Urban Development Planning Strategies in Integrated Response to Climate Change

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ABSTRACT：This study intended to develop urban planning strategies in integrated response to climate change. The expert delphi survey method was employed to verify these planning components. The survey was performed three times for about 60 days by 30 experts majoring urban planning, environmental planning, climate change, and so on. Mitigation, adaptation, and cultivation were basic sectors to respond to climate change with integrated approach under city level. The detailed objectives included carbon-reduction, carbon-sequestration, controling urban heat island(UHI) effect, water management, operations and management system, and the cultivation activities. And the planning domains were composed of energy, industry and resources, urban spatial structure, architecture, urban forest and agriculture, urban heat reduction and air quality control, flood and water quantity management, water quality control, governance and community, mitigation-adaptation program, eco-industrial cluster development program, education and public relations(PR), and the vitalization of carbon-neutral eco-community. Also, this study developed the strategies in accordance with the planning sectors. The mitigation and adaptation, which include spatial sector, were composed of spatial and physical planning uints. The cultivation sector included operations and management system or planning system for mitigation and adaptation, so that this study could respond to climate change in an integrated manner, considering both physical and non-physical elements.

KeyWords：Integrated Response to Climate Change, Urban Planning Model, Mitigation, Adaptation, Cultivation

I. Introduction

The core components of urban planning in response to climate change are mitigation and adaptation. By reducing greenhouse gas (GHG), climate change is mitigated and its effects are reduced (adaptation).

Looking at the history of climate policy, scientific and political attention has been focused on the mitigation of climate change and has taken a dichotomous approach (Biesbroek et al., 2009).[1] Therefore, at present, the need for a citywide integrated and comprehensive approach is being recognized (Bart, 2010; Becken, 2005; Biesbroek et al., 2009; Chang and House-Peters, 2010; Falloon and Betts, 2009; Hamin and Gurran, 2009; Jo et al., 2009; Larsen and Gunnarsson-

[1] Looking at the evolution of climate policy, although adaptive strategies are required at the initial stages, scientific and political attention has been focused on the mitigation of greenhouse gasses emission. The elements for adaptive strategies were ignored as defeatists, and for a long time, scientific and political discourse placed improper limits towards mitigation (Schipper, 2006; Tol, 2005).

Ostling, 2009; Laukkonen et al., 2009; Puppim de Oliveira, 2009; Roy, 2009; Saavedra and Budd, 2009; Schwarz et al., 2010; Wagner, 2008; Wilbanks et al., 2003). In particular, urban planning, with its perspective on sustainability science, has primarily focused on the mitigation approach, whereas adaptation has been considered only as one of the aspects (Chang and House-Peters, 2010), and the integrated urban planning system for climate change has remained at the initial stages of research. Wende et al (2010) proposed a plan for a compact urban spatial structure and suggested the need to present a comprehensive plan. Therefore, an urban planning model that can respond to climate change through an integrated and comprehensive measure needs to be developed. On the other hand, Falloon and Betts (2009) examined the importance of interaction and feedback on evaluating the impact of climate change on agriculture and water and they conducted a quantitative evaluation study.

In the 2007 Synthesis Report, IPCC (2007) reported that high certainty on mutual supplementation of adaptation and mitigation can significantly reduce the risk of climate change (Saavedra and Budd, 2009) and, even though it is hard to find the interconnectedness of mitigation and adaptation, formulation of mutual synergies is urgently required.

As such, mitigation and adaptation are responses to the causes and consequences of climate change, which is contradictory in conceptual terms. However, because generation of the synergistic effects between mitigation and adaptation is needed, a citywide integrated response to climate change is required. For this, a citywide area that can comprehensively respond to climate change must be selected and a strategy must be set up according to the selected area.

Climate change is a very important factor in spatial planning because mitigation and adaptation gave spatial extents (Biesbroek et al., 2009). Furthermore, in order to solve the issue of climate change, it is required to enhance the ability to adapt to, cope with, and formulate the change without losing the option of future adaptability in communities (Folke et al., 2003; Saavedra and Budd, 2009). Moreover, governance research is being accelerated, which is a very important component for an integrated response to climate change. Because the vulnerability to climate change varies depending on their class in its degrees of impact, thus accompanying equity problems., a governance-based approach is required, which promotes stakeholder engagement and is community-oriented.

In fact, in order to implement the holistic approach, various planning areas such as the combined use of land within the strategic framework, transportation, regional economic development, environmental justice, and urban planning are required (Roy, 2009).

The purpose of this study can be presented in two statements. First, it is to propose an urban development plan for a citywide integrated response to climate change. Strategic frameworks, such as the planning sector and planning area, are presented and a strategy based on the strategic framework is proposed. Furthermore, non-physical elements (in the form of governance and community programs) are presented in addition to factors regarding spatial planning. Second, its purpose is to set strategic weights on planning sectors and planning areas and to prioritize strategies for each area based on the set weights.

Ⅱ. Theoretical Consideration

1. An integrated urban development area in response to climate change mitigation

Responding to climate change generally occurs through mitigation and adaptation, and the aspects of response are as follows. The focus of mitigation is on the reduction and sequestration of GHG emission whereas adaptation focuses on the sensitive areas regarding the impact of climate (Wilbanks et al., 2003). In other words, mitigation is comprised of GHG emission mitigation and GHG sequestration and adaptation can be interpreted as the adaptation to climate

sensitivity and vulnerability.

〈table 1〉 urban development area proposed for an integrated response regarding climate change by researchers

researcher	mitigation	adaptation	Cultivation
Ruth and Rong(2006)	transportation infrastructure: road. land use energy system	water supply system water quality and flood management system urban heat island(UHI) health of species	-
Murley(2007)	buildings land use planning renewable green energy transportation waste management	urban landscape water/waste water	economic development education and promotion
Falloon and Betts(2009)	mitigation/adaptation of agriculture mitigation/adaptation of water management mitigation/adaptation of ecosystem		-
Wagner(2008)	simplified traffic system building	-	citizen participation policy and practical strategy
Griffiths et al.(2007), Bulkeley and Kern(2006), Granberg and Elander(2007)	-	-	climate change response governance urban governance

In this respect, mitigation measures can be largely categorized as reduction measures regarding the GHG that is emitted from the GHG emission source and sequestration measures regarding the emitted GHG.

When examining the local government GHG emission volume determining guide,[2] items regarding direct emissions are classified in sections such as energy, industrial processes, and waste as well as agriculture, forestry and other land use and, among these, energy, industrial processes, waste, agriculture, and livestock are categorized as emission sources whereas forestry and land use are categorized as sequestration sources. Of which, the energy sector is categorized into direct combustion, fugitive emission, and carbon capture/storage. Direct combustion can be largely categorized into the urban energy industry, manufacturing/construction industry, commerce/home/agriculture-forestry-fishery industry, and energy consumption by transportation. The transportation sector is closely related to urban spatial structures, as in the roads and land usage, which are the foundations of the city. This is because roads are elements directly related to the infrastructure of transportation and land usage is an element that determines the behavior of transportation. In other words, urban spatial structures determine the travel characteristics of the individual and travel characteristics influence the energy consumption for transportation in the entire city (Kim, et al., 2009). In addition, Bart (2010) noted the occurrence of a stronger correlation between carbon dioxide emissions of the transportation sector and the increase of artificial land in comparison with the correlation regarding GDP or

[2] Korea Environment Corporation, 2010, the municipal greenhouse gas emission estimation guidelines.

population, through which it can be confirmed that land usage is closely related to GHG emission by the transportation sector.

