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AN ANALYSIS OF REGIONAL DIFFERENCE IN INHABITANTS' CONSCIOUSNESS TO THE ROAD CONSTRUCTION BY FUZZY CLUSTERING

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Road construction have been made without adequate consideration of inhabitants' consciousness. The objective of the study is to investigate the inhabitants' consciousness of the road construction and to explore their application in the planning. The data were gathered from the questionnaire survey from 27 areas of Kinki district. They were analyzed by Fuzzy Clustering. As a result of the analysis, the sample areas were clearly classified into three clusters. In addition, it became clear that the scale of city and inhabitants' consciousness of the road building are correlated strongly. Finally, it was also concluded that information about inhabitants' consciousness according to the scale of city should be incorporated in the planning.

Keywords : inhabitants' conciousness, fuzzy clustering, road construction

1. INTRODUCTION

The demand for the road usage has been drastically increased in Japan as the number of vehicles increases. Though the large-scale road construction has been continued for 30 years after the the war, the level of the road construction is lower than the level in Europe and United States in quantitatively and qualitatively. For example, the total length of expressway in Japan became only 3 555 km in 1984 that is very short itself compared to 8 100 km in West Germany or 5 900 km in Italy[1]. As a consequences, the construction and development of new road is still due to the prime objectives of public section. In addition, the road is the most important traffic facility that supports our daily lives and industrial production. The people in the rural area want the trunk road to be made for their comfortable and convenient life.

On the contrary, in urban areas, people are reluctant to road building due to its adverse effects such as traffic accidents, traffic congestion and air pollution on the roads near their residences. If roads are constructed more than now, the environmental influence gives worse state of traffic in urban area. The additional road construction, therefore, is considered to be unnecessary in these area in recent years. These facts show there are many difficulties in making the plan of new road construction.

In spite of these multi-dimensional and complex situations, only physical indices have been used in the previous survey of the road construction projects. The pavement ratio and improvement ratio are the oldest standards. The former is defined that the length of paved sections of the road is divided by the total length of the road. The latter is also defined that the length of improvement sections of the road is divided by the total length of the road (Improvement sections are the sections which meet the standard by act of road structure in Japan).

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These two indices were enough to know the state of the road construction in 1960's, because the roads were constructed to the simple purposes in those days such that two cars could pass each other on the road or that no car made a cloud of dust.

They have become inadequate because they could not evaluate the relation between the capacities of the roads and traffic demand. The new index, the construction ratio has been added to two previous indices : The index is defined that the length of improvement and no-congested sections of the road is divided by the total length of sections on the road (No-congested road means the sections that degree of congestion is less than 1.0).

It can evaluate the state of traffic congestion additionally to some extent. Though these three indices are mainly used to the present state of road construction, they are still imperfect for describing the important factors of the road construction planning. The plan which was made neglecting of inhabitants' consciousness about the road construction will probably come out to be failure, because such a plan is difficult to be accepted by inhabitants of the concerned area.

The indices, therefore, which show the inhabitants' consciousness of the road construction should be used and it becomes very important that inhabitants' consciousness is analyzed and incorporated in the planning of road construction and development.

In the analysis of this study, it must be recognized that humans' consciousness is very complicated and it is very difficult to be expressed with its uncertainly aspects. Fuzzy set theory is utilized for describing the fuzziness in human perception. Some fundamental analyses of the study are already presented[2].

In order to analyze inhabitants' consciousness, the data were gathered from the questionnaire survey to the inhabitants in the 27 areas in Kinki district of Japan. The method of fuzzy clustering, an application of fuzzy set theory, is adopted to investigate the results of the questionnaire. Finally, the application method of the results of fundamental analysis of the questionnaire is also reported.

