Considerations of Regional Characteristics for Delivering City Compactness:
Case of Studies of Cities in the Greater Tokyo Area and Tohoku Region, Japan

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Abstract
The concept of sustainability has become a new paradigm in worldwide urban planning and development. The compact city concept has recently been the most popular alternative among sustainable urban development strategies. Although it has become a global strategy, it should also consider the local characteristics of cities. This study, using attributes developed from the main aspects of sustainability, first of all aims at measuring city compactness and some of its tendencies in two different regions within Japan. These are the Greater Tokyo Area, comprised of 110 cities within 4 prefectures, and the Tohoku Region, with 63 cities in 6 prefectures. Secondly, the results of the measurements and appearance of the tendencies will be appropriately discussed to implement future compactness strategy. Of course, clear differences between both regions would carry different policy measures for compactness development in their respective regions. With the cities' data, which provide appropriate indicators, this study is able to present the conditions of cities based on attributes of city compactness and their tendencies in various types of cities within the two different regions. The results will be useful in preparing an appropriate strategy to deliver more compactness in these cities.

Keywords: sustainable development; city compactness; region characteristics; Greater Tokyo Area; Tohoku Region

1. Introduction
The need to develop sustainable communities in urban areas has brought about greater efforts in finding new approaches and new philosophies to attain the objective of sustainability. One popular strategy is the compact city concept. This concept has emerged primarily in response to the widely acknowledged need to find more sustainable models for the towns and cities in the world (see Jenks, et al., 1996).

Originating from a global discussion level, mainly in Europe, the US, and Australia, this strategy has inevitably begun to be adopted and implemented as a local strategy worldwide, including some cities in Japan (Koide, 2001). As a representation of the sustainable development concept, the compact city proposal must consider space, time, and the objectives of sustainable urban development itself. It encompasses all sustainability factors in urban living: environmental, social, and economic sustainability are based on the character as well as the context of the city.

Furthermore, for an appropriate and stronger implementation of the compact city concept, it needs some type of policy measures. This set of policy measures plan, assemble, monitor, and analyze how many and which policies to use, and how extensively to apply them. The type, location, population, and rate of city compactness can be adjusted in a set of policy measures to reach the objectives and goals of the compact city concept. From this point of view, characteristics, including the type and condition of a city, must be the main considerations.

Having addressed the importance of examining city characteristics, this study focuses on some roles of regional characteristics in relation to the region's compactness. Drawing on case studies of cities in the Greater Tokyo Area (110 cities) and cities in the Tohoku Region (63 cities), with related data from 1980 to 2000, this study questions whether the current conditions would be affected differently in their respective regions, if both implemented the compact city strategy. The study highlights in detail the characteristics and tendencies of each region. By showing clear differences between the two case study regions, the study analyzes particular aspects of the nature of cities for compactness through a proposed set of compactness attributes. Moreover, the analysis offers appropriate information to provide sufficient means to face the issues and implementation of compact city issues in the future. These results will be meaningful in preparing appropriate strategies and policies to develop more compactness in cities.

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(Received November 8, 2004 ; accepted July 11, 2005)
2. Framework and Method
2.1 Compactness Attribute and City Characteristics
Preceding studies (Roychansyah, et al., 2003, 2004) have already analyzed many fundamental studies related to compactness, and which are comprised of some major focuses of many issues through several systematic literature reviews. These studies propose a categorization of several attributes of compactness as shown in Table 1. Each attribute has similar roles to and interdependencies among the others in producing a degree of compactness. They are, respectively: population densification, activity concentration, public transport intensification, city size and accessibility, the social-economic welfare target, and a process to realize compactness as described through a diagram in Fig. 1. Since compactness needs time, space, and characteristics in its process, this study has indeed acknowledged the dynamic aspect of compactness in the wide range of characteristics of the cities, encompassing each aspect of sustainability. Understanding city characteristics by knowing the regional characteristics is one motivation behind this research.

