DEVELOPMENT OF EVALUATION INDICATORS FOR SMART SHARING CITY

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The idea of smart sharing city recently emerged in the field of urban planning as a result of continuous development of ICTs, expansion of sharing economy and necessity of sustainable development. To help cities to monitor their performance and to set plans to transform towards the smart sharing city, development of the new indicator framework is necessary. This paper focuses on developing an indicator framework for smart sharing city, by clarifying characteristics of the existing indicator frameworks for sustainable cities and reviewing ongoing sharing activity involved policies.

Key Words : *smart sharing city, sustainable development, sharing economy, indicator frameworks*

1. INTRODUCTION

(1) Background

According to the United Nations report on urbanization, urban population is increasing every year and by 2030, it is estimated that over 60 percent of the world population will reside in urban areas[1)]. Rapid urbanization and concentration of the population to urban areas brought several urban sustainability challenges, such as local traffic problems, growth in general wastes, high and inefficient consumption of energy and social exclusion.

As a solution to overcome urban sustainability problems, several urban design concepts have been actively discussed. One of the urban design concepts is the smart sustainable city, which highlights the use of information and communication technologies (ICTs) to increase efficiency of urban operations and quality of life, according to International Telecommunication Union (ITU)[2)].

Another concept is the sharing city. Although the definition of sharing city is not yet clearly established, Seoul, which proclaimed Sharing City Seoul Project from 2012, is explaining the sharing city as "a city where communication and cooperation are well established between individual citizens, public societies and enterprises and where sharing activities are actively performed[3)]".

Smart sharing city, a new urban design concept suggested by Japan Society of Civil Engineers Smart Sharing City Subcommittee, integrates the idea of the smart sustainable city and the sharing city. Smart sharing city is defined as a city which aims to achieve sustainable development by sharing underused assets with the help of ICT infrastructure, thus, maximizing benefits of the public and individuals at the same time[4)].

In urban planning, indicators are often used as a quantitative, qualitative or descriptive measure to assess the performance of the city or to set the target or goal which the city aims to achieve. However, smart sharing city has no tools developed to monitor its performance as it is a recently proposed urban design concept. Therefore, in this study, an indicator framework for the smart sharing city is developed, which can be used as a tool to set the measurable targets and to monitor the performance of the city as the smart sharing city.

(2) Research Objectives

Through the evaluation on existing indicator frameworks for sustainable cities and review on sharing economy policies and projects, this study aims to develop an indicator framework which can evaluate the city's progress of transformation towards the smart sharing city. Using the developed indicator

framework, progress of Seoul and Kitakyushu towards the smart sharing city and urban sustainability will be evaluated.

2. LITERATURE REVIEW

(1) Preceding Studies

a) Research on smart sharing city

Komeiji[4] organized existing models of urban planning for sustainable development, suggested the smart sharing city as a new model and defined it as a city which effectively and efficiently utilizes sharing activity, and which pursues the concept of compact city and smart city. He also emphasized that in smart sharing city, sharing activity must provide benefits to both social and personal at the same time. In another study, Komeiji[5] introduced benefits followed by sharing mobilities and sharing urban spaces on individuals and society.

b) Research on sharing economy and sharing city

Hamarai[6], in his study on sharing economy and collaborative consumption, defined sharing economy as an activity of sharing the access to resources and services between people within the community. Chang[7] defined the sharing city as a city which economic activities are driven by sharing economy and sharing spaces are provided enough for citizens to use. He also derived an index to measure sharing city level of three major cities in Korea. Chasin[8] analyzed 522 sharing economy enterprises all over the world. Then he categorized the type of resources shared by peer-to-peer sharing activity and sorted out resource types based on their popularity.

c) Research on comparative analysis of city-scale indicator frameworks

Neirotti[9] provided an overview of domains and sub-domains of smart city highlighted in several urban development studies. Ahvenniemi[10] divided the indicators from smart city and sustainable city assessment frameworks refer to the 10 sector categories, to see the difference between the smart city frameworks and urban sustainability frameworks. Huovila[11] developed a taxonomy for smart sustainable city frameworks and used it to analyze the difference in the balance of indicators in indicator standards based on their urban focus and evaluation purposes.