2. THE METHOD OF FUZZY CLUSTERING

Fuzzy set theory was proposed at 1965 by L. A. Zadeh[3]. The theory can be recognized an extension of ordinary set-theory. Fuzzy set on universe $X=\{x\}$ is defined by membership function as follows :

$$\mu_A(x) : X \rightarrow [0, 1] \quad \cdots (1)$$

If the value of $\mu_A(x)$ is close to 1, the x almost belongs to the fuzzy set A. On the contrary, the x does not belong the subset A at all when the value of the membership function is 0. The fuzzy set theory is applied in many fields such as operations research, approximate reasoning, control theory[4] and so on. The other new methods are also developing in the field of fuzzy set theory.

The cluster analysis is one of the methods in multivariate analyses. The main purpose of cluster analysis is to classify the data according to some basic standards. The analysis is very useful to know the structure of the data and is applied to the problems in many fields. Cluster analysis has been developed rapidly since 1960's and many new algorithms of clustering have been introduced in the literature. It becomes conceived to be the method of pattern recognition. The fuzzy set theory also could be used as a base for clustering. In classical clustering algorithm, every sample point is always determined to be in one specific cluster or not. Therefore, it is difficult to express fuzziness in classification such that the data include the points whose cluster could not be determined.

The integration of fuzzy set theory and cluster analysis has given birth to several new interesting methods[5)~9)].

A good example is the Ruspini's approach [1969~1973, 5)~7)], which adopts the concept of fuzzy partition to represent the cluster in the data set. The abstract of the method is described as follows : (The formulations are shown in Table 1.)

There are m objectives to be classified, that is

$$\boldsymbol{E}=\{E_1, E_2, \cdots, E_m\} \quad \cdots (2)$$

The i-th objective E_i is expressed vector x_i with p-variables.

Then the total data set is displayed as the matrix,

$X=(x_1, x_2, \cdots, x_m)$ ··· (3)

When the number of clusters used in classification is N, the clusters are described as vector S:

$S=(S_1, S_2, \cdots, S_N)$ ··· (4)

Some types of standard are considered as measures to know the structure of the data.

The most popular standard is the distance between data which is defined as δ. The definition is shown in Table 1-c).

On the contrary, the relation among the data obtained by fuzzy clustering mathematically can be expressed by:

$P(S_j/x) \geqq 0$ (Table 1-d)) ··· (5)

$P(S_j/x)$ is so-called "the degree of belongingness", i.e. each point x is assigned $P(S_j/x)$ of belongingness to the jth cluster. It is recognized that $P(S_j/x)$ is a kind of membership function of S_j.

Considering the features of fuzzy clustering methods, Ruspini mentioned in his paper (1970), "Assigning each point a degree of each cluster provides a way of characterizing bridges strays, and undetermined point. This is especially useful when considering scattered data".

The outline of the method to find the best combination of $P(S_j/x)$ is also shown in the Table 1. $P(S_j/x)$ are obtained by minimizing the objective function I. Three types of clustering algorithms to calculate $P(S_j/x)$ were introduced in the same paper. The difference of each methods is depend on the difference of the objective functions that are shown in the Table 1 respectively.

It was also reported in his paper that clustering I and II failed to realize the expected fuzzi-ness of classification, but they are useful because they provide good starting points for the third method, Clustering III. The fact suggests the mixed model between Clustering I and III.

Ruspini's formula of Clustering III, which gives good result of classification is also shown in Table 1-g). In this method, $V(x, y)$ is the measure of distance of x and y by using $P(S_j/x)$ and $P(S_j/y)$. The requirement $V(g(x),$

Table 1 Fuzzy clustering (Ruspini's approach).

a) Obserbed vector(p-variables) : $x_i = (x_{i1}, x_{i2}, ---, x_{ip})$

b) Data set(m-points) : $X = (x_1, x_2, ---, x_m)$

c) Distance function $\delta : X \times X \to R^+$

1) $\delta(x, x) = 0$ for all $x \in X$
2) $\delta(x, y) = \delta(y, x)$ for all $x, y \in X$

d) Degree of belongingness : $P(S_j/x_i)$

$\Sigma_{j=1}^N P(S_j/x) = 1, \quad P(S_j/x) \geq 0$

e) Objective function I (Clustering I)