The industrial processing sector is closely related to the usage and flow of resources used and discarded by production.

<Table 1> shows the analysis of the urban development area proposed for an integrated response regarding climate change by researchers. The details are as follows.

Ruth and Rong (2006) suggested areas such as the water supply system, water quality and flood management system, transportation infrastructure, energy system, urban heat island (UHI), and the health of species as urban areas regarding the mitigation and adaptation of climate change. Murley (2007) suggested, in the Florida plan toolbox, areas such as the buildings, economic development, education and promotion, land use planning, renewable green energy, transportation, the urban landscape, waste management, water, and wastewater as areas in response to climate change. Falloon and Betts (2009) explained that elements of agriculture, water, and the ecosystem in defining climate change, adaptation/mitigation of agriculture, adaptation of water management, and the relationship among ecosystem components (vegetation, soil, etc.) all influence the biological GHG emission mitigation.

In the New Governance, where partnerships and networks between the government and the civil society play a crucial role, networks, cooperation and partnership, co-production, social orientation, and community culture are highly emphasized (Ban et al, 2009). In other words, citizen participation and a partnership-based, community-focused approach are essential to solve urban problems through New Governance.

In particular, in order to solve the issue of climate change, it is required to enhance the ability to adapt to, cope with, and formulate the change without losing the option of future adaptability in communities (Folke et al., 2003; Saavedra and Budd, 2009).

Ⅲ. Research Method

This study utilized the literature reviews, case studies, and expert Delphi and AHP surveys.

First, the concepts of mitigation and adaptation were defined and, based on the definitions, a strategic frame was set up from the relevant literature reviews. The strategic frame consisted of the planning objective and the planning domain.

Based on the strategic frame, the strategic factors were analyzed and derived from the city planning paradigms, such as ecological city, sustainable city, compression city, new and urbanism along with ecological industry development, ecology network, urban agriculture, heat island management, water quantity and quality management, flood control, ecological architecture, traffic normalization, Transit Oriented Development (TOD), Mixed Use Development (MUD), Smart Growth, and urban village. Furthermore, strategic factors were derived from investigations of new governance cases, community cases, and domestic and international cases of climate change response city planning.

The suitability verification of the derived strategic frame and the strategy were carried out through the expert Delphi surveys. A group of 30 experts (professors, researchers, etc.) was formed who had conducted studies on city planning, particularly regarding sustainable city planning, ecological city planning, and climate change response city planning. The verification was conducted through suitability evaluation and re-evaluation processes by using open questions and closed questions together for each evaluation item. The range of closed questions was from not very valid to very valid, the Likert scale of 5 points was used for evaluation, and, through the open questions, the opinions of evaluators were collected. The re-evaluation provided an opportunity to answer again by providing a frequency analysis and median values of the response results of the first evaluation.

〈Table 2〉 outline of expert delphi and AHP survey

time	period	survey method	contents	form of question	method of analysis	analysis program
1	25. Jan. 2010 ~30. jan. 2010	E-mail Fax	framework feasibility assessment of urban planning strategy in integrated response to climate change	closed question (5-point Likert scale)	content analysis, descriptive statistic (frequency, percentage, average, median value)	SPSS
2	08. Feb. 2010 ~12. Feb. 2010		framework feasibility reassessment of urban planning strategy in integrated response to climate change			
			feasibility assessment of urban planning strategy in integrated response to climate change			
3	26. Feb. 2010 ~05. Mar. 2010		feasibility reassessment of urban planning strategy in integrated response to climate change			
4	25. Mar. 2010 ~10. Apr. 2010		urban planning strategy in integrated response to climate change : determination of weight on basic direction, planning part, planning domain, and strategy	priority importance	AHP method	Expert Choice 2000

The expert Delphi surveys and AHP investigations were conducted a total of four times from January 25, 2010 to April 10, 2010. In the first survey, 23 of 30 people responded and suitability verification was conducted for the strategic frame of the planning part and the planning domain. In the second survey, 21 people responded and the re-evaluation of the strategic frame and the suitability verification of the strategy were conducted. In the third survey, 20 people responded and the strategy re-evaluation and the suitability verification of the planning factors were conducted. In the fourth survey, 21 people responded and the following were carried out: the basic direction of strategy for integrated climate change response city planning formation, the planning part, the planning domains, and the calculation of weights for the strategy by domain.

The age groups of the respondents were 40–49 (52.4%), and 30–39 and 50–59 (23.8% each). All respondents held Ph.D. degrees and the numbers of years of experience in their specialized areas were: 33.3% had experience for 5–10 years; 33.3 % had greater than or equal to 20 years' experience; 19% had 10–15 years' experience; and 14.4% had 15–20 years' experience. Summarizing these characteristics, it is expected that professional judgment can be expected from the surveys (refer to Table 3).

Using the data collected from the Delphi surveys, technical statistical analysis such as frequency analysis, averages, median values, and percentiles were performed. Using the percentiles, validity rates (rates of answering as average or higher), which are rates of responding for "very valid," "valid," and "average," were analyzed. Using the validity rates, averages, and median values, the suitability of each item was comprehensively determined.

In the AHP surveys, the consistency of respondents was increased by checking the importance score along with priorities.

〈Table 3〉 characteristic of expert group

sort		ratio(%)
age	20s	-
	30s	23.8

	40s	52.4
	50s	23.8
	over 60s	-
academic background	bachelor	-
	masters	-
	Ph.D	100
experience	5~10years	33.3
	10~15years	19
	15~20years	14.4
	over 20years	33.3

Ⅳ. Integrated Climate Change Response City Formation Strategy

1. Strategic frame set-up

Based on the theoretical study, the factors required for responding to climate changes comprehensively at the city level are mitigation, which reduces greenhouse gas emission and absorbs emitted carbon, and adaptation to changed climate. To realize these two basic domains efficiently, changes in the way of life must accompanied, such as civil practice, community-wise approach, non-physical plan and practice, and governance. As a comprehensive concept for these domains, this study proposes “cultivation” since the dictionary definition of cultivation is shown as way of life, belief/attitude, man-made things (art), and fostering/encouraging/promoting/active mingling. Amongst various meanings of cultivation, this study uses the meaning of mingling as a representative meaning in Korean.

In the survey results of the planning part, the mitigation (100), adaptation (100), and mingling (95.4) all showed a validity rate of more than 90% and the averages and median values showed the validity results overall of each item (refer to Table 5). Therefore, mitigation, adaptation, and cultivation were selected for the planning part.

