# INFRASTRUCTURE DEVELOPMENT AND CITIZENS' CONCERN ABOUT REGIONAL SUSTAINABILITY: CASE STUDY OF THE SMART-IC

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## ABSTRACT

Social infrastructures such as roads, railways, and water supply are built to improve public welfare and to enhance national and regional economies. However, such infrastructure developments usually impact the living and natural environment. Therefore, if such developments cause damage to the living and natural environment, the citizens' concern about regional sustainability might increase and the sustainability of the region would be discouraged. In this study, the influence of the infrastructure and commercial development on the citizens' concerns about regional sustainability was examined. Concretely, a project concerning the development of a smart-IC (smart interchange) in a region where a large-scale shopping complex was built was focused on.

*Keywords: sustainability, structure equation model, consciousness analysis*

## 1. INTRODUCTION

Social infrastructures such as roads, railways, electricity supply, water supply, sewerage system, and information and telecommunication system are built to enhance public welfare and to develop national economy. However, the scale of such infrastructure developments is physically large so that they might have negative impacts on living and natural environment. If the burden of the development on living and natural environment exceeds contentment of citizens, the area surrounding the site of the development cannot attain sustainable area development. Therefore, the concerned enterprising body of the development must measure the possible impacts in advance of construction work. Moreover, depending on the measurement results of the impacts, the enterprising body must revise the plan to meet the conditions and alternatively abort the plan.

As a research on sustainable development, Kachi (2004) mentioned that the role of urban planning changed to focus on the improvement of Quality of Life (QOL) that includes amenity, preservation of nature and environment, safety, and town-scape. Moreover Kachi (2004) explains that urban planners and all other stakeholders are required information of changes in citizens' life and improvement of QOL as a result of implementation of urban planning. Then, Kachi (2004) has developed an evaluation method of QOL in urban area combining two complementary methods that are "Method of Measuring satisfaction" and "Dramatizing Method". Nagoya city zone, which is radius of 20km within the circle on center of Nagoya, was examined as the case study. Population distribution scenario in Nagoya city was set as urban planning alternatives. The case study proves efficiency of "Dramatizing Method" for evaluation of urban planning alternatives.

Moreover, Fujiwara(2005) describes that sustainability has various dimensions and is affected various factors. Fujiwara also mentioned that some practical, cost effective and easily measured indicators are needed to support policy decision in developing countries facing challenges towards sustainable societies. Fujiwara summarized the existing indicator systems of sustainable development and also built a dynamic structural equation model which can capture complex cause-effect relationships existing in the measurement of sustainability over time, considering data availability on developing countries.

Furthermore, Kiminami(2004) analyzed local citizens' intention about infrastructure development in rural areas. Kiminami mentions that among the residents there are discrepancies in the interest and sense of values about the land improvement and rural development projects. Then, Kiminami clarified the structure of the local residents' consciousness of the development project and the formation of such awareness by quantification theory type II and III analysis that are respectively regarded as discriminant analysis and principle component analysis considering qualitative data.

These researches focused on the consciousness of the citizens living over the wide area and the objects of evaluation were relatively comprehensive urban or regional planning. Thus, there is few researches that directly analyzed change of local citizens' consciousness brought about area development.

Therefore, this study examined the change of local citizens' consciousness about expectation for the sustainable development of small area after implementation of area development. In this study, a project of highway ramp implementation and commercial zene development around the ramp was focused on. The highway ramp has installed as Smart-IC (smart interchange) which is a Japanese unique transport facility as described in the next chapter.

This paper is organized as follows. The characteristics of the smart-IC are introduced in chapter 2. The study area and the data used for analysis are explained in chapters 3 and 4, respectively. Changes in the local citizens' behaviour concerning the frequency of using the expressway and the shopping complex adjacent to the smart-IC and their cognition of the living and environmental conditions are explained in chapter 5. Evaluation factors of area development are extracted by factor analysis, and a structural equation model concerning the local citizens' expectation of regional sustainable development is developed in chapter 6. Finally, several policy implications concerning large-scale area development are described in chapter 7.

# 2. DEVELOPMENT OF SMART INTERCHANGE

In Japan, the length of arterial high-standard roads is 9,500 km, which is equivalent to 70% of the total length of the planned development. Moreover, the number of vehicles that use expressways reaches about 1,600 million per year. However, the usage rate of expressways in Japan is lower than that in other countries as shown in Figure 1. This fact is mainly attributed to the peculiar Japanese road toll system that most expressways charge for use. It is necessary to integrate a function that enables the collection of user charge into the abovementioned system for most ramps. However, because the spatial scale of ramps was so large and costly, the number of ramps had to be limited. Consequently, the interval between ramps in Japan became long as compared to that in other countries.

To reduce traffic congestion around toll gates and to enhance the use of expressways, an electronic toll collection system (ETC) has been installed in expressways in Japan. In 2004, before the complete installation of this system, the Japanese Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) performed a social experiment to study the feasibility of the installation of a ramp having only an ETC system called smart-interchange (smart-IC). Except for five cases, the smart-IC, which was experimentally installed at the edge of the service areas of expressways, has been continuously in use. Figure 2 shows the number of smart-ICs being used.