$I_1 = \Sigma_{i=1}^m [P(x_i)P(S_{(i)})M_{(i)}(x_i)/M(x_i)]^2 \to \min$

$P(S_{(j)}/x_i) = \max P(S_j/x_i), \ 1 \leq i \leq m$

$M(x_i) = \Sigma_{k=1}^m P(x_k)\delta(x_i, x_k)$

f) Objective function II (Clustering II)

$I_2 = \Sigma_{i=1}^m P(x_i)\Sigma_{j=1}^N P(S_j)[P(S_j)M_j(x_i)/M(x_i)]P(S_j/x_i) \to \min$

g) Objective function III (Clustering III)

$I_3 = \Sigma_{x \in X} \Sigma_{y \in X} (\sigma V(g(x), g(y)) - \delta^2(x, y))^2 \to \min$

σ : constant

$V(g(x), g(y)) = \Sigma_{j=1}^N (P(S_j/x) - P(S_j/y))^2$

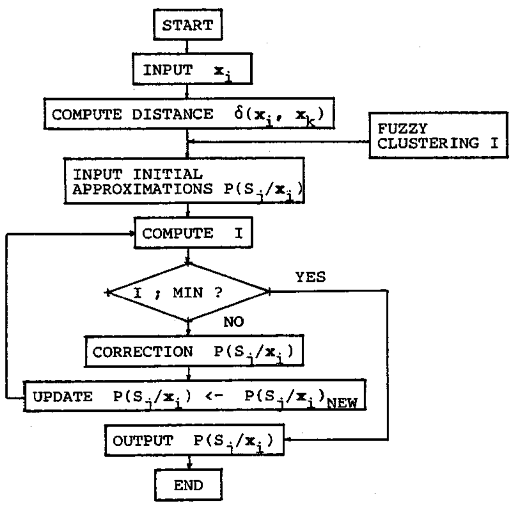

Fig. 1 The flow diagram.

$g(y))=F(\delta(x, y))$ means distance preservation between $P(S_j/x)$ and $P(S_j/y)$. When this requirement cannot be satisfied, it would be replaced by objective function I_3.

In this study, referring to Ruspini's result, the method of Clustering III with result of Clustering I as initial approximations is used to analyze the inhabitants' consciousness.

The actual outline of algorithm is shown in Fig. 1. The correction of $P(S_j/x)$ is repeated until the values of function I_3 becomes smallest. Updating process is formulated by quadratic programming. The detail of the methods could be known in reference 6). The computing program was written in FORTRAN 77 according to Ruspini's paper [6) & 7)], and FACOM M 382 computer in Data Processing Center of Kyoto University was utilized in its computations.

3. APPLICATION OF FUZZY CLUSTERING TO INHABITANTS' CONSCIOUSNESS ANALYSIS

(1) Database

At the beginning of fundamental analysis of the inhabitants' consciousness, the roles of the trunk road are considered.

The roads play many roles such as supporting social and economic activity, making good environment for dwelling, becoming the place for emergent disaster and so on[10]. After considering these roles of the road, the road construction should be conceived to give many influences to the inhabitants' lives. Thus, the inhabitants consciousness should become an important factor for road construction planning.

In this study, it is concluded that the inhabitants' consciousness about road construction should be classified to some factors. Before the analysis of fuzzy clustering, it was determined that inhabitants' consciousness about road construction consists of three factors after due considerations. Identification of these major factors was discussed in the research group under Kinki Bureau of the Ministry of Construction. These are :

(a) the needs of the road construction on account of low standard of living (inconvenience in performing life activities).

(b) the needs of road building on account of lack of balance between traffic demand and supply.

(c) no needs of the road building because of traffic flows which are creating noise or air pollution.

This means that in reality, there are positive and negative consciousness about the road construction.