Examining the planning part from the opinions of respondents, it becomes clear that the classification of mitigation, adaptation, and cultivation is agreed on overall, is valid, and mitigation and adaptation are the two main axes. Furthermore, looking at the cumulative carbon amount up to now and the occurrence trend for the future, it is determined that the validity of adaptation and cultivation will be high. However, regarding the business feasibility and market selection possibility, difficulty is expected in reality for the possibility of their realization and, at the city level, the placement and design of physical facilities should be focused on being able to adapt to changes based on the formation of consensus.

On the other hand, the reason why adaptation appears relatively late seems to be consistent with the opinion of Chang and House-Peters (2010) who regard adaptation as a partial domain because they approach the city planning domain mainly through mitigation as can be seen from the opinions of respondents who answered that measures for reducing the cause at the planning stage, eliminating causes, and savings are top priorities in response to climate changes. In addition, there was an opinion that the reason for mitigation being high in other parts was because the mitigation type is very important for building a new city that is not an existing city.

〈Table 4〉 strategy framework(plan)

planning part		planning domain
Mitigation	Reduction	energy
		industry.resource

		urban spatial structure
		architecture
	Sequestration	forest
		agriculture
Adaptation		urban heat island management
		water management
Cultivation		community
		governance
		education and promotion

〈Table 5〉 planning part 1st delphi survey result

	validity rate(%)		average	median value
	valid	normal		
Mitigation (reduction, sequestration)	95.5	4.5	4.50	5
Adaptation	68.2	31.8	3.91	4
Cultivation	81.8	13.6	4.05	4

Since cultivation is recognized as a required condition for an effective response to climate changes, its criterion becomes relatively lower. It was pointed out that while cultivation is an absolutely necessary value, it is too abstract to set it as an objective and carry it out. Therefore, practical alternatives are required to be derived for effective responses in future strategies and in planning index development.

As a result of the suitability surveys regarding the mitigation, adaptation, and cultivation of the planning domains of the planning part, in the planning domains of carbon reduction as mitigation, all domains of energy, industry/resources, urban spatial structure, and architecture were determined to be valid since they showed the validity rates of 100% and the averages and median values of 4 or higher. Regarding this, there was an opinion that, since the technology development and marketability of carbon reduction are questions of time and cost, step-by-step approaches according to implementation of techniques of urban spatial structure and environment-friendly architecture is valid.

For the planning domain of mitigation through carbon sequestration, forest and agriculture were determined to be valid although, relatively, agriculture had a high response rate on average. This response propensity confirms that, although its importance and validity is acknowledged, as shown in the opinions of respondents that setting up the criteria for a green area ratio and a green area system to absorb carbon is very important,[3] because of the following several aspects, it was determined to be average. In the development of new cities, conserving forests and agricultural lands for carbon sequestration is very meaningful, but the efficiency (carbon transaction) of forests and agricultural lands in absorbing carbon is not large relative to the costs (efficiency aspect) and the role of city forest is

[3] Similar opinions include: "I think it is better to develop forest for carbon sequestration in the outer skirt of 'city. The forest in the city should be set up for city-wise uses. Nevertheless, it is better to have as many forests as possible in the city."

mainly regarded in factors required for adaptation to the urban heat island and water circulation[4] instead of the carbon sequestration source (redundancy aspect of mitigation and adaptation). Particularly, as it was pointed out that the absorption through agricultural activities is very limited, its application scope will vary depending on individual attributes and the carbon emitted due to agricultural production needs to be rather controlled[5]; its validity will be relatively evaluated low due to the double-sidedness of agriculture being an emitting source and an absorption source and a question mark for agriculture itself in the city.[6] Because of efficiency, redundancy, and double-sidedness, the carbon sequestration showed lower validity than the planning domain in carbon reduction; but, in general, the domain that reduces carbon emission and absorbs emitted carbon is a mandatory factor even though the effect of absorption is very small for the mitigation of climate changes compared to the reduction. Thus, the carbon sequestration by forests and agriculture was maintained as the strategic frame. Furthermore, although the effects of forest and agriculture are included in mitigation and adaptation, from the aspect of land use in the city, since the land use for absorption is represented by green areas, which are forests and agricultural areas, and is directly related to absorption rather than adaptation, forest and agriculture were included in the planning part for mitigation.

〈Table 6〉 strategy framework(plan) assessment: 1st Delphi survey result

planning part		planning domain	validity rate(%)		average	median value
			valid	normal		
Mitigation	Reduction	energy	95.5	4.5	4.50	5
		industry.resource	86.4	13.6	4.09	4
		urban spatial structure	86.4	13.6	4.36	4.5
		architecture	90.9	9.1	4.27	4
	Sequestration	forest	68.2	27.3	3.91	4
		agriculture	54.5	45.5	3.09	3
Adaptation		urban heat island management	68.2	31.8	3.86	4
		water management	54.6	31.8	3.55	4
Cultivation		community	81.8	9.1	3.86	4
		governance	77.3	13.6	4.05	4
		education and promotion	68.2	27.3	4.05	4

Regarding the adaptation sector, the validity rate, average, and median value of urban heat control and water control all turned out to be valid. However, some experts pointed out that the adaptation field would encompass many other sectors, including the ecological environment other than urban heat control and water control. The domains of adaptation are various in kind when specified in detail, but, in the present research, the urban heat island and water, as Ruth and Rong (2006), Murley (2007), and Falloon and Betts (2009), suggest, were set as the planning domains in the aspect of urban environment management for the sake of urban climate change adaptation. The ecology field

[4] Similarly, there was one opinion that was, "the purpose of forest in the city is not to absorb carbon, but to create pleasant city environment."

[5] As an alternative for this, the preparation of a resource recycling system is proposed, whereby realistically economical and popular new renewable energy is used to produce agricultural energy.

[6] One opinion was that there is a problem in having agriculture as a main objective in a city.

was not classified in the planning domain as it is deemed the purpose of management regarding environmental elements such as the green spaces, water, or climate (urban heat island) in the perspective that specifies diversity preservation.

Regarding the harmonization sector, the community, governance, education, and promotion domains were assessed to be valid in general. In this regard, experts gave detailed opinions as follows. Urban governance and education, and community formation would be the cultural foothold encompassing all steps of mitigation and adaptation. In the early stage, education and promotion are highly significant and creating human activities and behaviors as the culture of the life of an ecological community would be highly difficult but deemed to be fundamentally necessary value standards. However, it is necessary to consider the works of people.

As a result of examining the validity regarding the planning sector and the planning domain through the primary survey, a primary strategy framework was determined to be valid in general. However, in order to set the primary strategy framework (item) derived from previous research as a strategy framework for suggesting a strategy, the following supplements were required. The hierarchy within the strategy framework and the depth within the items were differently suggested. When compared to the planning domain of the harmonization, the planning domain of the adaptation was set at a higher level. The planning sector can be understood as the purpose that the planning sector and the strategy pursue.