(2) Novelty in this research

There are various existing indicator frameworks designed to evaluate the performance of sustainable city smart sustainable city and several comparative analyses between these indicator frameworks have been done. However, these studies have barely focused on the indicators measuring sharing activity or sharing economy.

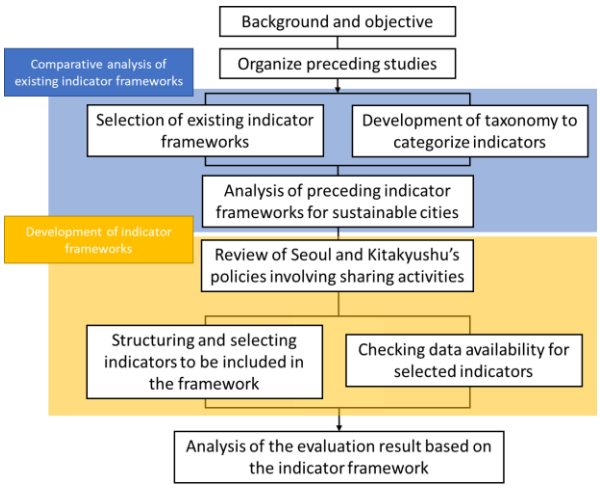

Fig.1 Flow of research

Also, the smart sharing city does not have an assessment tool to evaluate the performance. Indicator framework developed for smart sharing city would be necessary to monitor the performance and development progress of the city.

(3) Research framework

The research is conducted as shown in **Fig.1**.

First, after definitions of smart sharing city and sharing economy are clarified through the review of existing studies, characteristics of existing indicator frameworks for sustainable cities are evaluated through comparative analysis. Then, based on the analyzed results, indicator framework for smart sharing city is developed.

3. COMPARATIVE ANALYSIS OF INDICATOR FRAMEWORK

(1) Selection of frameworks for analysis

This study evaluates eight sets of existing indicator frameworks, which are listed in **Table 1**, to clarify the characteristics of indicator frameworks designed

Table 1 Selected eight indicator frameworks for analysis

Abbreviation	Full Name of Indicator Framework	Year published	Target region	Target city type	No. of indicators
SMGSDP	Seoul Metropolitan Government Sustainable Development Plan	2015	Seoul	Sustainable	30
CASBEE-City	Comprehensive Assessment System for Built Environment Efficiency for Cities	2013	Cities in Japan	Sustainable	26
SSSD	Swedish Strategy for Sustainable Development	2006	Cities in Sweden	Sustainable	87
CICI	China Integrated City Index	2017	Cities in China	Sustainable	175
OneNYC	OneNYC 2050: New York City's Strategic Plan	2019	New York City	Sustainable	83
ISO 37120	The International Organisation for Standardization 37120: 2018 Sustainable cities and communities — Indicators for city services and quality of life	2018	International	Sustainable	104
ISO 37122	The International Organisation for Standardization37122: 2019 Sustainable cities and communities — Indicators for smart cities	2019	International	Smart sustainable	80
UNECE-ITU	The UNECE-ITU Smart Sustainable Cities Indicators	2015	International	Smart Sustainable	72
Total Number of Indicators to be Analyzed					657

for sustainable cities. Among large variety of indicator frameworks, eight sets of indicator framework are selected, based on the four criteria designed for this research.

The frameworks are chosen by using four criteria: 1) the target area to be evaluated by the framework must be a city scale; 2) the framework must be published by the major international standardization organizations or developed by local government for reliability; 3) the framework must have enough description or measurement method of the indicator; 4) the framework must include indicators that measure urban sustainability.

(2) Evaluation of indicator frameworks through categorization

As a result, in total of 657 indicators from 8 different sets of indicator frameworks are analyzed. Indicators are categorized by city sectors and urban focuses according to the structure as in **Fig.2**.