Further, in 2009, MLIT revised the outline about the installation of the smart-IC, making it unnecessary to perform the social experiment in advance. The revised outline reduces the administrative and financial burden on the municipality, and the installation of the smart-IC becomes easier. As a result, the installation of the smart-IC has started in 18 places. This fact reflects the municipalities' expectation for the smart-IC as a tool for enhancing regional development, which increases employment and tax revenue. In fact, large-scale commercial developments around the smart-IC led by municipalities have been detected. This study investigates the local citizens' evaluation of such developments and verifies the local citizen's expectation for sustainable development of a region.

Several researches on this facility have been conducted. Hamaya (2006) examined the situation concerning the utilization of smart-IC in many regions and examined the influence of the construction of smart-IC on the local traffic. Moreover, the factors that influence traffic where the smart-IC is used are clarified, and the forecast of traffic is enabled. On the other hand, on the basis of the results of the questionnaire distributed to smart-IC users, Fujita (2006) constructed a choice behaviour model concerning the use of the IC. In addition, a structural equation model concerning users' satisfaction was constructed by using the covariance structure analysis. Thus, these researches are considered from the road users' point of view. This study evaluates the influence of the area development from the citizens' point of view.

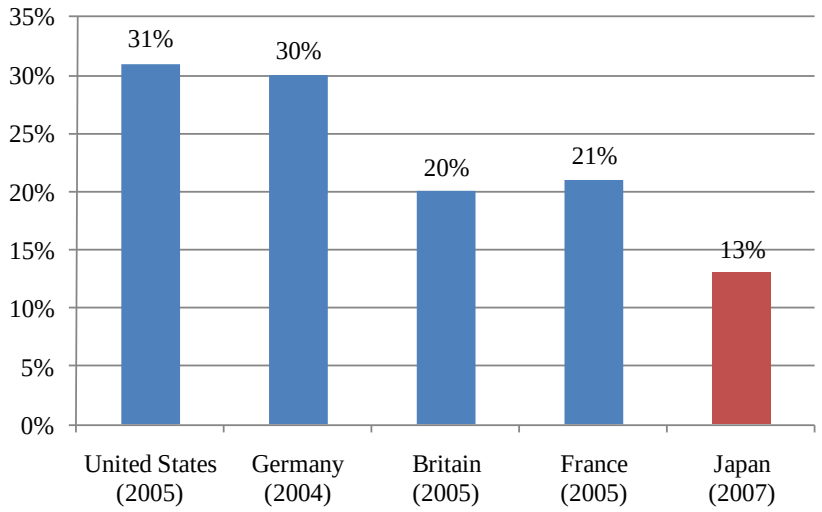


Figure 1 – Usage rate of expressway

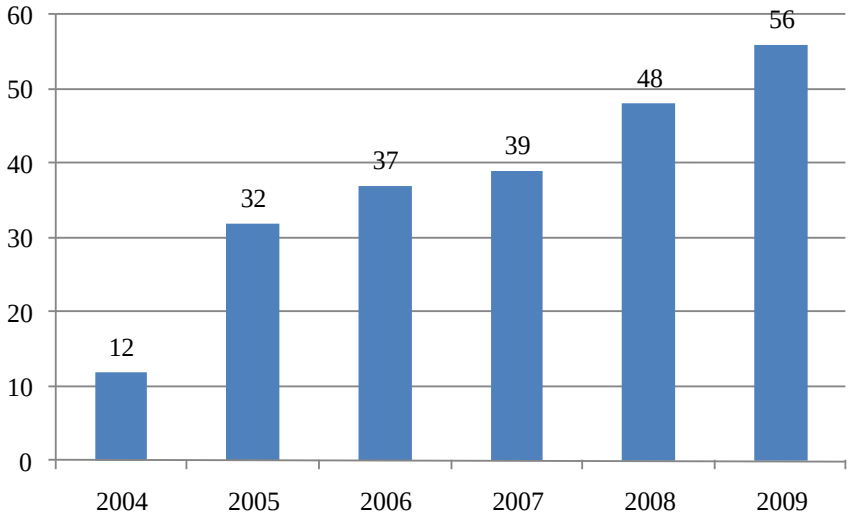


Figure 2 – Number of Smart-IC

## 3. STUDY AREA

The Enshu-Toyoda smart-IC was selected as the study area because a large shopping complex, which impacts the neighbors' living and environmental conditions, was developed beside the smart-IC. As seen in Figure 3, the smart-IC was installed in the Enshu-Toyoda service area, which is located alongside the Tomei-expressway. The traffic volume on the expressway around Enshu-Toyoda is about 70,000 vehicles a day.

Then, the land use inside a circle with a radius of 300 m, with the service area as the center, was analyzed. The distribution of the land use before and after development is shown in Table 1. Before the installation of the smart-IC, the land was mainly used for agriculture and for road transport, and not as a residential area or for business purposes. After the

installation of the smart-IC, the land for agriculture has been converted to land for commerce and business. Moreover, land formation has started for the preparation of future development. The development process and the traffic using smart-IC are shown in Figure 4. As seen in this figure, it becomes obvious that the development was promoted on a large scale. The traffic after the opening of the shopping complex increased to three times of the previous traffic. At present, the average daily traffic is about 3,000 vehicles.

