are renewable, such as food, water power, human labor, etc., and most of them, such as land, gas, coal, uranium, etc., are non-renewable. Most technical efforts are trying to reduce the growing consumption of non-renewable resources and to stabilize the consumption of renewable resources. Hence, the approaches to rebuilding a compact urban must also try in some way to

meet this effort. Although there are many problems blocking the way, such approaches have provided an opportunity to overview the problems. The approaches for reviewing problems or resolving problems should be studied continuously, integratively, and broadly, according to the variations within the entire human world.

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THE APPROACHES TO
URBAN ENERGY CONSERVATION ON TRANSPORTATION:
INTEGRATING URBAN DENSITY, TRANSPORTATION, AND OPEN SPACE
TO REBUILD A COMPACT URBAN AREA

by

HIA-SUE CHEN

B. Archi., Chung Yuan University
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AN ABSTRACT OF A MASTER'S REPORT

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ABSTRACT

This master's report reviews issues involved in relating urban density, urban transportation, and urban open space and then suggests guidelines for developing compact urban areas, which respond to the positive attributes of higher densities and public transportation with urban open space.

In the Introduction, problems of urban growth relating energy used for urban transportation are defined. The responses to the population growth within urban areas is as the major focus of this aspect of the urbanization process.

Chapter One reviews the processes of urban growth before and after suburbanization and identifies these influences on the changing of urban form. Two types of urban growth and two types of urban form are used to illustrate the energy component of urban transportation. The urban growth policies of selected countries are examined for their response to changing urban forms.

In Chapter Two, the urban density in an urban area is inspected in order to understand population distribution patterns within an urban form. Since population distribution pattern affects various trips within an urban area, density also is as an indicator of economic scale for mass transit operation.

Urban transportation system before and after suburbanization are reviewed in Chapter Three. The interrelations of urban geographical size and urban spatial distribution relating to transport modes is examined. It inspects the possibility of operating mass transit in urban areas in terms of population size, density, and nucleation. The policies regarding urban transportation for the selected countries is also reviewed.

In Chapter Four, urban open space patterns within an urban area are inspected. The functions of open spaces in a compact urban area need to be carefully considered. The relationship between urban open space and urban form is also as a key point to be analyzed. The policies for urban land-use of selected countries is presented.

Chapter Five proposes guideline for urban planning and for rebuilding a compact urban area. Preliminary estimates of energy to be conserved within a compact urban model are calculated. Some techniques for planning to achieve compact urban forms are discussed.

An evaluation of urban planning proposals that rebuilding compact urban areas are the subjects of Chapter Six. This chapter also reviews the planning process of rebuilding compact urban areas in terms of comprehensiveness, integration, appropriateness, and feasibility. A conclusion regarding planning efforts to meet an urban future is also drawn.