The questionnaire survey of the road building which is used in the study was sent out to 27 cities, towns, and villages of Kinki district in Japan. (Fig. 2). These locations were selected in such a way that different city size is adequately represented in the data base. The first nine locations are relatively small towns and villages, the next nine locations are middle size cities, and the last nine locations are big cities.

The questionnaire consists of 13 questions about the road construction. It is designed for exploring and investigating the inhabitants' reactions about the road building planning. This survey was conducted in 1980 by Kinki Bureau of the Ministry of Construction. The total number of responses from this questionnaire survey was 3 027.

The eighth questionnaire (Q-8) whose results is used for the analysis in the study is presented in the Table 2. It was recognized that the responses to questions are reflecting the three factors of inhabitants' consciousness of the road construction. The answer No. 1 to 3, 4 to 6, and 7 to 9 denote the needs (a), (b), (c) respectively. Each response, therefore, is classified by combination and order of three factors. For example, answer No. 1, No. 7, and No. 9 reflects [(a) (c) (c)] pattern. For all responses, the number of combination is as follows.

$$[(a)\ (a)\ (a)],\ [(a)\ (a)\ (b)],\ \cdots,\ [(c)\ (c)\ (c)]\ :\ {}_3H_3=10 \qquad (6)$$

[(a) (a) (c)] to [(c) (c) (c)] represent patterns of needs of samples. Thus, the inhabitants' consciousness of each cities and towns is expressed by the observed vectors with ten variables. That is,

$$x_i=(x_{i1}, x_{i2}, \cdots, x_{ik}, \cdots, x_{ip}) \qquad i=1, \cdots, 27 \qquad (7)$$

1 Sasayama cho (Hyogo)	10 Wakayama si (Wakayama)	19 Kita ku (Osaka)
2 Mineyama cho (Kyoto)	11 Himeji si (Hyogo)	20 Nakagyo ku (Kyoto)
3 Sannan cho (Hyogo)	12 Fukui si (Fukui)	21 Ikuta ku (Kobe)
4 Asago cho (Hyogo)	13 Omihachiman si (Siga)	22 Neyagawa si (Osaka)
5 Minabegawa mura (Wakayama)	14 Sakurai si (Nara)	23 Nisinomiya si (Hyogo)
6 Tsuchiyama cho (Siga)	15 Sabae si (Fukui)	24 Toyonaka si (Osaka)
7 Izumi mura (Fukui)	16 Singu cho (Hyogo)	25 Nagaokakyo si (Kyoto)
8 Nosegawa mura (Nara)	17 Siga cho (Siga)	26 Minoo si (Osaka)
9 Kamikitayama mura (Nara)	18 Kanazu cho (Fukui)	27 Uji si (Kyoto)

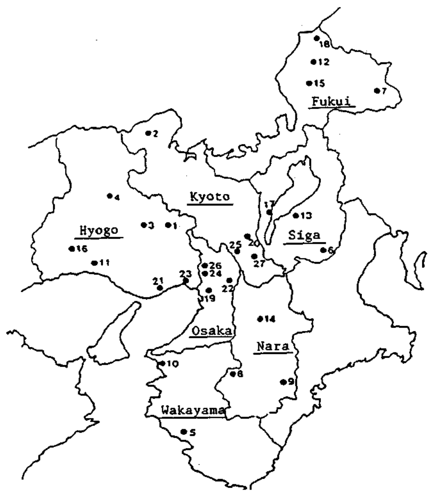

Fig. 2 Object area of questionnaire.

Table 2 The questionnaire.

Q: It is known that construction of the trunk road create positive and adverse effects and influences.
Please choose three points orderly that you think are most important if the trunk road is constructed in your city, ward, town and village.

1st. 2nd. 3rd.