〈Table 7〉 revised strategy framework(plan) assessment : 2rd delphi survey result

planning part		planning domain	validity rate(%)		average	median value
			valid	normal		
Mitigation	Reduction	energy	100	-	4.86	5
		industry.resource	90.5	9.5	4.10	4
		urban spatial structure	90.5	9.5	4.43	5
		architecture	85.7	14.3	4.24	4
	Sequestration	forest	95.2	-	4.24	4
		agriculture	47.6	52.4	3.10	3
Adaptation	urban heat island management	temperature reduction	85.7	14.3	4.10	4
		air quality management	71.4	28.6	3.86	4
	water management	flood quality management	71.4	28.6	3.57	4
		water quantity	57.2	33.3	3.95	4
		water quality management	71.4	23.8	3.71	4
Cultivation	operational method	community	66.6	28.6	4.10	4
		governance	85.7	9.5	4.00	4
	harmonization activities	education and promotion	80.9	14.3	4.24	4
		mitigation.adaptation program	90.5	4.8	4.05	4

In order to supplement such deficiencies and suggest a strategy, a revised version of the structured strategic framework (shown in <Table 7>) was suggested. As it was deemed that detailed planning sectors for urban heat control and water control for adaptation, the sectors were suggested. Because planning sectors, including community, governance, and educational promotion and programs were necessary, the operational method and harmonization activities were suggested.

Because an agreement was derived about most of the planning sectors and domains in the primary survey, the assessment regarding the suggested revision of the strategy framework was comprehensively requested through

the planning sector.

As a result of the validity assessment regarding the strategy framework revision, it was confirmed that each item was valid in general, and the average and medium values also showed validity. The planning sector consists of mitigation, adaptation, and harmonization. Mitigation consists of carbon reduction and carbon sequestration; adaptation consists of urban heat control and water control; and harmonization consists of operational methods and harmonization activities. The planning sectors of carbon reduction are energy, industry, resources, urban spatial structure, and architecture; and carbon sequestration consists of urban forest and agriculture. Urban heat control consists of temperature reduction, air quality management, and water quality management. Operational method consists of governance and community and harmonization activities consist of an mitigation adaptation program, ecological industry cluster establishment program, resident education and promotion program, and community vitalization program.

〈Table 8〉 revised strategy framework(plan)

planning part		planning domain
Mitigation	Reduction	energy
		industry.resource
		urban spatial structure
		architecture
	Sequestration	forest
		agriculture
Adaptation	urban heat island management	temperature reduction
		air quality management
	water management	flood quality management
		water quantity
		water quality management
Cultivation	operational method	community
		governance
	harmonization activities	education and promotion
		mitigation.adaptation program

2. Strategy formation

By extracting the strategy corresponding to the strategic framework for responding to comprehensive climate change derived from previous research and experts' surveys, a strategy regarding mitigation, adaptation, and cultivation was prepared.

According to the mitigation sector strategy (plan) assessment, mostly validity rate, average and medium values turned out to be high (see <Table 9>). Among them, conversion to and introduction of new renewable energy, improvement of energy efficiency, establishment of a resource cyclical system, TND, TOD, pedestrian-friendly spaces, introduction of eco-friendly construction techniques, and urban forest formation showed validity rates of more than 80%, and the average and medium values also showed a scope between 4 and 5 and, thus, these

strategies can be classified as highly adequate strategies. Traffic calming, the introduction of urban aquiculture, and buffer farmland secure strategy appeared to have a relatively high regular adequacy while the average and medium values were formed at the level of 3 and, thus, a determination on whether to accept them as strategies was required.

〈Table 9〉 assessing strategy(plans) of mitigation part : 2nd delphi survey result

strategy framework		strategy by domain	validity rate(%)		average	median value
			valid	normal		
Reduction	energy	conversion to and introduction of new renewable energy	100	-	4.67	5
		improvement of energy efficiency	100	-	4.62	5
	industry.resource	establishment of a resource cyclical system	85.7	14.3	4.33	4
		Eco-Industrial Cluster	71.4	28.6	3.86	4
	urban spatial structure	MUD(Mixed-Used Development)	66.7	23.8	3.86	4
		TND(Traditional Neighborhood Development)	80.9	14.3	3.90	4
		TOD(Transit Oriented Development)	90.5	9.5	4.52	5
		Traffic calming	52.4	47.6	3.57	4
		pedestrian-friendly spaces	81.0	19	4.24	4
	architecture	introduction of eco-friendly construction techniques	85.7	14.3	4.19	4
Sequestration	forest	urban forest formation	90.5	4.8	4.33	4
		creation and management of large scale forest	85.7	9.5	4.24	4
		building ecological network	76.2	14.3	3.86	4
		protection and restoration of wetland	71.4	23.8	3.81	4
	agriculture	introduction of urban agriculture	47.6	47.6	3.52	3
		buffer farmland secure strategy	38.1	52.4	3.29	3

Regarding the mitigation sector strategy (plan), some experts gave the following opinions. First, in the case of mixed-use development (MUD), there are many research results reporting that it helps to reinforce the function of the urban center and increases the vitality thereof, but the assertion that it is helpful in energy consumption has not been accurately proved. That is, it is deemed that the strategy can be appropriate for land use planning but not for carbon reduction yet. In this regard, improving the efficiency of land use by comprehensively considering land use and transportation through a mix of functions and a mix with public spaces, mutual contact between functions, a social mix, multi-dimensional space uses, job-housing proximity, etc., is a significant purpose of mixed-use development and, thus, it can be deemed that mixed-use development is closely connected to carbon reduction. Second, traffic-calming methods are for improving the degradation of a residential environment resulting from an increase in through traffic, reckless drivers, etc., and it is deemed irrelevant to carbon reduction. In this regard, traffic calming is a physical road equipment installation method for decreasing the rate of car use and speeding and, thus, deemed to be an adequate strategy for reducing carbon dioxide in the traffic sector.

〈Table 10〉 mitigation part, revised strategy(plan)assessment

planning part		planning domain	strategy by domain	revised strategy	modification
Mitigation	Reduction	industry.resource	establishment of a resource cyclical system	establishment of a resource cyclical system/ Eco-Industrial Cluster	integration
			Eco-Industrial Cluster		
		urban spatial structure	TND	space arrangement	modify level
			TOD	revitalizing public transportation	
			Traffic calming	decreasing the rate of car use and speeding	
			pedestrian-friendly spaces	pedestrian/bicycle-friendly spaces	
		architecture	introduction of eco-friendly construction techniques	Passive Design	modify level
				Active Design	
	Sequestration	urban forest	creation and management of large scale forest	creating stadtwald	integration after deletion
			protection and restoration of wetland		
		agriculture	buffer farmland secure strategy	introduction of urban agriculture	integration after deletion

However, because it was determined that the judgments of the experts turned out to be different by suggesting the level item of urban planning methods in the strategy level, the strategy was revised as shown in <Table 10> so that the level was revised and the overlapping contents were deleted and integrated, and a re-assessment, shown in <Table 11> was implemented.

Regarding the mitigation sector strategy revision (plan), every strategy was adequately assessed in general. However, the introduction of urban agriculture was not assessed to have high adequacy, but, as mentioned in setting the strategy framework, because the validity thereof is acknowledged to have efficiency, redundancy, double-sidedness, etc., it appears that the average turned out to be relatively higher and, thus, the introduction of urban agriculture was introduced as an mitigation sector strategy.

