ESTIMATION OF URBAN COMPACT INDEXES IN THE THREE CITIES OF SOUTHEAST ASIA -CASE STUDY OF KHON KAEN, VIENTIANE AND DA NANG-

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1. INTRODUCTION

Compact city might be one of the solution to realize low-carbon society in developing cities in Southeast Asia region. However, each city is in the difference stage of development so that it is very hard to evaluate the compactness of a city.

Therefore, in this study, the urban compact indexes to represent the compactness of a city were nominated, and these indexes were calculated in Khon Kaen, Vientiane and Da Nang to grasp the situation of compactness of the three cities. Also, this study was analyzed relationship of compact city indexes and CO_2 emissions of three cities.

2. LITERATURE REVIEWS

Watanabe et al. statistically organized the definition of compact city from existing study and analyzed the compactness of small and medium cities in Japan. In addition, Takeda et al. proposed ten types urban compact indexes using obtainable data and analyzed the characteristics of each urban compact indexes based on the results in cities in Japan. However, these studies are evaluated the degree of compact city of regional cities in Japan by using the urban compact indexes.

This study estimated by using obtainable data. In Khon Kaen, Vientiane, and Da Nang, BRT is under planning. Accordingly, urban compact indexes which is considered for BRT plan was selected. Therefore, in this study, the three types of compact indexes proposed by Takeda et al. are taken up. Also, this study selected three cities in developing countries such as Khon Kaen, Vientiane, and Da Nang as a case study and estimated summarizing degree of configuration, population density of DID, coverage rate of BRT station sphere by using urban compact indexes.

3. METHODOLOGY

3.1 Estimation of urban compact index

This study selected three types of urban compact indexes by using GIS software. Densely Inhabited District (DID) is defined 4,000 people / km^2 or more in this study. The area is considered as DID. Fig. 1 shows the study area and DID of 3 cities. Also,Table 1 shows equations for estimating urban compact indexes.

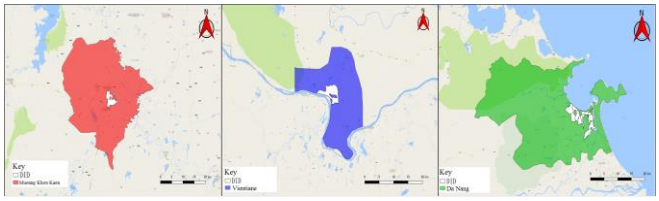

Fig. 1 Areas and DID of 3 Cities

Table 1 Index equation of compact city

Indexes	Equations	
Summarizing degree of configuration	$s = \frac{2\sqrt{\pi AD}}{L}$ (1)	S: Summarizing degree of configuration AD: DID area (km^2) L: DID perimeter (km)
Population density of DID	$DP = \frac{PD}{AD}$ (2)	DP: Population density of DID (population/ km^2) AD: DID area(km^2) PD: DID population
Coverage rate of BRT station sphere	$CS = \frac{AS}{AD}$ (3)	CS: Coverage rate of BRT station sphere AD: DID area(km^2) AS: Station's territorie (km^2)

(1) Summarizing degree of configuration

This index shows the complexly of configuration and which it is calculated by Eq. (1). The more summarizing degree of configuration is higher, the more fringe is simple.

(2) Population density of DID

This index shows the population of DID and which it is calculated by Eq. (2). In this index, the more population density of DID is higher, the more density of dwelling is higher.

(3) Coverage rate of BRT station sphere

This index shows percentage of available areas around the BRT stations and which it is calculated by Eq. (3). The more coverage rate of BRT station sphere is higher, the more the available area of public transportation is wider. The more target of station is many, the more coverage rate of BRT station sphere is higher. In this study, radius of the BRT station sphere was defined 600 m. In three cities, BRT is under planning and estimates are based on the planned route after completion.

4. RESULTS

4. 1 The estimated Value of urban compact indexes

The estimated value of urban compact indexes are shown in Table 2.

Keywords: Urban compact index, Summarizing degree of configuration, Population density of DID, Coverage rate of BRT station sphere, CO_2 emissions
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The estimated values of Japan urban compact indexes are shown in Table 3.