2.2 Method
To achieve the research objectives, first, we present attributes of compactness from the previous studies, which strongly establish a certain level of city compactness and drive many related indicators towards implementing compact city development. This means that these attributes will be more effective for measuring the degree of compactness in the city. Furthermore, it assumes that all indicators are of equal importance. Thus, Table 2 represents the simplified version of the measurement, presenting the influential indicators (20 indicators) which can reflect any aspect of compactness of the city for study.

The analysis was carried out using data from the case studies, in which the research focuses on 110 cities in the Greater Tokyo Area and 63 cities in the Tohoku Region. The analysis uses the PCA (Principal Component Analysis) as a principle tool. To ease comparison analysis of the results, calculations of each region are separated, but carried out in the same manner. At the end of the study we discuss the results intensively and offer some concluding remarks.

Table 1. Attributes of Compactness and Their Descriptions
(Summarized from Some Fundamental Studies of the Compact City)

| Attributes                      | Summary from Representative Descriptions                                                                 |
|--------------------------------|----------------------------------------------------------------------------------------------------------|
| Population densification       | High density is a fundamental attribute of urban vitality and, according to many investigators, it is the way to achieve sustainability (see McLaren, 1992). Newman's idea started to be implemented, higher density is believed to be an essential component of the walkable city, where many activities can easily be carried out without depending on vehicles, especially on private car usage. In urban areas, higher density development usually implies a sufficient infrastructure. Other arguments specifically related to transport state that the development of higher density along transport nodes or corridors sufficiently encourages public transport provisions (Nikamp and Riera, 1996). Similarly, the arrangement of density levels throughout the city may be significant for energy consumption requirements. |
| Activity concentration         | It confirms the activities of living, working, and traveling to one area. It also encourages the direction of growth to appropriate local areas, and the setting of facilities and housing close to urban public transport nodes. It is argued that utility of activity in the same location by means of mixed-use development will lead to greater opportunities for successful sustainability in the area, balancing residential and non-residential uses. In this case, the central location of residential area becomes a key factor to make this concentration suitable living environment for many other activities. The other activities are semi-permanent and do not take as much time in the concentration areas. Burton (2000) has pointed out in his case that the mixing of different activities within an area should serve to strengthen social integration and civic life. |
| Public transport intensification| The issue of transportation in the compact city is arguably the single biggest environmental argument relating to urban form. Barrett (1996) has stated that public transport intensification may serve to strengthen urban activities. A competitive public transportation system may be a key initial action to overcome other crucial problems in transportation, although it may produce long commutes. Moreover, intensifying urban transportation may lead to a reduction in private car dependency, and may change the travel behavior of the residents. This effort, when comprehensively implemented, will also address the greater concerns of reducing emission and energy consumption in urban areas, as well as overcoming parking difficulties. In addition, urban transport intensification should be developed in those areas that have mixed-use areas with attractive housing and business facilities. One advantage is that it will open up new possibilities for developing urban nuclei in the nodes where the system connects to the existing lines. This means that the new public transport system may promote higher density activities and population. |
| City size and access consideration| Prud'homme and Lee (1999) have observed that the relative location of jobs and homes (compactness of jobs and homes) will influence the effective size of labor, the market, and the size of the city itself. From the viewpoint of localization economies, distance between jobs and homes should influence the degree of agglomeration economies. Explicitly, Cervero (2001) has also pointed out that employment densities and urban primacy size are positively associated with worker productivity, suggesting the presence of agglomeration economies. In a concept practice, Thomas and Constan (1996) have suggested some concepts to compromise with its certain scale, aimed at providing as many daily needs as possible within minutes of most habitation. Ultimately, it is necessary to consider certain city attributes in order to determine a more manageable city where a certain population, activities, and the physical pattern of the city work together in harmony. |
| Social economic welfare target | Our benefit that the compact city claims to have is to promote as increased quality of life for residents. Greater urban compactness is associated with benefits in living conditions for the disadvantaged, reducing the gap between the advantaged and disadvantaged (Crookston, et al., 1996). These are claimed as positive results of higher density, ease with which activities can be carried out, affordable city size, and higher availability of transportation, particularly public transportation. As an integral part of sustainable development strategy, city compactness should be closely connected to social equity, with a focus on quality of life, represented not only by equitable access to urban facilities, but also social and economic welfare, including space allocation. It is especially important to examine the feasibility of urban renewal in consideration of the limited available resources and population trends of the future. However, this attribute has received the least attention in the study of the compact city (Burton, 2000). |