1. It makes easier to carry perishable foodstuffs to consumption area and convenient to transport industrial productions and goods.
2. Factory, retail, and employment activities increase.
3. Agriculture, Forestry, Marine, and local industry activities increase.
4. Traffic congestion disappears and traffic accidents decrease.
5. It becomes convenient in daily life such as commuting to school and office.
6. It becomes easy to go shopping in urban area and large hospital, etc.
7. Automobile pollution such as noise, vibration, and exhaust occurs.
8. Environment and cultural assert is destroyed.
9. The danger of traffic accident increases due to arise of large vehicles' traffic demand.

$$C_i=\sum_{k=1}^{p} x_{ik}$$

x_{ik} : total number of sample persons whose reaction are pattern k

C_i : total number of sample persons of area i

According to the formulation in fuzzy clustering of this study, the problem was formulated with the number of objectives to be twenty seven ($m=27$), the number of cluster to be three ($n=3$), and the number of observed values to be ten ($p=10$).

(2) The results of fuzzy classification

Ruspini's method Ⅰ (Fuzzy Clustering Ⅰ) was used as the starting measure for each point's degree of belongingness to each cluster. The result of calculation is shown in Table 3.

As Ruspini mentioned in his paper, most points were absolutely classified in one set, that is,

$$P(S_j/x_i)=1 \quad \text{for most value of } i \quad 1\leqq i\leqq 27 \qquad (8)$$

Only one point No. 20 (Nakagyo-ku, Kyoto), has the value of (0, 0.4304, 0.5696), showing fuzziness.

The value of membership function usually should be the value between 0 to 1. This analysis does not always succeed to express the fuzziness of consciousness, but it obviously shows that the three clusters exist. It was found that almost the same number of points belongs to each set according to initial three types of 27 cities and towns of Fig. 2. This result is expected to be the same result that ordinary cluster analysis gives three sharpened clusters from the same type of data.

The next conducted analysis was detailed classification by Fuzzy Clustering Ⅲ. Clustering Ⅰ is a convenient procedure to find approximations of clustering and provides a good starting point for Clustering Ⅲ as this approach has been recommended by Ruspini. The results shown in Table 3, was adopted as the initial approximations of Clustering Ⅲ.

Clustering Ⅲ resulted in a better classification as it is presented in Table 4. In this case, the degrees of belongingness have many kinds of values. For further classification, three degrees of belongingness of each point are shown in Triangram of Fig. 3. The values of $P(S_j/x)$ for each cluster could be presented in

Table 3 The degrees of belongingness by fuzzy clustering Ⅰ.

No.	$P(S_1/x)$	$P(S_2/x)$	$P(S_3/x)$
1	1.0000	0.0000	0.0000
2	1.0000	0.0000	0.0000
3	1.0000	0.0000	0.0000
4	1.0000	0.0000	0.0000
5	1.0000	0.0000	0.0000
6	1.0000	0.0000	0.0000
7	1.0000	0.0000	0.0000
8	1.0000	0.0000	0.0000
9	1.0000	0.0000	0.0000
10	0.0000	1.0000	0.0000
11	0.0000	0.0000	1.0000
12	0.0000	1.0000	0.0000
13	0.0000	1.0000	0.0000
14	0.0000	1.0000	0.0000
15	0.0000	1.0000	0.0000
16	0.0000	1.0000	0.0000
17	0.0000	1.0000	0.0000
18	0.0000	1.0000	0.0000
19	0.0000	0.0000	1.0000
20	0.0000	0.4304	0.5696
21	0.0000	0.0000	1.0000
22	0.0000	0.0000	1.0000
23	0.0000	0.0000	1.0000
24	0.0000	0.0000	1.0000
25	0.0000	0.0000	1.0000
26	0.0000	0.0000	1.0000
27	0.0000	0.0000	1.0000

Table 4 The degrees of belongingness by fuzzy clustering Ⅲ.