City sector includes 10 categories which are: *Natural environment; Built environment; Water and waste management; Transportation; Energy; Economy and innovation; Education and culture; Health and safety; Governance and public engagement;* and *ICT*. City sector represents the urban living sector where city's project can be intervened and its implication on urban sustainability improvement can be reflected.

Urban focus includes 3 categories which are: *Sustainability*, *Smart* and *Sharing*. As the main purpose of adopting smart technology and sharing economy in the city is to achieve urban sustainability, *Sustainability* is considered as a concept which includes *Smart* and *Sharing* category. Urban focus represents the strategy which city adopts to achieve urban sustainability by means of smart technology such as ICT or sharing economy. Urban focus is further divided into *Society*, *Environment* and *Economy*. It is to identify the indicators relevance to either social, environmental or economic sustainability.

For evaluation, scores are distributed based on each indicator's relevance to city sectors and urban focuses. Thus, to what extent do indicators associated with each of city sector and urban focus can be clarified.

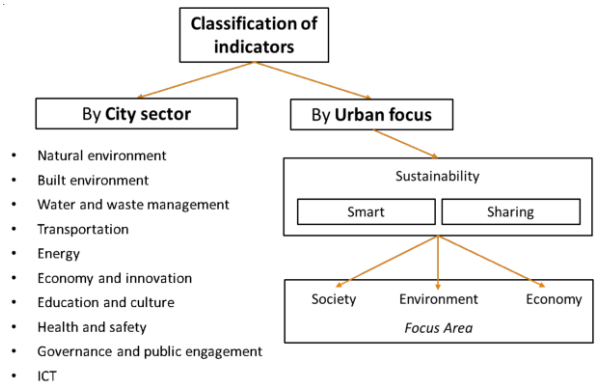

Fig.2 Categorization structure for comparative analysis of indicators

(3) Characteristic of indicator frameworks

Based on the result of score distribution by city sector category, **Fig.3** is drawn. It shows the proportion of indicators relevant to each of city sector. According to **Fig.3**, it is found that majority of indicator frameworks except ISO 37122, included "Health and Safety" and "Economy and Innovation" as top two sectors which gained the highest points (average 20%). On the other hand, "Energy" (average 5%), "Transportation" (average 6%) and "Built Environment" (average 6%) are sectors which gained the lowest points.

Fig.4 is drawn based on the score distribution result by urban focus category, showing proportion of indicators associated with each of urban focus. It is observed that majority of indicators in every framework are directly associated with sustainability (average 89%), with no connections to or integration with smart technology or sharing economy. Overall, only few numbers of urban sustainability indicators are reflecting smart technology (average 8%) or sharing economy (average 3%).