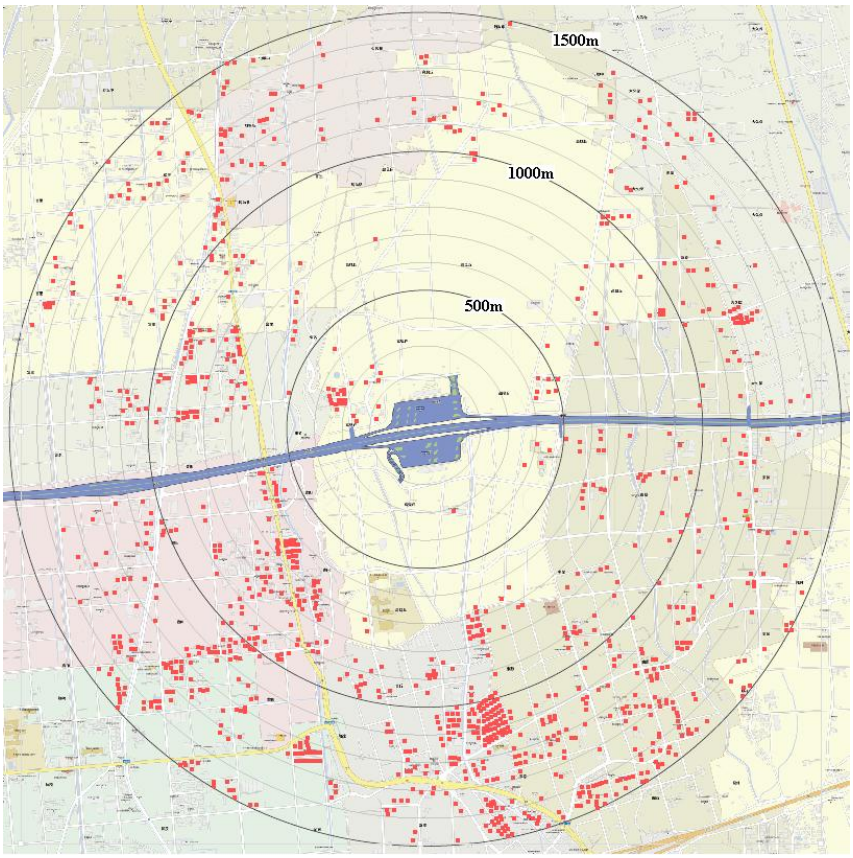


Figure 3 – Studied area (Dots in red indicate the residences where questionnaire sheet was distributed)

Table 1 – Share of the land use

| | Before development (2004) | After development (2008) |
|---|---|---|
| Agriculture | 56% | 14% |
| Improved land | 0% | 14% |
| Residential quarter | 3% | 2% |
| Commercial and business | 1% | 31% |
| Road | 37% | 38% |
| River, lakes, and marshes | 2% | 0% |
| Other | 2% | 2% |

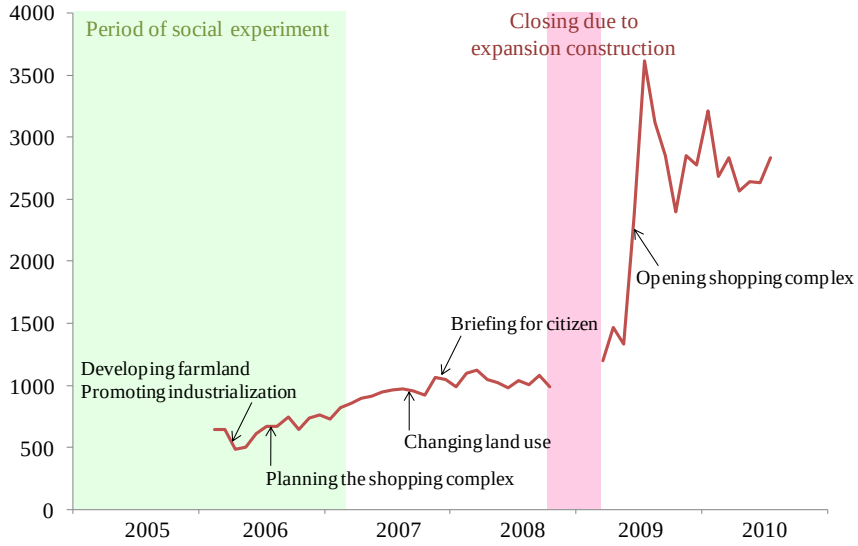


Figure 4 – Development process and traffics using the Smart-IC

# 4. OUTLINE OF SURVEY

A questionnaire survey was conducted in the study area. The respondents of the survey were local citizens living within a radius of 1.5 km from the smart-IC. The questionnaire was distributed to all the residences.

The questionnaire included questions on the frequency of using the smart-IC, frequency of using the shopping complex adjacent to the smart-IC, evaluations of the living and natural environment, evaluations of the regional development plan, and individual attributes. Table 2 lists the contents of the questions.

Table 3 summarizes the questionnaire survey. The number of returned sheets was 361. This number is enough to satisfy the required number of samples under the condition that the confidence level is 95% and that the tolerance limit for the sampling error is 5%.