Process to become compact
Another important understanding is the status of compactness. Compactness is dynamic and the measures advocated by many authors are static. This results in a gap over understanding in attempting to compact the city. In this case, a compactness model needs to be dynamic and interactive. It means that city compactness development needs a process, which can be transformed into certain efforts, namely, intensification, infill, consolidation, or whatever guiding development the city is employing toward the goals of higher density with mixed-use activities in the central area (Burton, 2000). Implementation of the process to fulfill compactness needs must not only be sensitive to the ecological imperative, but also to social and economic needs (Lenks, et al., 1996).
3. Case Study and Data

3.1 Japanese Urban Development

Since the end of World War II, Japan has become one of the most highly developed countries. At that time, a number of big cities began to emerge very quickly. Compared with other large cities in the developed world, Japan is leading in the total population, mainly through high level of density (Pacione, 2001).

There are both advantages and disadvantages which follow from Japan's rapid urban development (Alden, et al., 1994, Murayama, et al., 2000, and Sorensen, 1999). Disadvantages such as dispersion of regional structure and development of urban sprawl have grown due to the expansion of large cities into surrounding areas. Another recent problem is that most regions in Japan are facing a serious problem in decreasing population. But at the same time, the positive effects of "back to the center development" are becoming apparent recently. In the future, it will be increasingly important to direct development in the cities toward significantly more sustainable communities.

3.2 Case Study

The study focuses on the Greater Tokyo Area and Tohoku Region to examine the differences between these two types of region (see the map in Fig. 2). Although both are located on Honshu Island and connected by a good network between regions, the characteristics of the cities in each region have significant differences.

The Greater Tokyo Area consists of Tokyo, the capital of Japan, and the three neighboring prefectures of Saitama, Kanagawa and Chiba, and is located in the center of Honshu Island. This megapolitan area, home of about 30% of Japan's total population, is located in a basin with Tokyo bay at its center. This area, with the remaining parts of the Kanto Region (Gunma, Tochigi, Ibaraki and Yamanashi prefectures) is the economic heart of Japan, with many industries and services, and much commerce. In this study, 110 cities of this region are studied as a representation of the cities in this area.

The Tohoku Region, comprised of 6 prefectures (Aomori, Akita, Iwate, Fukushima, Miyagi, and Yamagata), consists of 63 cities and all are considered in this case study. This region is located in the northeast part of Honshu Island, Japan. Its development is dominated by agricultural works, where the differences among cities in this area are smooth. A largely mountainous region encompasses all of northeastern Japan. Centers of population are found along the coastlines of the Pacific Ocean and the Sea of Japan, and in several basins. The Tohoku Region takes up about 10% of the land mass of Japan, and about 18% of Japan's total population. The economic activity is primarily agriculture and agriculturally-based industries. Table 3. shows the main differences between the Greater Tokyo Area and Tohoku Region. The different characteristics of each region may have a great influence on the development of compact cities in their respective regions.
In Tables 4 and 5, we can compare the data of both regions. Indicators with a shaded background indicate that their score’s average is higher than the other region. From the average of 20 selected indicators, both regions perform the dominant results in balance. Almost all the higher indicators in the Tohoku Region (in 1990 and 2000) actually belong to workplace concentration, non-motorized trips, DID size, and daily activity performance related indicators. On the other hand, in population density, public transport performance, and welfare related indicators, the Tohoku Region has a lower score than the Greater Tokyo Area. All of these indicators observed during a period of 20 years tend to be higher in the earlier times and lower in more recent times (scores in 2000 are lower than scores in 1980). Indeed, the limited nature of the indicators cause some general problems in attempting to develop strategies related to the compact city. For example, decreasing density in DID areas may be a result of development spreading into suburban or new areas. Meanwhile, either a decrease of all scores in public transport use related indicators, or an increasing rate of persons per private car indicate greater car dependency in the study area. The PCA, or principal component analysis, is then used to analyze these data separately.