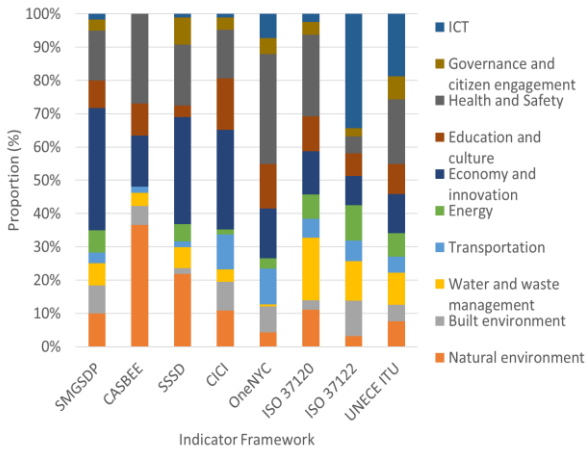

Fig.3 Proportion of indicators by city sector

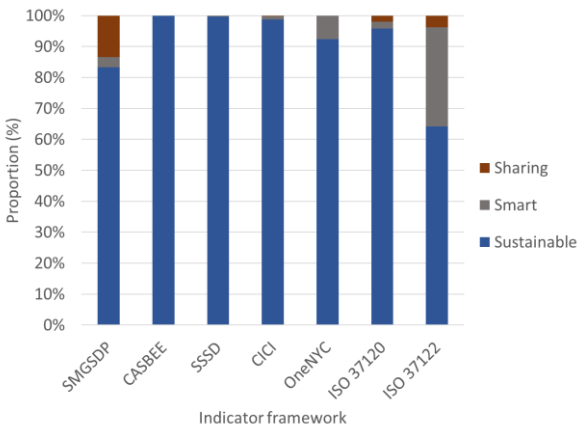

Fig.4 Proportion of indicators by urban focus

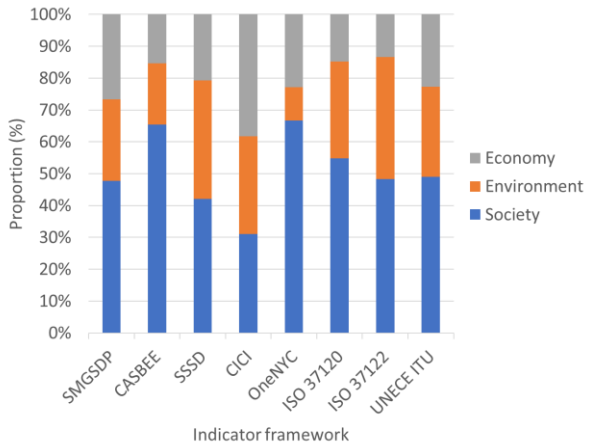

Fig.5 Proportion of indicators by focus area

Fig.5 shows the proportion of indicators associated with economic, environmental and social sustainability. From the result, it is confirmed that 7 out of 8 indicators included indicators which are relevant to social sustainability the most (average 50%). Indicators related to economic and environmental sustainability are relatively evenly distributed, by average 22% and 28%, respectively.

To summarize, the result of comparative analysis highlights that for some of city sectors, such as "Transportation" and "Built Environment", their implication on improved urban sustainability resulted by city's project is underrepresented.

The result of comparative analysis also showed that analyzed frameworks significantly lack indicators which represent implication of smart technology or sharing economy, implying that current indicator frameworks to measure urban sustainability are not incorporating smart technology and sharing economy as means to achieve sustainability.

4. SEOUL AND KITAKYUSHU'S STRATEGY ON URBAN SUSTAINABILITY

(1) Selection of case study area

Seoul, Korea and Kitakyushu, Japan are selected as case study areas. Their government-driven and private organization driven city projects are reviewed and indicator framework is developed based on the review. Consequently, Seoul and Kitakyushu's progress on smart sharing involved programs is evaluated.

Seoul is one of the leading global cities with a specific strategy devoted to the sharing economy[12]. Its leading effort to realize sustainable city through urban development which incorporates strategies for smart city and sharing city corroborates Seoul's preparedness to work towards the smart sharing city and achieve urban sustainability.

Although Kitakyushu does not have a specific urban development strategy which is entirely devoted to the sharing economy or smart city, the city is operating several projects which integrates sharing economy. Additionally, its remarkable performance towards the UN Sustainable Development Goals (SDGs) and acknowledgment as SDGs Future City by the Japanese government and SDGs Pilot Model City by OECD show Kitakyushu's possibility to transform towards smart sharing city.

(2) Seoul's strategy on urban sustainability

Seoul has been recognizing the necessity of sustainable urban development. The city's commitment to sustainability is evident in the Smart Seoul 2015 project and Sharing City, Seoul project.

Through the Smart Seoul 2015 project, Seoul attempted to integrate smart technologies into the city. One of the main achievements of the project was building up smart infrastructure by expanding areas with free public Wi-Fi connection accessible throughout the city, providing an environment where sharing activity can spread.

Sharing City, Seoul project was first announced in 2012, aiming to create new jobs, to solve environmental issues and to recover trust-based reciprocity between people by incorporating the concept of sharing economy into the city's urban policy. As a part of the strategy, the city introduced new ways to share resources between people, including car sharing, public bike sharing and house sharing.

Three policies of Seoul listed on **Table 2**, which are related to sharing activity and imposed in city sector of transportation and built environment are reviewed.