Table 2 Estimated value of urban compact indexes

Indexes	Cities		
	Khon Kaen	Vientiane	Da Nang
DID area (km^2)	16.22	19.50	36.44
DID population	92,996	109,472	638,175
DID perimeter (km)	28.74	33.34	47.50
Summarizing degree of configuration	0.48	0.47	0.45
Population density of DID (population/km^2)	5,733	5,613	17,511
Coverage rate of BRT station sphere (%)	0.22	0.18	0.30

Table 3 Average values of urban compact indexes of Japan

Indexes	Average Values of Japan
Summarizing degree of configuration	0.26
Population density of DID (population/km^2)	4,653
Coverage rate of BRT station sphere (%)	0.30

(1) Khon Kaen

The summarizing degree of configuration was the highest. Therefore, the configuration of the city is resemble circle. Each indexes of Khon Kaen relatively average among three cities. In this study, one BRT route in each cities were focused.

(2) Vientiane

The summarizing degree of configuration of Vientiane is lower than its of Khon Kaen. The summarizing degree of configuration of this city is higher because of the average of summarizing degree of configuration of Japan is 0.26. On the other hand, the coverage rate of BRT station sphere of this city is lower because the average of coverage rate of BRT station sphere of Japan is 0.30.

(3) Da Nang

Compared to the other two cities, population density of DID and coverage rate of BRT station sphere in this city were the highest. Therefore, Da Nang has many target of stations. By comparing with other cities, population is concentrated. Furthermore, BRT goes through the center of the city, it is thought possible for this city to move without depending on a car. Therefore, Da Nang proved to be the most compactness.

4. 2 Relationship between urban compact indexes and CO_2 emissions

This study was analyzed the relationship between urban compact indexes and CO_2 emissions. The values of CO_2 emissions which estimated by Fukuda et al were used in this study.

Fig. 2 and Fig. 3 shows the relationship between summarizing degree of configuration and CO_2 emissions and the relationship between coverage rate of BRT station sphere and CO_2 emissions. In relationship of summarizing degree of configuration and CO_2 emissions, the more summarizing degree of configuration is higher, the more CO_2 emission is reduction. On the other hand, in relationship between the coverage rate of BRT station sphere and the CO_2 emissions, the more coverage rate of BRT station sphere is higher, the more CO_2 emissions reduction. Therefore, the more city is compactness, the more CO_2 emissions is reduction.

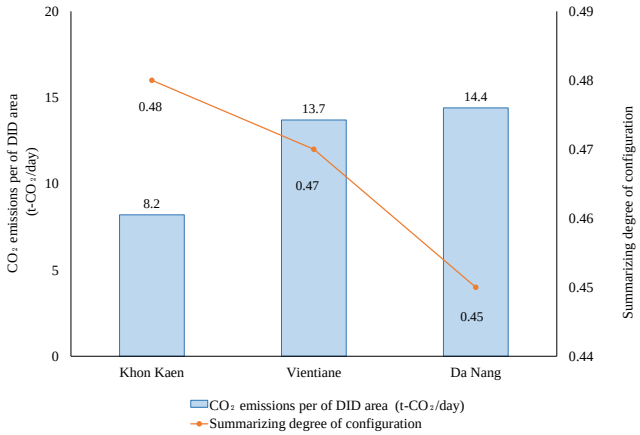

Fig 2 Relationship between summarizing degree of configuration and CO_2 emissions

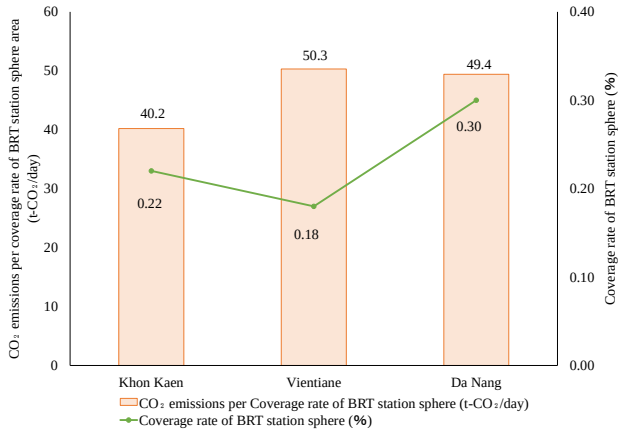

Fig 3 Relationship between coverage rate of BRT station sphere and CO_2 emissions

5. CONCLUSION

This study were estimated the urban compact indexes of three cities, analyzed the relationship between these indexes and CO_2 emissions. The results were concluded that Da Nang has the most compactness, and obvious that increasing the area of the station's territories, public transportation will increase the compactness of the city and lead to a reduction in CO_2 emissions.

In further study, In this study, only one route is estimated, but considering the other routes in Khon Kaen and Vientiane, BRT station's territories coverage rate is also likely to be higher.

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