4.2 Results and Analysis

By using the PCA, the results as shown in Table 5 and Figs. 3 and 4, place each data-set of each region into three different categories: Population densification, Activity concentration, and Public transport intensification.
groups of compactness factors. In both regions, the first component is similar, named "transport efficiency" or TE. It is dominated by a higher eigen vector result of indicators related to the use of public transport. In the Greater Tokyo Area, the second factor is called "city densification" or CD, which covers some indicators related to densification, ratio or person per car, and the number of elderly people. In the Tohoku Region, the second factor is named "city concentration" or CC, and combines indicators related to activity concentration and better accessibility. This second factor of the Tohoku Region is the same as the third factor for the Greater Tokyo Area. The third factor in the Tohoku Region is "city independence", or CI. It combines indicators that suggest a self-reliant city, like working and living in the same city, and the ability to reach destinations in less than 30 minutes.

The compositions of each factor are obtained from the contribution ratio shown in Table 6. The Greater Tokyo Area has an eigen value combination 37% of TE, while CD and CC have 16% and 12% respectively. Cities in the Tohoku Region have composition in eigen value as 28% of TE, 26% of CC, and 15% for CI. This composition of eigen value is an important factor in calculating the degree of compactness. To be more understandable, the final figure of each factor is represented by 4 cities to depict each city rank condition (metropolitan, big, medium, and small).

The result reached by each city should be interpreted by its data position due to their principal factors, viewed from three different axes x, y, and z (3 dimensions). The compactness of a city would be principally higher if each axis yields the maximum score to simultaneously reach the
highest total value (shown by the direction of the arrow in the figures). In the cities of the Greater Tokyo Area, the transport efficiency factor shows a stable condition for nearly all 20 years of observation. This is in contrast with the condition of city densification, which shows a dramatic decrease. It may indicate that the sprawl development in the region has had a bad effect. Another fact that supports this negative conclusion is that the city concentration is less than before. The results of the factors in the cities of the Tohoku Region are rather different. Here, transport efficiency shows bad performance throughout years of observation. With regard to the other factors, city concentration performs a little better in recent years, while city independence has a stable condition.

Moreover, based on the analysis results, it is clear that the compactness condition would really worsen in the future, although there has only been a visible movement in an unbeneﬁcial direction during the time the compactness condition was measured (in this case, from 1980 to 2000). During this time, the movement of the cities in the Greater Tokyo Area to reach a compactness condition is different compared to the cities in the Tohoku Region. In recent times, both regions have decreased in the development of city compactness compared to previous times, because the movement of all cities in both regions stays away from a high compactness pole. If the analysis turns to the city size classiﬁcation, as shown in Figs. 3 and 4, bigger cities in both regions also show higher results in considering the inﬂuential factors. It can comprehensively be understood that the compactness tendencies in the study area provide unsatisfactory results. Nevertheless, as stated by Koide (2001), in Japan, compact development strategy transformed into policy has only just begun, and it is still too early to reach an ideal one. However, the results may provoke a positive analysis to ﬁnd the causes and guide future development.

Furthermore, the degree of compactness (DC) is reached by a balanced score condition from related inﬂuential factors. As described before, these factors are provided by an accumulation ratio as shown in Table 6, and can be taken into account to produce a degree of compactness. The total degree of compactness can be reached by the total of multiple numbers between the score index of each factor and its eigen value index. In both cases, DC = 0.37 TE + 0.16 CD + 0.12 CC is the degree of compactness in the cities of the Greater Tokyo Area, while DC = 0.28 TE + 0.26 CC +0.15 CI is the degree of compactness in the cities of the Tohoku Region, as completely represented in Figs 5 and 6, ordered by city rank. Using these ﬁgures, the different results of each city in both regions can be fully understood.