Table 2 Summary of Sharing Policies in Seoul

	Car Sharing	**Bike Sharing**	**Shared House**
Policy	*"Nanum Car"*	*"Seoul Bike"*	*"Room Sharing Between the Generations"*
Purpose	▪ Reduce traffic demand ▪ Improve air quality ▪ Resolve shortage of parking space ▪ Reasonable transportation expenses	▪ Promote environmentally friendly transportation mode ▪ Resolve traffic congestion, ▪ Improve infrastructure for bicycle	▪ Resolve housing problem of students and elders ▪ Provide extra income for elders
Decision makers	Cooperation between local government and private enterprises	Local government driven	Local government driven
Characteristic	▪ Partially electric vehicles ▪ Private enterprises manage and maintain the service/ cars ▪ Government enact regulation and promote the service	▪ Nonelectric assist bicycle ▪ Rent and pay by smartphone	▪ Application accepted via website

"Nanum Car" is a shared car program in Seoul which began from 2013 in order to reduce heavy traffic demand and to secure a pleasant public urban space. "Seoul Bike" is a public bike sharing program which has been operated since 2015 in order to resolve traffic cognition, air quality problems, and to improve citizen's health. "Room Sharing Between the Generation" is a room sharing service for university students and elderly people who live alone in the house they owned. These three policies are part of the Sharing City, Seoul project.

(3) Kitakyushu's strategy on urban sustainability

Kitakyushu has been working on developing into a sustainable city, by incorporating SDGs and concept of sharing economy into the city's development plans.

Through the Kitakyushu Environmental Capital Comprehensive Transportation Strategy, the city is endeavoring to provide environmentally friendly mode of transportation and to improve mobility of elderly people and students. As a part of the strategy, the city introduced new transportation mode services including car sharing and public bike sharing.

Kitakyushu has been also working on creating an environment where people can freely share their ideas and start a new business. Thus, the city is operating a shared office which provides coworking space to anyone in need.

Three policies of Kitakyushu related to sharing activity and imposed in city sector of transportation and built environment are reviewed. These policies are listed on **Table 3**.

"Eco-drive" is a Kitakyushu's car sharing program initiated in 2010, in order to resolve environmental problems raised by private transports. "City Bike" is a public bike sharing service operated for the purpose of reducing the use of private cars and providing connections between public transit systems. Kitakyushu teleworking center is a coworking space located in Kokurakita-ku, Kitakyushu city which provides coworking space, smart devices and start-up counseling program.

Table 3 Summary of Sharing Policies in Kitakyushu

	Car Sharing	Bike Sharing	Shared Office
Policy	*"Eco-drive"*	*"City Bike"*	*Kitakyushu Teleworking Center*
Purpose	▪ Promote the use of next-generation vehicle ▪ Raise awareness of low emission vehicle ▪ Reduce CO_2 emission from vehicles	▪ Promote environmentally friendly transportation mode ▪ Reduce personal car usage, ▪ Support public transportation mode	▪ Create employment opportunity ▪ Revitalize economy ▪ Support SMEs' business
Decision makers	Non-profit organization (NPOs) (cooperate contract)	Cooperation between local government and non-profit organizations (NPOs)	Cooperation between local government and social enterprises
Characteristic	▪ All electric vehicles (EV) ▪ Major role is the promotion of EV ▪ Service area mostly limited near the city office	▪ All electric assist bicycle; ▪ Rent and pay by smartphone (24 hours available) ▪ Managed and maintained by NPO	▪ Reservation available by phone or online

5. INDICATOR FRAMEWORK FOR SMART SHARING CITY

(1) Composition of indicators

In order to access the result of activities and to monitor the desired long-term changes, the input-process-output-outcome-impact model is selected and adopted as a backbone structure of conceptual model. Therefore, the process of implemented policies in Seoul and Kitakyushu generating results in relation to urban sustainability will be effectively visualized. The structure and brief explanation of each stage of the model is presented in **Fig.6**.

Indicators will be grouped into five different stages: input, process, output, outcome and impact.