Regarding the adaptation sector strategy (plan), strategies of constructing urban waterways, improving surface cover, suppressing anthropogenic heat, increasing green land placed in dots, and increasing green land placed in areas were suggested. As for atmospheric quality management, strategies of securing wind corridors, inducing smooth traffic flow, and reducing vehicle emissions' volume were suggested. For flood management strategy, flood prevention through sustainable drainage system/natural drainage system and rainwater management were suggested. For water volume management strategies, rainwater storage, green land/rain water storage reservoirs, use of rainwater and reused water, and securing ecological water space were suggested; and water quality management through nonpoint solution source management was suggested as a strategy. An adequacy survey on the suggested adaptation sector strategy (plan) was conducted and an assessment was derived as shown in <Table 12>.

〈Table 11〉 revised strategy(plan) of mitigation part assessment : 3rd delphi survey result

planning part	planning domain	strategy by domian	validity rate(%)		average	median value
			valid	normal		

Mitigation	Reduction	energy	conversion to and introduction of new renewable energy	100	-	4.50	4.5
			improvement of energy efficiency	100	-	4.50	4.5
		industry.resource	establishment of a resource cyclical system/Eco-Industrial Cluster	87.5	12.5	4.06	4
		urban spatial structure	MUD	62.5	37.5	3.88	4
			space arrangement	68.8	18.8	3.69	4
			revitalizing public transportation	93.8	6.2	4.44	4.5
			pedestrian/bicycle-friendly spaces	68.7	31.3	4.13	4
			decreasing the rate of car use and speeding	81.2	18.8	4.00	4
		architecture	Passive Design	68.7	31.3	4.00	4
			Active Design	75.1	18.8	3.88	4
	Sequestration	urban forest	creating stadtwald	93.8	-	4.19	4
			building ecological network	81.3	12.5	4.00	4
		agriculture	introduction of urban agriculture	43.8	56.2	3.50	3

〈Table 12〉 adaptation part, strategy(plan) assessment : 2nd delphi survey result

planning domain		strategy by domain	validity rate(%)		average	median value
			valid	normal		
urban heat island management	temperature reduction	urban waterway construction	90.5	4.8	4.00	4
		improvement of surface cover	90.5	9.5	4.19	4
		suppressing anthropogenic heat	61.9	28.6	3.67	4
		increasing green land placed in dots	66.7	33.3	3.81	4
		increasing green land placed in areas	95.2	4.8	4.57	5
	air quality management	securement of wind corridors	85.7	14.3	4.19	4
		inducing smooth traffic flow	61.9	38.1	3.71	4
		decreasing engine displacement	90.5	9.5	4.14	4
water management	flood management	sustainable drainage system/natural drainage system	80.9	14.3	3.90	4
		flood prevention through rainwater management	61.9	28.6	3.62	4
	water quantity management	rainwater storage, green land/rain water storage reservoir	81.0	14.3	4.00	4
		use of rain water and reused water	76.2	19.0	3.81	4
		securing ecological water space	76.2	14.3	3.76	4
	water quality management	non-point pollution management	66.7	28.6	3.86	4

All medium values turned out to be over 4, showing that every strategy was adequate as an adaptation sector strategy. To be specific, urban waterway construction, improvement of surface cover, increasing green land placed in areas, securement of wind corridors, inspection of vehicle emissions' volume, sustainable drainage system/natural drainage system, rainwater storage, green land/rain water storage reservoir, use of rain water and reused water, and securing ecological water space turned out to be "valid" for over 75%, showing significantly high validity. Although the rest of the strategies also turned out to be "'valid'" for over 60%, it appears that they were assessed relatively low due to a lack of understanding of the concepts, redundancy, and/or diversity. This phenomenon could be inferred from the expert opinion arguing that in the case of the meaning of anthropogenic heat and urban heat island management, various aspects should be strategically promoted. The strategy was renamed, deleted, re-leveled, and integrated in the direction of improving understanding and avoiding redundancy as is shown in <Table 13>.

〈Table 13〉 adaptation part, revised strategy(plan)

<table>
<tr><th colspan="2">planning part</th><th>planning domain</th><th>strategy before modifying</th><th colspan="2">revised strategy</th><th>modification</th></tr>
<tr><td rowspan="9">adaptation</td><td rowspan="5">urban heat island management</td><td rowspan="4">temperature reduction</td><td>urban waterway construction</td><td colspan="2">securing urban water space</td><td>modify level</td></tr>
<tr><td>improvement of surface cover</td><td colspan="2" rowspan="4">minimize the impervious area</td><td rowspan="4">rename after integration</td></tr>
<tr><td>suppressing anthropogenic heat</td></tr>
<tr><td>increasing green land placed in dots</td></tr>
<tr><td>increasing green land placed in areas</td></tr>
<tr><td rowspan="3">air quality management</td><td>securement of wind corridors</td><td colspan="2">securement of wind corridors</td><td>–</td></tr>
<tr><td>inducing smooth traffic flow</td><td colspan="2">–</td><td>deletion</td></tr>
<tr><td>decreasing engine displacement</td><td colspan="2">air pollution management</td><td>modify level</td></tr>
<tr><td rowspan="4">water management</td><td rowspan="2">flood management</td><td>sustainable drainage system/natural drainage system</td><td rowspan="4">flood and water quantity management</td><td>sustainable drainage system</td><td>rename</td></tr>
<tr><td>flood prevention through rainwater management</td><td rowspan="3">use of rain water and reused water</td><td rowspan="3">rename after integration</td></tr>
<tr><td rowspan="3">water quantity management</td><td>rainwater storage, green land/rain water storage reservoir</td></tr>
<tr><td>use of rain water and reused water</td></tr>
<tr><td>securing ecological water space</td><td>–</td><td>deletion</td></tr>
<tr><td>water quality management</td><td>non-point pollution management</td><td colspan="2">non-point pollution management</td><td>–</td></tr>
</table>

Construction of urban waterways and reduction of vehicle emissions were suggested in a detailed level when compared to other strategies and, thus, were revised to be urban water space securement and atmospheric pollution management. Improvement of surface cover, suppressing anthropogenic heat, increasing green land placed in dots, and increasing green land placed in areas overlapped in content and it was necessary to differentiate them from the absorption sector and, thus, those strategies were integrated and renamed as the minimization of impervious surfaces. Inducing smooth traffic flow overlapped with the mitigation sector while ecological water space

securement overlapped with the urban heat island management strategy and, thus, they were deleted. As to the sustainable drainage system/natural drainage system, the same concepts were redundantly suggested and, thus, only the sustainable drainage system was suggested. Based on the above revised adaptation sector strategy (plan), an expert survey was conducted to verify its adequacy and the results are shown in <Table 14>. According to the assessment results, every strategy showed a validity rate over 85% and both the average and medium values were assessed to be more than "valid."