5. Discussion

According to the results based on city rank, as shown in Tables 7 and 8, the tendencies of compactness degree in both regions are conﬁrmed once again to have decreased signiﬁcantly. For detailed observation of each region as illustrated in Table 7., in the cities within the Greater Tokyo Area, the highest degree of compactness (DC) during 20 years of observation is reached ﬁrst by metropolitan cities (6), followed by big cities (60), medium cities (36), and ﬁnally, small cities (8). These conditions are supported by high score results from city
transport efficiency (TE) and city concentration (CC), which have shown tendencies to improve in recent years, while the higher city densification (CD) score is reached by smaller cities. This might prove that bigger cities, with their economic potential related indicators, show an ability to reach compactness more easily than smaller cities, which have some limitations.

Cities from the Tohoku Region, as shown in Table 8, metropolitan cities (1) and big cities (13) between 1980-2000 still have a higher degree of compactness (DC), which results from the domination of TE, CC, and CI, compared with medium size cities (20) and small size cities (29) classification. The background of the tendencies might be the same as cities in the Greater Tokyo Area, in which bigger cities may have enough economic potential to reach a better condition. In the case of city concentration (CC) and city independence (CI) of cities in the Tohoku Region, in recent years both factors show better performance than previously. The big cities especially perform better in terms of city independence than the other ranks of city. Self-reliance is related to the capacity and size of a city, by reducing their interdependence factors from other cities. To show the proportion and development of each factor in each time observation, Figs. 7 and 8 are depicted based on the classification of prefecture condition. For example, better performance of transport efficiency may be reached more easily by cities closer to the center of the region (Tokyo area cities) than cities which are farther away from the center (Chiba Prefecture).

In addition, to give a description of the comprehensive condition in Japanese cities, using the cities of the Greater Tokyo Area and Tohoku Region, the study finally produced tendencies of these 173 cities in the same city rank categorization, as represented in Table 9. The most influential factors for a degree of compactness in Japanese cities are represented by factors named "containment densification" (CD), "public transport intensification" (PTI), and "optimal city size" (OCS). The total degree of compactness (DC), CD, and PTI are reached better by bigger cities, while OCS is performed better by smaller cities. In this case, despite the fact that better compactness is usually reached by bigger cities, the limitation is that optimal size capability in the city should be importantly considered. Besides this, from the viewpoint of time change, there is a consideration of time in the compactness process, and this should be considered as an integral part of the analysis.

![Fig.7. Aggregate Factors of Compactness Degree for the Greater Tokyo Area Based on City Average in Each Prefecture](image1)

![Fig.8. Aggregate Factors of Compactness Degree for the Tohoku Region Based on City Average in Each Prefecture](image2)

### Table 7. Condition of Each Factor and the Degree of Compactness Based on Population Rank of the City in Tokyo Greater Area

| City Type               | Transport Efficiency | City Densification | City Concentration | Degree of Compactness |
|-------------------------|----------------------|--------------------|--------------------|-----------------------|
|                         | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  |
| Metropolitan Cities (>500,000 pop., 6) | 0.71  | 0.58  | 1.00  | 0.21  | -0.02 | -0.46 | 0.23  | 0.34  | 0.30  | 0.32  | 1.29  | 1.12  | 0.83  |
| Big Cities (>100,000 pop., 20)        | 0.52  | 0.36  | 0.48  | 0.37  | -0.32 | -0.02 | -0.02 | -0.03 | 0.11  | 0.11  | 0.17  | 0.16  | 0.09  |
| Medium Cities (5,000-100,000 pop., 30) | -0.30 | -0.35 | -0.21 | 0.34  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |
| Small Cities (<5,000 pop., 8)          | -1.50 | -1.70 | -1.90 | 0.29  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |

### Table 8. Condition of Each Factor and the Degree of Compactness Based on Population Rank of the City in Tohoku Region

| City Type               | Transport Efficiency | City Densification | City Concentration | Degree of Compactness |
|-------------------------|----------------------|--------------------|--------------------|-----------------------|
|                         | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  |
| Metropolitan Cities (>500,000 pop., 1) | 1.57  | 0.72  | 0.28  | 1.91  | 1.57  | 2.06  | 0.10  | 0.10  | 0.17  | 3.64  | 2.38  | 2.52  |
| Big Cities (>100,000 pop., 13)        | 0.91  | 0.22  | -0.39 | 0.22  | 0.49  | 0.65  | 0.21  | 0.21  | 0.28  | 1.33  | 0.81  | 0.62  |
| Medium Cities (5,000-100,000 pop., 20) | 0.31  | 0.38  | -0.66 | -0.19 | 0.08  | 0.51  | -0.04 | -0.04 | 0.04  | 0.62  | 0.38  | 0.27  |
| Small Cities (<5,000 pop., 29)          | 0.62  | 0.22  | -0.92 | -0.58 | -0.38 | -0.05 | -0.17 | -0.10 | -0.05 | -0.69 | -1.09 | 0.27  |

### Table 9. Total Condition the Degree of Compactness in Japan

| City Type               | Containment-Densification | Public Transport Intensification | Optimal City Size | Degree of Compactness |
|-------------------------|---------------------------|---------------------------------|-------------------|-----------------------|
|                         | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  | 1980  | 1990  | 2000  |
| Metropolitan Cities (>500,000 pop., 7) | 0.94  | 0.74  | 0.84  | 0.17  | -0.13 | -0.28 | -0.38 | -0.35 | 0.83  | 0.38  | 0.17  |
| Big Cities (>100,000 pop., 13)        | 0.84  | 0.87  | -0.14 | 0.24  | -0.09 | -0.22 | -0.06 | -0.11 | 0.24  | -0.16 | -0.47  |
| Medium Cities (5,000-100,000 pop., 56) | -0.75 | -0.39 | -0.46 | 0.29  | -0.02 | -0.35 | 0.00  | 0.03  | 0.01  | -0.10 | -0.72  |
| Small Cities (<5,000 pop., 33)          | -0.56 | -1.27 | -1.45 | 0.34  | -0.01 | -0.34 | 0.06  | 0.00  | 0.00  | -0.64 | -1.73  |
6. Concluding Remarks

This study has worked to measure city compactness based on a set of compactness attributes. These are population densification, activity concentration, urban transport intensification, certain city size consideration, social economic welfare target in the city areas, and finally, a development process to deliver compactness condition. All of these attributes comprehensively represent the sustainability objective for the compact city strategy.

By the influential indicators, the study has verified the existence of compactness attributes and its tendencies in a Japanese city context by a case study of 110 cities in the Greater Tokyo Area and 6 cities in the Tohoku Region. With the same work, these two regions with different characteristics resulted in two different tendencies of compactness. Each region has also presented a different composition of influential factors. In the Greater Tokyo Area, transport efficiency (TE) performance dominates the composition, more than the other two factors, city densification (CD) and city concentration (CC). Meanwhile, the degree of compactness in the Tohoku Region is also dominated by the factor of transport efficiency (TE), though the other factors (city concentration (CC) and city independence (CI)) also play a significant role. In addition, the general findings showed a significant decrease in almost all factors, but there are tendencies to be higher in more recent years (2000), especially in the cities of the Greater Tokyo Area, for transport efficiency, and in cities in the Tohoku Region for city concentration and city independence.

Finally, all of these findings rely very much on information concerning the existence of compactness attributes and their relationship with city characteristics. A careful consideration, or anticipation, of future conditions and characteristics will enhance the development of appropriate policies, and understanding the importance of attributes will generate more meaningful attempts toward a compactness condition in urban developments.

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