The first three stages, input, process and output, will mainly represent the process of the project introduced and become established. Therefore, these stages will be composed of indicators which measure allocated resources and investigation for a program to take root and its immediate progress. The last two stages, outcome and impact, will mainly represent the short term and long-term result which a program intended to achieve. Additionally, impact indicators is connected to one of 17 SDGs proposed by United Nations to represent long-term contribution to urban sustainability.

Consequently, two sets of indicators, each for assessment on shared mobility related policies and shared built environment related policies, will be developed.

(2) Development of conceptual model

Referring to the purpose and characteristic of Seoul's and Kitakyushu's policies reviewed, the conceptual model is developed. Conceptual model is designed each for shared mobility and shared built en-

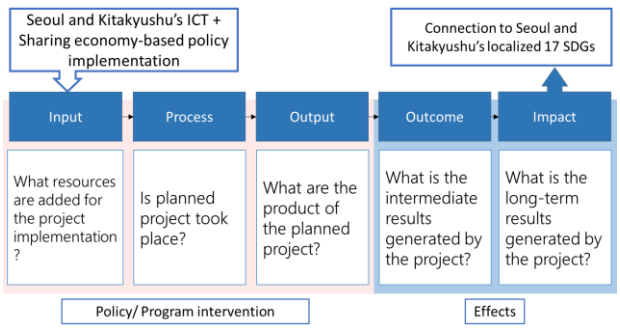

Fig.6 Structure of Conceptual Model

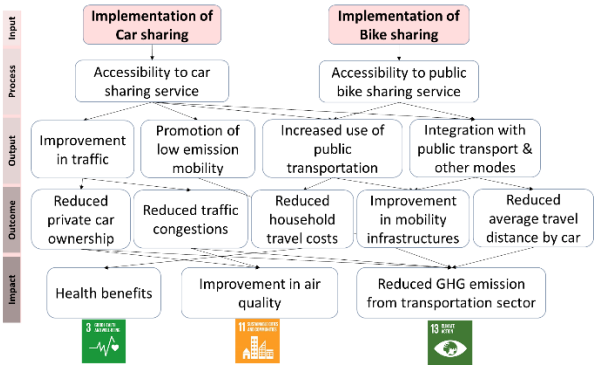

Fig.7 Conceptual model for shared mobility

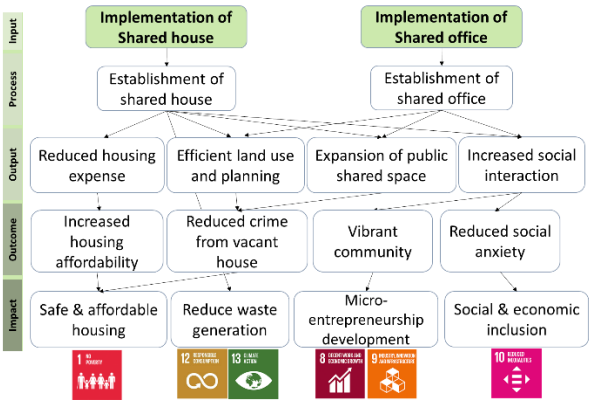

Fig.8 Conceptual model for shared built environment

vironment. Conceptual model on shared mobility addresses policies imposed in transportation sector, including car sharing and bike sharing programs, and shared built environment addresses policies on shared house and shared office.

Fig.7 and **Fig.8** show conceptual model created for shared mobility and shared built environment, respectively.

The conceptual model of sharing economy is designed to summarize the intervention of implemented sharing economy policy and its gradual impact to sustainable development in 5 stages (input-process-output-outcome-impact). It also visualizes the connection between implications in each stage by arrows. Then, based on the conceptual model designed, objectively verifiable indicators which can measure the performance of policy at each stage are selected.

(3) Selection of indicators

Then, 18 indicators and 20 indicators are selected and included in the framework based on the conceptual model on shared mobility and shared built environment, respectively. While selecting indicators, availability of the data is checked simultaneously.

Part of indicator framework for shared mobility is shown in **Table 4**. The column, "what to measure?" is linked to the contents in each bubble of the conceptual model.