〈Table 14〉 adaptation part, revised strategy(plan) assessment 3rd delphi survey result

planning part		planning domain	strategy by domain	validity rate(%)		average	median value
				valid	normal		
adaptation	urban heat island management	temperature reduction	securing urban water space	87.6	6.3	4.38	5
			minimize the impervious area	93.7	-	4.25	4
		air quality management	securement of wind corridors	87.5	6.3	4.31	4.5
			air pollution management	93.8	6.2	4.19	4
	water management	flood management and water quantity management	sustainable drainage system	87.5	12.5	4.13	4
			use of rain water and reused water	93.8	6.2	4.31	4
		water quality management	non-point pollution management	87.5	12.5	4.06	4

Based on the strategy framework of the operational method of community and governance and harmonization activities of the education and promotion and the mitigation and adaptation programs, a strategy per sector was suggested, as shown in <Table 15>, and the validity was examined using the expert survey. The formation of a carbon-neutral ecological community, governance of creating carbon-neutral villages, operating a consultative group of carbon-neutral cities, support systems for carbon-neutral constructions, and education of residents about a carbon diet were assessed to be valid strategies with rates over 80%, showing high validity. Regarding the formation of an urban agricultural community, the formation of carbon-neutral city landmarks, and the introduction of local currency, the assessment of "average" was relatively high.

〈Table 15〉 cultivation part, strategy(plan) assessment 2rd delphi survey result

strategy framework		strategy by domain	validity rate(%)		average	median value
			valid	normal		
operational method	community	formation of carbon-neutral ecologic community	85.7	4.8	4.14	4
		formation of stadtwald protection·management community	71.4	19.0	3.76	4
		formation of urban agriculture community	23.8	71.4	3.33	3
	governance	carbon-neutral community planning governance	85.7	4.8	4.14	4
		operating carbon-neutral council	81.0	9.0	3.95	4
		backup program for carbon-neutral	95.2	4.8	4.24	4

		architecture				
harmonization activities	education and promotion	carbon diet education program for residents	90.4	-	4.14	4
		operating experience·education program for urban agriculture	61.9	38.1	3.86	4
		building carbon-neutral city landmark	28.5	57.1	3.24	3
	mitigation.adaptation program	implementation of green purchasing campaign	66.6	28.6	3.81	4
		introducing local currency	28.6	47.6	3.10	3
		implementation of carbon point system	71.4	28.6	3.95	4
		introducing urban green space(include wetland) total emission regulation	76.2	19.0	3.76	4

In addition to such quantitative evaluations, the following open ideas were also proposed. First, categorization and strategy by domain are appropriate, but a detailed content formation of each strategy is also very important since the effect of each strategy may appear differently depending on its detailed item constitution. Second, it is considered that, in the future, setting elements that require adaptation (episodes of adaptation) and their corresponding relation and, afterward, supplementing the strategy of each domain, is necessary when it comes to forming a strategy by adaptation domain. This implies that it is necessary to identify possibly or actually occurring adaptation elements related to climate changes in cities and to have a strategy to manage these. An example of this is seeking for an adaptation strategy for an episode of adaptation in which harmful insects emerged due to the occurrence of a subtropical climate. Third, since it is somewhat ambiguous whether automobile emissions' reduction means "reduction in total amount of automobile gas emission" or "reduction of automobile's gas emission such as expansion of lightweight car supply," it needs revision. Fourth, including an "implementation of minimum quota for urban green area (including wetland)" is not consistent with other strategies and, rather, an adaptation strategy is appropriate. Fifth, a green purchase movement and a carbon point system are considered to produce a synergy effect when introduced along with other related programs.

As such, in the cultivation category, evaluation results are extremely divided, unlike the mitigation and adaptation categories, and, in particular, there were many strategies showing low appropriateness rates and there was an aspect in which the operation method, system, and program are not clearly distinguished; thus, overall constitutions were modified. In particular, it is necessary to propose consistent strategies based on the strategy framework. In addition, it will be necessary to propose objective strategies with clear meanings in a way that shows the strategies of each domain in a common form, like an expert's opinion. Cultivation is a concept that includes changes in ways of life through citizen action, communal approach, non-physical plan and action, and governance that aim to effectively fulfill mitigation and adaptation. Hence, it is necessary to modify the planning domain to include a non-physical plan and action for the effective realization of mitigation, adaptation, and the effective realization of community.

For this reason, the operation method was modified such that it proposes the interested parties of village community and governance from the strategic aspect as shown in <Table 16>. The cultivation activity was set with a plan domain of a program that can support mitigation, adaptation, village community, and a program for the education of residents for effective operation. In particular, the mitigation and adaptation programs were proposed with strategies that support adaptation and mitigation strategies.

〈Table 16〉 revised strategy by domain

planning part		planning domain	strategy before modifying	revised strategy		modification
cultivation	operational method	community	formation of carbon-neutral ecologic community	community	residents community, civic group, expert, administration	modify level
			formation of stadtwald protection·management community			
			formation of urban agriculture community			
		governance	carbon-neutral community planning governance	governance	central government, local governmant, civic group, citizen, expert, press and media, company	modify level
			operating carbon-neutral council			
			backup program for carbon-neutral architecture			
	harmonization activities	education and promotion	carbon diet education program for residents	mitigation.adaptation program /eco industrial cluster building program/education and promotion program for residents/ community vitalization		addition and relocation
			operating experience·education program for urban agriculture			
			building carbon-neutral city landmark			
		mitigation.adaptation program	implementation of green purchasing campaign			
			introducing local currency			
			implementation of carbon point system			
			introducing urban green space(include wetland) total emission regulation			

The modified strategies such as those shown in <Table 17> were made through level adjustment, addition, and reallocation, and the second suitability survey was conducted. As shown in the evaluation results in <Table 17>, all the strategies of each domain are suitable since they all show a median value higher than 4. Most of strategies displayed appropriateness rates higher than 80% of "appropriate," whereas the city agriculture activation program, air pollution management program, training of talented individuals, and regional promotion had relatively low appropriateness.

〈Table 17〉 cultivation part, revised strategy(plan) assessment : 3rd delphi survey result

planning part		planning domain	strategy by domain	validity rate(%)		average	median value
				valid	normal		
cultivation	operational method	governance	central government, local governmant, civic group, citizen, expert, press and media, company	100	-	4.38	4

		community	resident community, civic group, expert, administration	100	-	4.50	4.5
	harmonization activities	mitigation.adaptation program	new renewable energy supply activation program	93.8	6.2	4.31	4
			program for improvement of energy efficiency	93.8	6.2	4.44	4.5
			revitalization program of riding a bicycle	81.2	18.8	4.25	4
			public transportation network construction program	87.5	12.5	4.38	4.5
			low-energy urban spatial structure(job-housing balance) program	87.5	12.5	4.25	4
			low-energy building certification & supporting program	93.8	6.2	4.25	4
			urban green area securing program	93.8	6.2	4.19	4
			city agriculture activation program	56.2	43.8	3.69	4
			urban heat island management foundation setup program	81.2	18.8	3.81	4
			air pollution management program	68.8	31.2	3.88	4
			water management program	87.5	12.5	3.94	4
			carbon diet campaign	81.2	18.8	4.06	4
			recycling of resource	87.5	12.5	4.19	4
		program of eco-industrial cluster establishment	revitalization program of company participation	93.8	6.2	4.19	4
			community collaboration program	93.8	6.2	4.19	4
			propulsion and management system program	87.5	12.5	4.19	4
		education for residents/promotion program	resident education program	100	-	4.44	4
			training of talented individuals	68.7	31.3	4.06	4
			regional promotion	68.7	31.3	3.88	4
		community vitalization	formation of ecological community	93.8	6.2	4.31	4

The city construction strategy for integrated climate change response, that was finally confirmed after numerous modifications for suitability of the city construction strategy framework for integrated climate change response and strategies through three sessions of the Delphi survey, is shown in <Table 18> and it is formed with 16 plan domains and 42 strategies.