Table 2 – Question items

| | |
|---|---|
| Evaluations to the living and natural environment | Natural environment / Traffic noise and vibration / Emission / Traffic accident / Traffic congestion / Traffic volume / Liveliness of the region / Willingness to continue to live in the region / Feeling of the attachment to the region |
| Evaluations to the regional development plan | Contents of provided information / Timing of information provision / Size of planned development / Timing of the respondent's recognition / Privately investigations into the development plan / Expectations to development to region / Importance of the smart-IC in the region |
| Frequency in use of the smart-IC, shopping complex | Frequency in use of shopping complex / Frequency in use of the smart-IC by business purpose / Frequency in use of the smart-IC by personal purpose |
| Individual attributes | Age / Occupation / Period of residence / Family structure |

Table 3 – Outline of survey

| | |
|---|---|
| Date | Nov.15-16,2009 |
| Method of distribution/return | Handing, Posting / Mailing |
| Number of distribution | 1110 |
| Number of necessary samples | 286<br>(for satisfying the confidence coefficient 95% and tolerance limit 5%) |
| Number of available samples | 361 |

# 5. ANALYSIS OF LOCAL CITIZEN'S SATISFACTION TO THE DEVELOPMENT

In this chapter, the local citizens' satisfaction concerning the development is analyzed using the data collected by the survey. The influence of the frequency of using the smart-IC, the frequency of using the shopping complex near the ramp, and the local citizens' evaluation of the procedure of the development on the local citizens' satisfaction level is analyzed.

## 5.1 Characteristics in Using Smart-IC

First, the nearby residents' purpose for using the smart-IC was analyzed. Figure 5 shows the distribution of the purpose of using the smart-IC. As shown in this figure, half of the respondents used the smart-IC. Concerning the purpose of use, the share of the users who used the smart-IC for only business purposes was 2%. The share of the users who used the smart-IC for only personal purposes was 27%. Furthermore, the share of the users who used the smart-IC for business and personal purposes was 23%.

Figure 6 shows the distribution of the frequency of using the smart-IC depending on the purpose, i.e., business or personal purpose. Most of the users who used it for personal purposes did so less than once a week. Furthermore, almost 50% of the respondents used it only once a month. Almost 30% of business users used the smart-IC more than two times a week. Thus, it can be said that this smart-IC is used especially for business purposes.

Next, the level of satisfaction regarding the development of the smart-IC was analyzed. Figure 7 shows the relation between the frequency of using the smart-IC and the level of satisfaction. As seen in this figure, almost all users of the smart-IC were satisfied with the development. However, the share of the non-users who were satisfied with the development was only 30%. In short, the level of satisfaction was influenced by the frequency of use.

Figure 8 shows the relation between the frequency of using the shopping complex and the level of satisfaction with regard to the smart-IC development. As seen in this figure, the level of satisfaction of high frequency users is slightly larger than that of low frequency users.

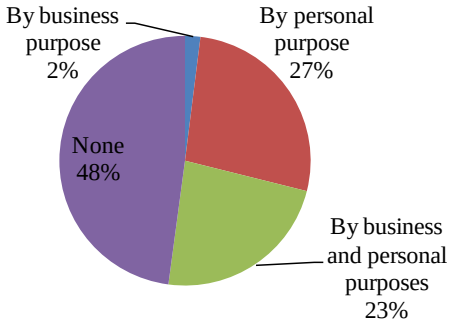


Figure 5 – Share of the purpose using the smart-IC

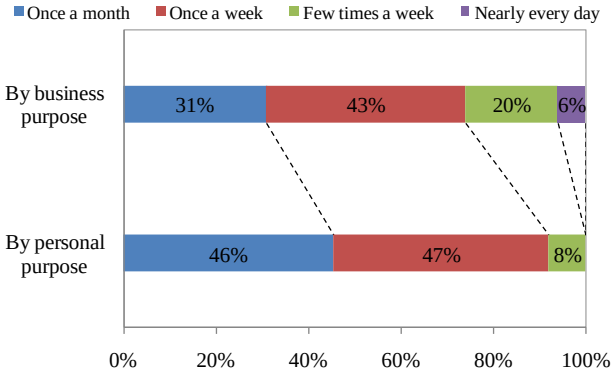


Figure 6 – Share of frequency of using the smart-IC by its purposes

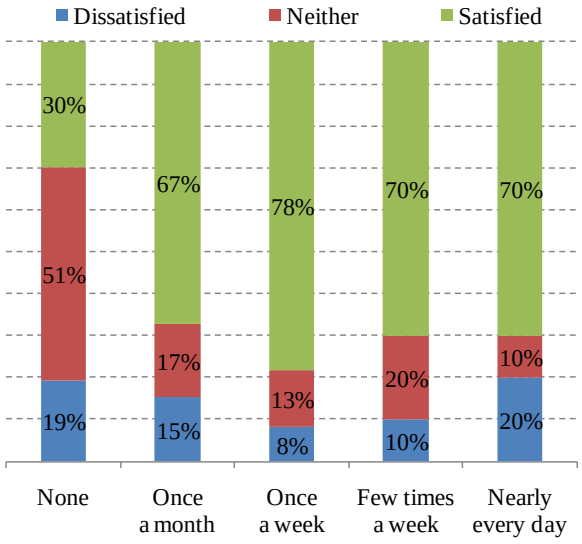


Figure 7 – Relation between frequency of using smart-IC and level of satisfaction