No.	$P(S_1/x)$	$P(S_2/x)$	$P(S_3/x)$
1	0.6968	0.0000	0.3032
2	0.7661	0.0379	0.1961
3	0.6873	0.0635	0.2492
4	0.6628	0.2397	0.0975
5	0.7849	0.0916	0.1235
6	0.6063	0.1936	0.2000
7	0.9166	0.0834	0.0000
8	0.7636	0.0375	0.1989
9	0.6583	0.1944	0.1473
10	0.3117	0.1496	0.2687
11	0.1512	0.2544	0.5944
12	0.2825	0.4157	0.3018
13	0.1368	0.4016	0.4617
14	0.2634	0.2279	0.5087
15	0.3606	0.4197	0.2197
16	0.3752	0.2829	0.3418
17	0.2531	0.3556	0.3913
18	0.3103	0.2982	0.3914
19	0.1143	0.1299	0.7558
20	0.1673	0.4382	0.3945
21	0.1157	0.1391	0.7452
22	0.0976	0.1902	0.7122
23	0.0618	0.0383	0.8999
24	0.0115	0.0919	0.8966
25	0.0000	0.1522	0.8496
26	0.0869	0.1337	0.7794
27	0.1588	0.2408	0.6004

the same Triangram. For example, the point No. 17 (Shiga-cho, Shiga) is located at almost the center of the Triangram. It represents the degrees of belongingness, $(P(S_1/x), P(S_2/x), P(S_3/x)) = (0.2531, 0.3556, 0.3913)$.

In addition, the symbol in this figure represents the cluster which each point's degree of belongingness is largest.

Interpretation of Table 4 and Fig. 3. concluded that :

1) Three fuzzy subsets were expressed by using this method, especially No. 1 to 9 (sample from small towns and villages) mostly belonged to cluster 1 and No. 19 to 27 (samples from large cities) mostly belonged cluster 3. From the relations between samples and clusters, it is concluded that the cluster 1, 2, 3 represent subsets which reflects the needs (a), (b), and (c) respectively. It is known by the formative mechanism of inhabitants' consciousness which is discussed in introduction.

2) Fuzzy clustering provided stray and undetermined points. For example, point No. 13 or No. 17 is the bridge points between cluster 2 and cluster 3. No. 20 belongs cluster 3 strongly in spite of sampling from large scale cities. It was found that for many consciousness of the road building, fuzziness did indeed exist.

(3) Analysis of the result

The next analysis was to explore the cause of inhabitants' consciousness differences due to reliability of attributes of cities and towns, and especially the scale of city. It is requested that the some measurable factors will be able to estimate the tendency of the inhabitants' consciousness before the making projects.

In previous section, the degree of belongingness regarded as the one of the index of the inhabitants' consciousness were calculated, and it was found that every city, town, or village have different level of three factors of inhabitants' consciousness. Nevertheless, the degree of belongingness cannot be treated as a proportional number. It means that relation of the value 0.8 as compared with 0.4 is not equal to the relation of 0.4 with 0.2 for example. Therefore, the ratio should not be used directly but used as a ranking index for inhabitants' consciousness.

The density of population (persons/km^2) which could be measured quantitatively was adopted to represent one index of the scale of cities and towns. The density of population is usually regarded as an index of concentration to the cities. In Table 5, the actual number of density, the rank of density and the

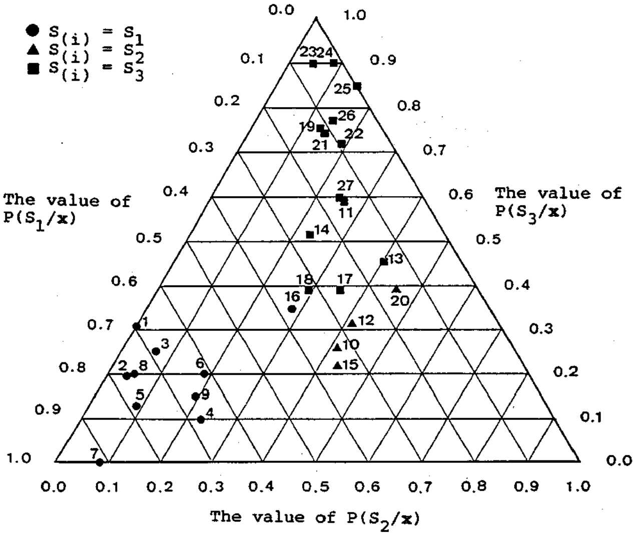

Fig. 3 Triangram.