Because the integration of response measures for climate changes is facing difficulties due to discrete approaches dividing it into the two parts of mitigation and adaptation and a technology-development based approach rather than a space-planning based approach, the structural integration method of climate change response city construction method was considered.

〈Table 18〉 Urban planning strategies in integrated response to climate change

planning part		plnning domain	strategy by domain
mitigation	reduction	energy	conversion to and introduction of new renewable energy
			improvement of energy efficiency
		industry.resource	establishment of a resource cyclical system/ Eco-Industrial Cluster
		urban spatial structure	Mixed-Used Development
			space arrangement
			revitalizing public transportation
			pedestrian/bicycle-friendly spaces
			decreasing the rate of car use and speeding
		architecture	Passive Design
			Active Design
	sequestration	urban forest	creating stadtwald
			building ecological network
		agriculture	introduction of urban agriculture
adaptation	Urban Heat Island management	temperature reduction	securing urban water space
			minimize the impervious area
		air quality management	securement of wind corridors
			air pollution management
	water management	flood and water quantity management	sustainable drainage system
			use of rain water and reused water
		water quality management	non-point pollution management
cultivation	operational method	governance	central government, local governmant, civic group, citizen, expert, press and media, company
		village community	residents community, civic group, expert, administration
	harmonization activities	mitigation.adaptation program	new renewable energy supply activation program
			program for improvement of energy efficiency
			revitalization program of riding a bicycle
			public transportation network construction program
			low-energy urban spatial structure(job-housing balance) program
			low-energy building certification & supporting program
			urban green area securing program
			city agriculture activation program

			urban heat island management foundation setup program
			air pollution management program
			water management program
			carbon diet campaign
			recycling of resource
		eco-industral cluster construction program	revitalization program of company participation
			community collaboration program
			propulsion and management system program
		education for residents/promotion program	resident education program
			training of talented individuals
			regional promotion
		community vitalization	formation of ecological community

Strategies of the mitigation, adaptation, and cultivation domains based on space planning must be proposed in order to effectively devise an integrated climate change response plan. Climate change policies and planning elements are proposed and performed by each element. A technique that derives spatial planning elements and proposes planning elements and strategies can be performed for each spatial planning element.

Moreover, the city must be categorized by downtown and sub-downtown, new town and city regenerating zone such as redevelopment and rebuilding, and use district. Moreover, an integrated response measure for mitigation, adaptation, and cultivation must be proposed by evaluating its suitability.

Some elements similar to sustainable city and ecological city presented in the paradigm of sustainable development were divided, but there were differences in the allocation and application method depending on the suitability of the item. This is due to the fact that ecological cities and climate change response cities are based on the sustainable city paradigm. Ecological cities focus on the construction of a city in an ecological aspect to conserve biological diversity and sustainable cities aim to propose a city construction method to form an economic, social, and environmental harmony. Meanwhile, climate change response cities aim to reduce unpredictable outcomes due to climate changes and the elements required for city construction as such were deduced.

The investigation so far was carried out mainly to integrate elements of climate change response. This study aims to propose measures to respond to climate changes comprehensively from the city construction aspect instead of from the climate change response domain or with the integration of elements. Therefore, it proposes a construction measure based on mitigation and adaptation with the most widely used IPCC categories. Since most domestic and overseas policies and plans are proposed according to the categorization system of mitigation and adaptation, basing such categorization is appropriate, from a realistic point of view. Moreover, it is necessary to effectively utilize developed plan elements. In the future, a categorization must be done depending on whether the plan elements aim for mitigation or adaptation in order to build a greenhouse gas inventory, compute aimed quantity, provide mitigation based on weakness evaluation, and an adaptation plan establishment, which are the most important elements for publicly developing a climate change response city construction plan. For this reason, it was categorized in mitigation and adaptation.

3. Strategy priority selection

Since an integrated climate change response city construction strategy, which is proposed for each planning domain, holds different levels of importance of strategy within each planning domain of the planning part, it is

necessary to set a weighted value of each strategy and the strategy priority must be set based on the weighted value.

Prior to AHP survey analysis, the inconsistency index was calculated in order to check the logical consistency of respondents for the research data. The analysis was made by setting an inconsistency index of 0.1 as the reference value[7].

The weighted value of each basic direction of integrated climate change response city construction resulted in mitigation (0.651), adaptation (0.211), cultivation (0.138), and, therefore, the planning directions of mitigation, such as "carbon reduction and carbon sequestration," are elements that need to be considered a priori to other planning directions for climate change response city construction. The weighted values of adaptation and cultivation directions were relatively lower than the weighted value of mitigation and the weighted value of adaptation (heat island and water management) was slightly higher than that of cultivation (operation method and cultivation activity).

<table 19> basic direction, planning part, planning domain, and priority

basic direction	weight	rank	planning part	weight	rank	planning domain	weight	rank
mitigation	0.651	❶	reduction	0.631	❶	energy	0.361	❶
						industry.resource	0.291	❷
						urban spatial structure	0.213	③
						architecture	0.134	④
			sequestration	0.369	②	urban forest	0.698	❶
						agriculture	0.302	②
adaptation	0.211	②	Urban Heat Island management	0.528	❶	temperature reduction	0.618	②
						air quality management	0.682	❶
			water management	0.472	②	flood and water quantity management	0.554	❶
						water quality management	0.446	②
cultivation	0.138	③	operational method	0.442	②	governance	0.538	❶
						village community	0.462	②
			harmonization activities	0.558	❶	mitigation.adaptation program	0.350	❶
						eco-industral cluster construction program	0.170	④
						education for residents/promotion program	0.261	❷
						community vitalization	0.219	③

Therefore, it is vital to consider adaptation as a priority over the other elements and carbon emission adaptation and overall management and then the cultivation elements need to be considered afterwards. The carbon reduction plan part result was more important than carbon sequestration plan part in the mitigation category; this implies that reduction in carbon emissions is more important than carbon sequestration after its emission. In other words, it is more important to manage carbon gases.

[7] If the inconsistency ratio, which is the inconsistency index divided by random index, goes over 0.1, the respondent is considered logically inconsistent and the answered item is re-evaluated.

The heat island management result was more important than water management in the adaptation category and cultivation activity was considered to be more important than the operation method in the cultivation category; but they showed less difference in weighted values than the difference in the mitigation category.