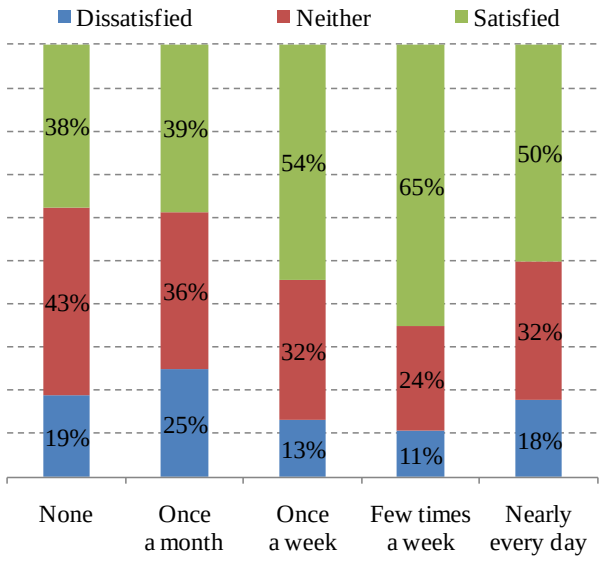


Figure 8 – Relation between frequency of using shopping complex and satisfaction level

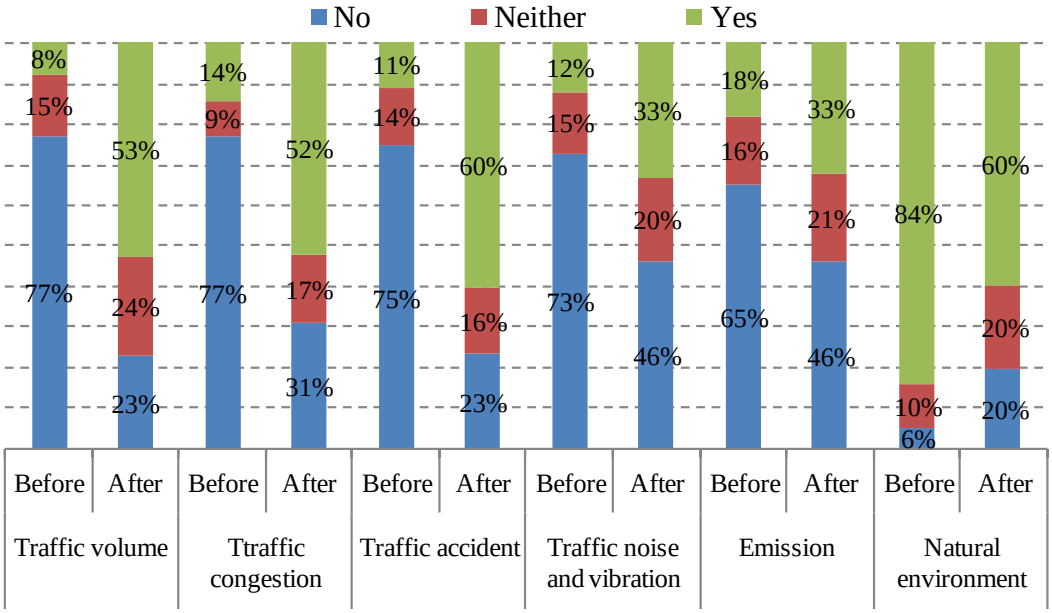


Figure 9 – Respondent's evaluation regarding the living environment

## 5.2. The consciousness change of the local citizen

Commercial development around the smart-IC has enhanced the convenience of living for local citizens. On the other hand, the living environment might worsen in terms of traffic safety, traffic noise, emissions, etc. Respondents' evaluations concerning the living environment before and after the smart-IC development were compared. Figure 9 shows the results of this comparison. Concerning traffic volume, almost all respondents found an

increase in the traffic volume. Further, the respondents became more anxious regarding traffic congestion, traffic accidents, traffic noise and vibration, and emissions. Meanwhile, the share of the respondents who thought that the natural environment was not good increased. Such changes in the evaluations of the living environment were caused by the increase in the traffic volume around the shopping complex and smart-IC.

## 5.3. Influence on sustainable development in region

In this section, status of using the smart-IC, the evaluation regarding the living environment and the evaluation regarding the development procedure are considered as factors which influence on the sustainable development in the region. In this research, regional sustainability was considered as citizens' attachment to the region and also citizens' willingness to continue to live in the region. The relation between the willingness to live and some factors is examined. Figure 10 shows the relation between the evaluations concerning the living environment and the willingness to continue to live in the region. As shown in this figure, respondents feeling the goodness of the natural environment have a high willingness. On the other hand, the willingness of the respondents who perceive a lot of traffic accidents and traffic congestion is low. This means maintaining the goodness of the living environment is necessary for sustainable development in the region. Next, the relation between the usage characteristics of the smart-IC and the willingness to continue to live is analyzed. As seen in Figure 11, the willingness of the respondents using the smart-IC and the shopping complex is high. Therefore, it is clear that the convenience of living influences sustainable development. Finally, Figure 12 shows the relation between the evaluation of the procedure of the development and the willingness to continue to live. The respondents acknowledging the importance of the smart-IC in this region and the necessity of development have a high intention of residing in the region. The causal relation that these factors give sustainable development is considered in the next section.