Table 5 The ranking of samples.

No.	(a)	(b)	rank of $P(S_1/x)$	rank of $P(S_2/x)$	rank of $P(S_3/x)$
1	125.0	7	23	1	12
2	233.0	12	25	3	5
3	149.0	8	22	5	9
4	62.8	4	21	17	2
5	73.8	5	26	7	3
6	75.9	6	19	14	7
7	4.6	2	27	6	1
8	7.2	3	24	2	6
9	4.5	1	20	15	4
10	1948.5	18	16	25	10
11	1631.6	17	9	19	19
12	706.6	15	14	24	11
13	785.3	16	8	23	17
14	567.6	13	13	16	18
15	704.4	14	17	26	8
16	178.4	9	18	20	13
17	184.1	10	12	22	14
18	218.6	11	15	21	15
19	7922.0	24	6	9	23
20	16523.3	27	11	27	16
21	3789.0	22	7	11	22
22	10483.7	25	5	13	21
23	4046.0	23	3	4	27
24	10679.6	26	2	8	26
25	3602.6	21	1	12	25
26	2043.7	19	4	10	24
27	2216.3	20	10	18	20
Spearman's ρ			-0.86	0.20	0.85

(a):density of population (persons/km^2)
(b):rank of the density

note : The rank becomes large as its value becomes large.

ranks of degrees of each cluster are shown.

The relation between the scale of city and inhabitants' consciousness, the Spearmann's rank correlation ratio calculating from the rank, is shown in the bottom of this Table. The Spearmann's rank correlation ratio between −1 to 1. That is :

$$\rho=1-6\sum_{i=1}^{n}(x_i-y_i)^2/n(n^2-1) \qquad (9)$$

The value shows the degree if the ranking of x_i is resemble to the ranking the data y_i. If the value of ρ is close to −1, strongest negative correlation exists, and if the values is close to 1, strongest positive correlation exists between rankings.

From the values of correlation ratio, it was concluded that the needs (a) and (c) have respectively strong negative ($\rho=-0.86$) and strong positive correlation ($\rho=0.85$) with the scale of city, but the needs (b) has no correlation.

The density of population is not every factor which represents the scale of the areas. The other three factors are utilized for same types of analyses. The other variables are :

(1) The traffic demand (vehicles · km/km^2) :

It is the index of the present state of traffic in each area. The traffic volume was divided by the area. (The data are made from Census Survey in 1977.)

(2) The road ratio (%) :

It is conceived to be one of the land-use indices for transportation. It is the ratio that the area of the road occupy in the all area (The data are made form the Census Survey in 1977).

(3) The annual gross sales by wholesaler and retailer (yen) :

It shows the economical activity of the cities (The data are made from the Statistics of Commerce in 1976).

The result of calculation the correlation ratio between each variables and the degrees of belongingness shows that the other variables correlate $P(S_1/x)$ and $P(S_3/x)$ respectively in the same way of the case with density of population (Table 6). After considering these factors are also concerned with the scale of

Table 6 Correlation between other indices and $P(S_j/x)$.

The index of city scale	Spearman's ρ $P(S_1/x)$	$P(S_2/x)$	$P(S_3/x)$
The traffic demand	-0.69	0.25	0.68
The road ratio	-0.82	0.28	0.77
The anual gross sale by wholesaler and retailer	-0.85	0.17	0.85

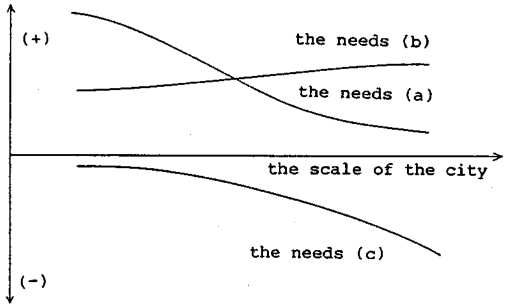

Fig. 4 The relation between the needs and the scale of city.

the cities, the relation between the scale of the city and the inhabitants' consciousness is shown qualitatively in Fig. 4.