Table 4 Example of indicators for shared mobility

#	Level	What to measure?	Indicator
1	Input	Implementation of car sharing service	Number of stations accessible for car sharing
2	Process	Accessibility to car sharing service	Number of cars available for car sharing service
3	Output	Increased use of public transportation	Traffic volume by public transportation
4	Outcome	Reduced private car ownership	Number of cars (passenger cars) registered
5	Impact	Reduced GHG emission from transportation sector: SDGs 13. Climate action	CO2 emissions from private cars

6. ANALYSIS BY THE DEVELOPED INDICATOR FRAMEWORK

(1) Data interpretation

To evaluate the change in each indicator over time, two numerical data in different years are acquired from the online database. Then, the change is considered by the traffic light rating system in order to show the trend of improvement, no change or deterioration for each indicator measure more easily.

After calculating the percentage point difference or the percent change between two data points of the start year and the end year, colored markers are labeled according to the condition set as in **Table 5**. For the rating, the desired direction of an indicator was considered as well. For example, the desired direction of the indicator, "CO_2 emission from the transportation sector" is "negative" as it is desirable that the value to decrease in the future.

(2) Assessment result by indicator framework

a) Results of Seoul

After applying the traffic light rating system to the developed indicator framework, the trend of each indicator is measured, and the overall direction of Seoul's urban policy related to the smart sharing city is identified.

Table 5 Traffic light rating system

Marker	Condition	Trend Description
▲	greater than 3% toward desired direction of indicator	Improvement
▬	between 3% and -3%	No significant change
▼	greater than 3% toward undesired direction of indicator	Deterioration
(blank)	Measurement not available	Cannot be assessed

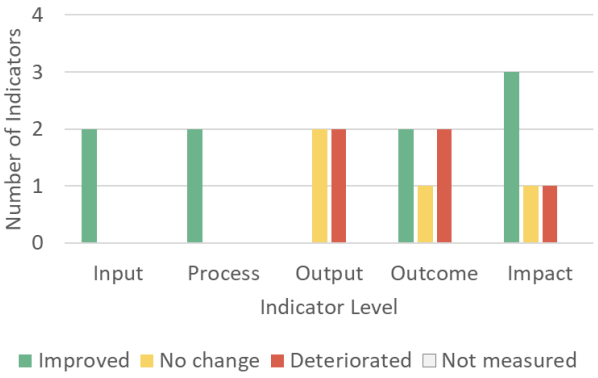

Fig.9 Summary of trend in shared mobility of Seoul

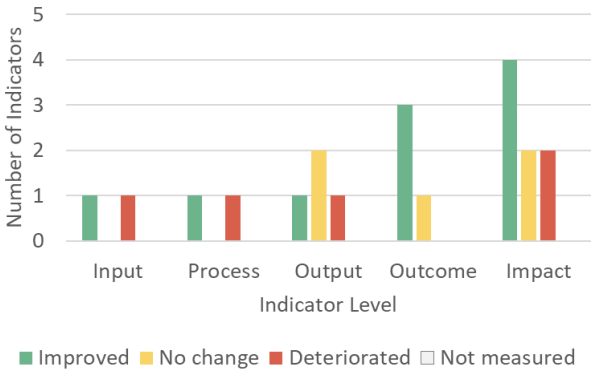

Fig.10 Summary of trend in shared built environment of Seoul

Fig.9 represents trend of indicators associated with "Nanum Car" and "Seoul Bike" policies of Seoul. Here, indicator measures under input and process level are improving while indicators under output and outcome level are showing mostly showing no change or degeneration. It can be comprehended that although the government's support and actions taken to carry out Nanum Car and Seoul Bike program have been well managed, the intervention that the programs produced is insufficient.

Fig.10 shows trend of indicators associated with "Room Sharing Between Generations" project and shared offices in Seoul. Here, in most of levels, indicators are showing mixed trends of improvement, no change and deterioration. Evaluating more specifically, majority of indicators in input-outcome level showing no change or degeneration are directly related to housing affordability. The result implies that Seoul achieved efficient use of urban spaces, however, its overall progress in providing affordable housing is failing.

b) Results of Kitakyushu

The trend of indicator measures and the overall direction of Kitakyushu's urban policy related to the smart sharing city is assessed by the traffic light rating system.