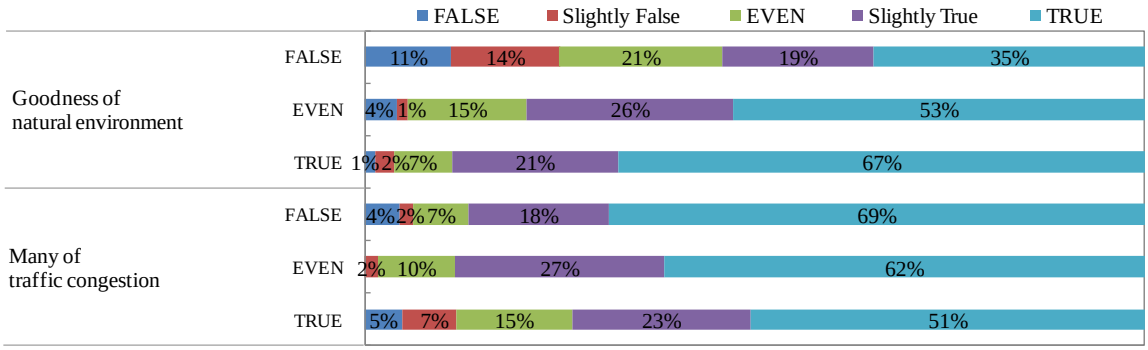


Figure 10 – Relation between the evaluation of living environment and the willingness to continue to live

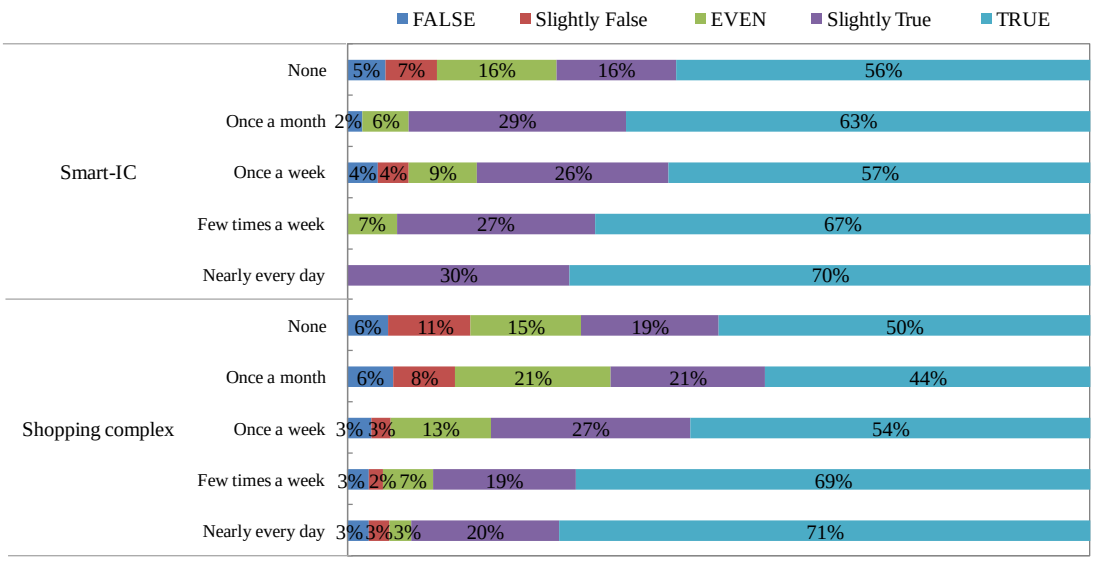


Figure 11 – Relation between the characteristic of using the smart-IC and the willingness to continue to live

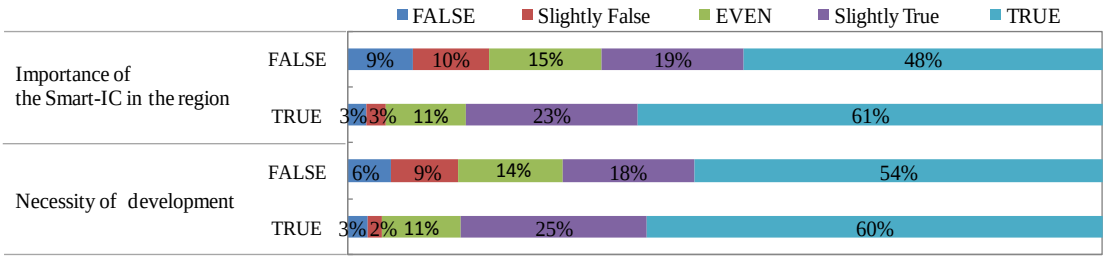


Figure 12 – Relation between the evaluation of development procedure and the willingness to continue to live

# 6. CITIZEN'S EXPECTATION FOR REGIONAL SUSTAINABLE DEVELOPMENT

In this chapter, citizens' evaluation factors of the smart-IC development were extracted by the factor analysis and the causal relations among those factors were verified by structural equation modeling (SEM).