The results from these investigations are summarized as follows :

1) The needs (a) increases as the scale of city decreases. This means that the needs (a) is influenced by inconvenience of daily life in rural villages and towns.

2) The needs (b) is scarcely influenced by city scale, but in some middle scale cities, this needs is larger than (a) and (c). Thus, the necessity of the road construction should be considered according to traffic demand due to insignificance of the needs (a) and (c).

3) The needs (c) becomes large as the scale of city becomes large. That is, in urban area, traffic accidents, traffic congestion and air pollution intensifies.

These results are conceived to give very useful informations to the planners of the trunk road construction. The following comments are proposed to the planning of the trunk road construction.

1) In small towns and villages, though it is unnecessary to construct the road in case of considering only the volume of the traffic demand, the needs of road construction on account of standard of living (needs (a)) is large. The plan neglecting the inhabitants' consciousness might not be accepted smoothly. Thus, in these areas the trunk road construction and development should incorporate more inputs of inhabitants' consciousness. The larger scale of the road construction should be profitable. In addition, the construction including the development of the access transport and the cultural facilities should be considered.

2) In the medium scale areas, the inhabitants have very complex feelings about the road construction (needs (a), (b), and (c) are mixed). It is recognized that the functional traffic network should be made and it is performed to construct the new roads according to the traffic demand of the cities.

3) The heavy traffic go through the large cities. The dislike for the additional road construction (needs (c)) becomes large because of the bad influences of large traffic such as air pollution, noise pollution and traffic accidents and so on. Though it is easy to consider the necessity of the new road construction in case of considering big traffic demand, the attention to the environment of the concerned area should be inevitable. Thus, in urban areas constructing of big road should be refrained with a high traffic demand.

4. CONCLUDING REMARKS

In the case of planning of the road construction, obtaining the information about the inhabitants' consciousness is important. Though the fundamental analysis such as the questionnaire survey for the inhabitants has been done previously. The plan of the road construction is generally studied by the indices that show the present state of the roads of the area. In this study, the data from the questionnaire survey of inhabitants' consciousness of the road construction were analyzed by fuzzy clustering. As a result of the analysis, it is concluded that inhabitants' consciousness consists in three main factors and could be classified by fuzzy sets who represent three factors.

The next investigation shows that these degrees of needs are mutually related to some indices corresponded to the scale of city (population density, road ratio and so on).

Finally, it is proposed that planners should be aware of the difference of inhabitants' consciousness, particularly when they plan to develop the trunk road in relatively small and large cities. The method reported here that estimate the inhabitants' consciousness of concerned area might be helpful to such a planning[11].

The three following further investigations are recommended :

1) The first point is about the technique of clustering. In this study, Euclidian distance was used in clustering approach. The result of classification depends upon the definition of distance. Effects of different definitions of distance should be explored and computed.

2) The second point is about the estimation of consciousness as reported herein. The degree of belongingness is only qualitatively investigated. That is, the degree of belongingness was used to the ranking of the localities. Further quantitative analysis is needed to develop indices of inhabitants, consciousness of the road construction. It should be considered that the indices of city scale such as previous four variables could be used directly for the planning.

3) Lastly the concept of the support system of the planning of the road construction is reported. The knowledge about the inhabitants' consciousness obtained from the various analysis should be at lized for new road construction. The knowledge should be preserved in the support system. If not, the knowledge could not be utilized for the determination of the road construction. The production system is one of the solution. If the all knowledge is described as the production rules, it will be easy to preserve the knowledge by rule-base system[12].

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