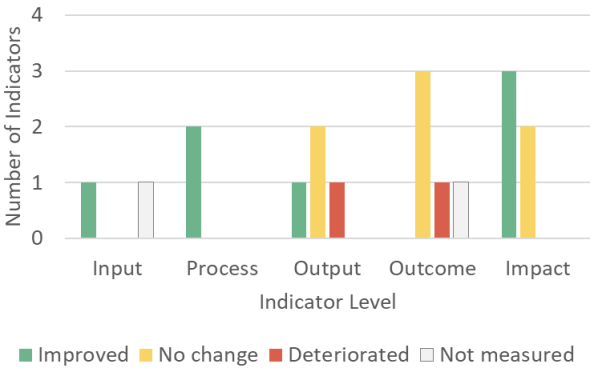

Fig.11 Summary of trend in shared mobility of Kitakyushu

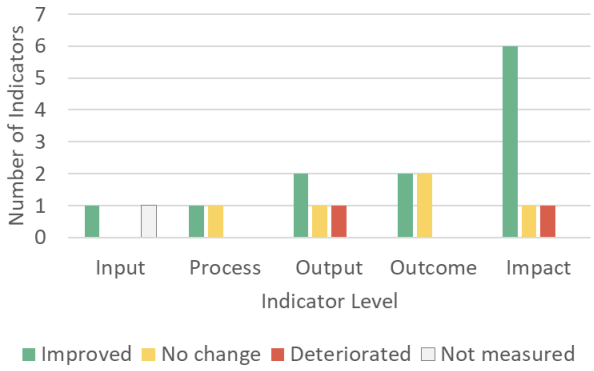

Fig.12 Summary of trend in shared built environment of Kitakyushu

Fig.11 represents the trend of indicators relevant to "Eco-drive" and "City Bike" policies of Kitakyushu. Figure is showing positive trends in input and process level, while showing relatively large number of indicators without remarkable changes in output to impact level. The result can be explained that product from the deployed projects is not reflected instantly as the scale of the projects is small relative to the city's population.

Fig.12 shows the trend of indicators relevant to Kitakyushu Teleworking Center and shared houses in Kitakyushu. In this figure, only two indicators in output and impact level are showing deteriorating trend. Although it is showing positive progress overall, Kitakyushu still need improvements in output and outcome level. It is observed that resources and essential infrastructures assisted by the city in input and process level are not fully utilized, thus not fully delivering the anticipated products.

7. CONCLUSION

(1) Key findings of research

In this research, eight indicator frameworks developed to evaluate the urban sustainability of the city are evaluated and policies related to sharing economy

in Seoul and Kitakyushu are reviewed. Then, based on the review, indicator framework which can assess the progress of Seoul and Kitakyushu toward smart sharing city is developed and applied.

Through this study, characteristic of existing indicator frameworks for sustainable cities is clarified: 1) only few of them includes indicators which measures sharing activity; 2) they are underrepresenting the implication on improved urban sustainability resulted by city's project intervened in transportation and built environment area.

Moreover, by the evaluation through the developed indicator framework, Seoul's and Kitakyushu's project and progress on car sharing, public bike sharing, shared house and shared office, whose implication on improved urban sustainability take place in the transportation sector and built environment sector, are carefully assessed. Consequently, policies' current strength and area to take remedial action in order to deliver the anticipated benefits of the sharing involved policy are clarified.

(2) Follow up

In this study, Seoul and Kitakyushu are chosen as case study areas and their policies are reviewed to measure the progress towards smart sharing city. Majority of indicators included in the developed indicator framework are compatible with cities around the world. Therefore, evaluating the progress of multiple cities which shows preparedness or potential to transform into smart sharing city with unified indicator framework will allow cities check their progress relative to other cities. Also, it will be possible to set international target for smart sharing city based on the city which shows the best performance.

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