First, the result of the factor analysis is described. Eighteen variables listed in Table 4 were used for the analysis. Furthermore, Table 4 summarizes the result of the analysis using varimax rotation. The values given in the last line are the eigenvalues of the extracted factors. Using the criterion proposed by Guttman (1954) and Kaiser (1960), five factors with eigenvalues greater than 1 were retained in this analysis.

Meanwhile, the values of factor loadings, which are correlations between the variables and the five factors, are shown in the table. In this study, the variables whose absolute values of the factor loadings were greater than 0.4 were used to interpret the meaning of the factors. Then, it was inferred that each factor respectively expressed "concern about the environmental change," "validity of the development procedure," "expectation of regional

sustainability," "necessity of the development in the region," and "traffic accessibility." Causal relation among these factors was examined by SEM as follows.

The information of the covariance among observed variables and latent variables was used to estimate the SEM that can test specific hypotheses about the factor structure. The five extracted factors were considered to be the latent variables. In this study, the hypothesis that the rising consciousness of "traffic accessibility," "validity of the development procedure," and "necessity of the development in the region" raises a consciousness of "expectation of regional sustainability" and that rising consciousness of "concern about the environmental change" reduces the consciousness of "expectation of regional sustainability" were verified.

Figure 13 shows the estimation results. Path coefficients, i.e., the values recorded in the arrow, show the strength of the causal relation between variables including observed variables and latent variables. It shows that all these values are statistically significant (p-value < 0.10).

Moreover, as seen in this figure, each latent variable was explained by several observed variables. For instance, latent variable of "concern about living environment change" was explained by "concern about air pollution" and "concern about traffic accidents."

Furthermore, explanation power of the estimated model was verified by the goodness of fit index (GFI) and the root mean square error of approximation (RMSEA). The GFI and RMSEA of the estimated SEM were 0.952 and 0.047, respectively, so that the criterion for the validity of SEM was satisfied.

Next, the causal relations between latent variables were examined. Path coefficient of the arrows between "transport accessibility" and "expectation of regional sustainability," and "acceptance of planning procedure" and "expectation of regional sustainability" are -0.01 and 0.07, respectively. These values are extremely small; therefore, there are no direct causal relations between the latent variables. This result indicates that the improvement in the transportation service and an increase in the acceptance level of the planning procedure do not directly contribute to an increase in the expectation of regional sustainability.

However, the path coefficient from those latent variables to "recognition of the necessity of smart-IC development" are 0.26 and 0.43, so that an improvement in the transportation service and an increase in acceptance level of the planning procedure increases the recognition of the necessity of the smart-IC development. Furthermore, since the path coefficient of the arrow from "recognition of the necessity" to "expectation of regional sustainability" is 0.30, those latent variables indirectly influence "the expectation of the regional sustainability."

On the other hand, "concern about living environment deterioration" directly influences the "expectation of regional sustainability" by the path coefficient, -0.41, between these latent variables. It indicates that the concerns about gas emissions, traffic accidents, noise, and vibration directly decrease the expectation of regional sustainability.

As mentioned above, the causal relations among latent variables were examined and the hypotheses made in this study were verified. From the result of the verifications, it was clear that "cognition of the necessity of smart-IC development" and "concern about living environment deterioration" directly influenced the "expectation of regional sustainability," and that "acceptance level of the planning procedure" and "status of the facilities' utilization" did not directly but indirectly influence the "expectation of regional sustainability."

Infrastructure development must contribute toward sustainable development of the region. However, it can be said that sustainable development will not be achieved if the concerns about the living and natural environment deterioration will not be solved and when citizens' acceptance concerning the relation between infrastructure development and regional sustainability will not be obtained.

Table 4 – Citizen's evaluation factors of the smart-IC development

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Traffic accident | 0.756 | -0.066 | 0.056 | -0.120 | -0.002 |
| Emission | 0.709 | -0.115 | -0.087 | -0.078 | -0.013 |
| Traffic congestion | 0.678 | -0.084 | -0.014 | -0.117 | 0.031 |
| Traffic noise and vibration | 0.660 | -0.108 | -0.131 | -0.038 | -0.037 |
| Timing of information provision | -0.117 | 0.808 | 0.063 | 0.205 | 0.080 |
| Contents of provided information | -0.134 | 0.795 | 0.024 | 0.164 | 0.074 |
| Timing of the respondent's recognition | 0.064 | -0.344 | -0.131 | -0.037 | -0.126 |
| Feeling of the attachment to the region | -0.044 | 0.112 | 0.731 | 0.077 | 0.063 |
| Willingness to continue to live in the region | -0.109 | 0.062 | 0.708 | 0.125 | 0.083 |
| Concern about natural environment deterioration | -0.392 | 0.067 | 0.409 | 0.207 | 0.004 |
| Liveliness of the region | 0.204 | 0.141 | 0.325 | 0.228 | 0.175 |
| Importance of the smart-IC in the region | -0.149 | 0.236 | 0.141 | 0.604 | 0.168 |
| Expectations to development to region | -0.095 | 0.104 | 0.087 | 0.478 | 0.195 |
| Size of planned development | -0.146 | 0.333 | 0.128 | 0.463 | 0.027 |
| Frequency in use of the smart-IC by personal purpose | -0.105 | 0.092 | 0.082 | 0.197 | 0.655 |
| Frequency in use of the smart-IC by business purpose | -0.017 | 0.092 | 0.043 | 0.031 | 0.582 |
| Frequency in visit the shopping complex | -0.102 | -0.056 | 0.146 | 0.277 | 0.254 |
| Privately investigations into the development plan | -0.079 | -0.048 | -0.016 | -0.067 | -0.202 |
| Eigenvalues | 2.293 | 1.680 | 1.431 | 1.151 | 1.012 |