<table 19> mitigation part, priority of strategy by domain

planning part	planning domain	strategy by domain		
reduction	energy	renewable energy	.410	❶
		new energy	.204	③
		improvement of energy efficiency	.387	②
	industry.resource	establishment of a resource cyclical system	.643	❶
		Eco-Industrial Cluster	.357	②
	urban spatial structure	Mixed Use Development	.175	③
		space arrangement	.163	④
		revitalizing public transportation	.327	❶
		pedestrian/bicycle-friendly spaces	.186	❷
		decreasing the rate of car use and speeding	.149	⑤
	architecture	Passive Design	.611	❶
		Active Design	.389	②
sequestration	urban forest	creating stadtwald	.633	❶
		building ecological network	.367	②
	agriculture	introduction of urban agriculture	1	❶

For the planning domain of each category, energy for carbon reduction, city forests for carbon sequestration, air pollution management for the heat island, flood/water volume control of water management, governance of the operation method, and a mitigation/adaptation program for cultivation activity, the result was more important than the other planning domains.

The renewable energy[8] strategy in the carbon reduction of the energy-planning domain had the highest weighted value and the resource recycling system development was considered more important than the ecological industry cluster in the industry and resource planning domain. Public transportation vitalization, walking and cycling-friendly spaces, and multi-functional development resulted as important strategic elements in the planning domain of the urban spatial structure. This shows that automobile usage must be restricted in order to vitalize public transportation and produce environment-friendly pedestrian spaces for carbon reduction. A natural type of design strategy was considered more important than a facility type of design in the planning domain of construction and city forest development's weighted value result was higher than that of the ecology network development in the planning domain of city forest for carbon sequestration.

Ensuring water spaces in temperature reduction planning in the domain of adaptation was derived as an important strategic factor, the weightage value of air pollution management was high in the air quality management planning domain, and the utilization of rain water and heavy water were high in the flood control and water quantity management.

<table 20> adaptation part, priority of strategy by domain

[8] New energy and renewable energy was distinguished in the survey.

planning part	planning domain	strategy by domain		
Urban Heat Island management	temperature reduction	securing urban water space	.607	❶
		minimize the impervious area	.393	②
	air quality management	securement of wind corridors	.478	②
		air pollution management	.522	❶
water management	flood and water quantity management	sustainable drainage system	.469	②
		use of rain water and reused water	.531	❶
	water quality management	non-point pollution management	1	❶

It can be observed that in the governance of cultivation, the weightage value of local government, citizens, and central government is high and, in the village community, the weightage values of the resident community and civic organizations are high. Furthermore, in the planning domain, where the mitigation and adaptation program of cultivation activity is applied, the weightage values of the public transportation network-building program, low-energy consuming urban spatial structure building program, urban green space ensuring program, renewable energy deployment activation program, and energy efficiency improvement program, were high. It can be observed that in the eco-industrial cluster building program of the planning domain, the community collaboration program is more important than other strategic factors. It can be observed that in the resident education and promotion program of the planning domain, resident education was a more important strategic factor with a high weightage value.

<table 21> cultivation part, priority of strategy by domain

planning part	planning domain	strategy by domain		
operational method	governance	central government	.137	❸
		local government	.260	❶
		civic group	.114	⑤
		citizen	.209	❷
		expert	.123	④
		press and media	.067	⑦
		company	.091	⑥
	village community	residents community	.460	❶
		civic group	.188	❷
		expert	.170	④
		administration	.182	③
harmonization activities	mitigation.adaptation program	new renewable energy supply activation program	.104	❹
		program for improvement of energy efficiency	.103	❺
		revitalization program of riding a bicycle	.052	⑨
		public transportation network construction program	.123	❶
		low-energy urban spatial structure(job-housing balance) program	.122	❷

		low-energy building certification & supporting program	.073	⑦
		urban green area securing program	.106	❸
		city agriculture activation program	.036	⑬
		urban heat island management foundation setup program	.051	⑩
		air pollution management program	.051	⑩
		water management program	.053	⑧
		carbon diet campaign	.046	⑫
		recycling of resource	.080	⑥
	eco-industral cluster construction program	revitalization program of company participation	.380	②
		community collaboration program	.399	❶
		propulsion and management system program	.221	③
	education for residents/promotion program	resident education program	.465	❶
		training of talented individuals	.312	②
		regional promotion	.223	③
	community vitalization	formation of ecological community	1	❶

Ⅴ. Conclusions

The necessity of integrated responses at the city level with regard to climate changes is increasing. In the present study, an urban development plan, consisting of the necessary mitigation, adaptation, and cultivation strategies for an integrated response to climate changes, was proposed. The mitigation and adaptation realms were constituted with a focus on spatial and physical planning elements, according to the characteristics of mitigation and adaptation, which include a spatial domain. Furthermore, in the cultivation aspect, because the planning, execution, operating system, and program are proposed by including non-physical planning elements for mitigation and adaptation, a city development plan, in response to harmonized integrated climate changes between physical and non-physical planning elements, was proposed.

The planning field, as a strategic framework (planning domain, planning field) and strategy, was constituted of mitigation, adaptation, and cultivation. Two detailed fields were proposed for each field, and 16 planning domains were created. 42 strategies were proposed based on the strategic frame. To ensure the effectiveness of the constituted strategic framework and the 42 strategies, weightage values by planning field, planning domain, and strategy were determined and, based on that, the priorities of the strategies were determined.

The classification and strategies of each domain are suitable. However, because the effects, according to the constitution of the detailed items of the strategies, differ and the constitution of the detailed content of each strategy is very important, according to expert opinion. Therefore, in the future, there is a need to develop detailed contents of development plans for each strategy. Furthermore, because the strategic frame has relatively different application proportions in urban spatial units, strategies for each spatial unit are necessary. Moreover, it is also necessary to devise a plan to apply different emphasis to parts according to urban and spatial characteristics.

The strategies derived in the present study were proposed based on the strategic framework that was derived by a top-down approach. In the planning field, for responses to climate changes, a strategic framework, which is based on mitigation, adaptation, and cultivation, was formulated and development strategies were proposed according to the strategic framework. There is a need for a mutual organic integration plan that is formulated through a system approach; the system approach derives planning elements through case analysis of similar domestic and

overseas cities in terms of the mutually integrated management of responses to climate changes, examines the degree of influences between the derived elements, and constitutes and integrates sub-systems of climate change responses.

In the present study, an expert Delphi and an analytic hierarchy process (AHP) survey were conducted with the purpose of obtaining various expert opinions on creating a strategic framework and determining the priorities of strategies. However, there is a need for an in-depth interview technique for proposing an organic integration plan.

In the future, there is a need for a study to determine the priorities among strategic frameworks, strategies, and planning elements and a study[9] on identifying cause-and-effect relationships, interaction, and feedback using empirical data for each domain.

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[9] About this, there was a following expert opinion: "There is a need for formulating three-dimensional relationship by creating relationship matrix between the detailed contents, and also I propose a relationship setting with regard to land-use planning." Furthermore, according to another expert opinion: "In the constitution of strategies for each future adaptation domains, there is a need to complement strategies for each domain after determining response relationships and the elements required for adaptation."

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