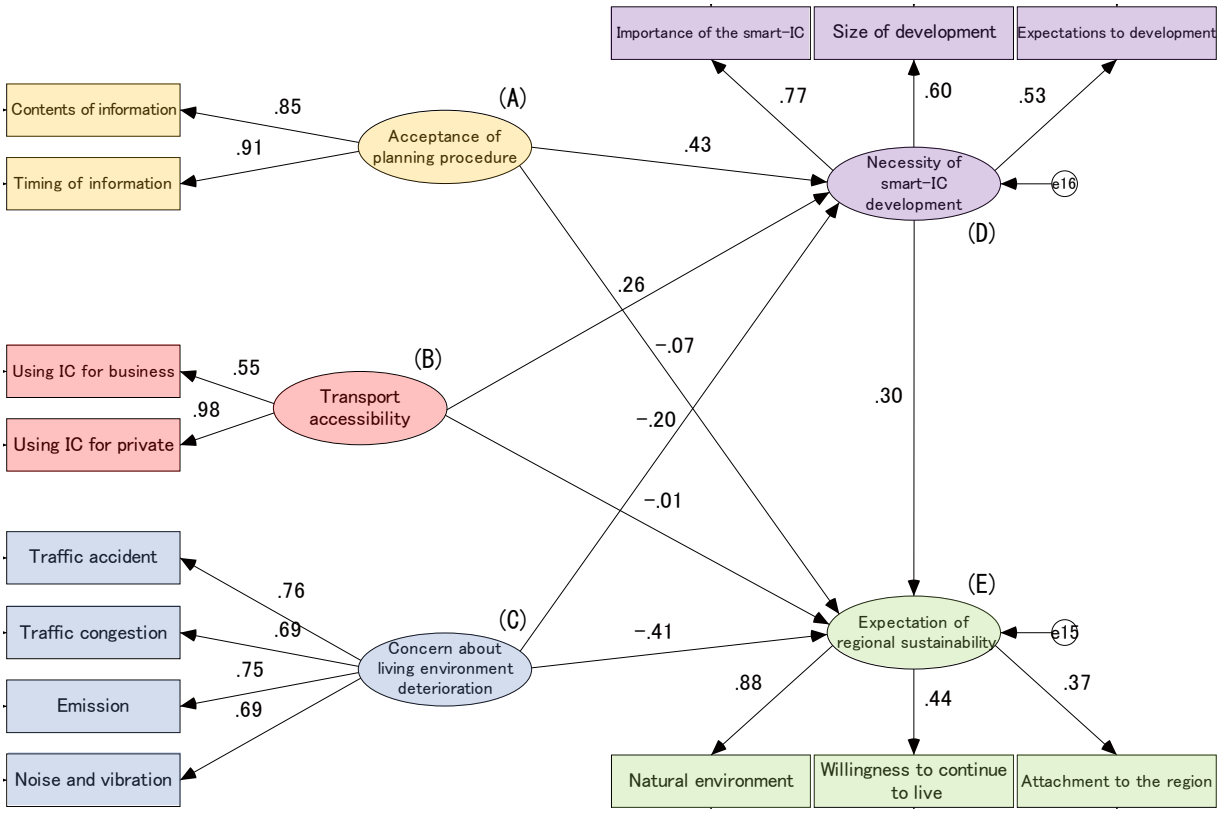


Figure 13 – Structural Equation Model on expectation of regional sustainable development

# 7. CONCLUSION

This study focused on the consciousness of the local citizens' expectation for sustainable development of small area. By estimating the SEM focusing expectation of regional sustainability, it was shown that the cognition of the necessity of development was important to enhance local citizens' expectation for sustainable development of the region, and that the cognition of the necessity of development can be achieved by obtaining the citizens' acceptance for the plan and improving the traffic service level. Therefore, it can be concluded that sustainable development will not be achieved unless the concerns about deterioration of living environment is solved and citizens' acceptance concerning the relation between infrastructure development and regional sustainability is obtained.

However, it is necessary to pay attention to the following point. This study examined only the change in citizens' consciousness in the short term. In general, evaluation of changes in the natural and living environment is going to vary over time. In that sense, it is thought that the long-term monitoring of the citizens' consciousness and the survey of moving-in and moving-out can contribute to the appropriate evaluation about the sustainability of the region.

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