Developing an Urban Planning Model for Climate Change Adaptation

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Abstract: As abnormal climate phenomena occur more frequently due to climate change, damage which results from meteorological disaster increases accordingly and its scale and variety are becoming wider. This paper draws out planning and design elements and application techniques to build cities more adaptive to climate change from urban development cases in US and Europe. An urban model is suggested, that enables built environment to be more resilient to risks caused by climate change is applicable to urban development projects in practice.

Keywords: Urban Planning, Climate Change, Adaptation, Resilience, Urban Metabolism

I. Introduction

According as abnormal climate phenomena have become more frequent due to climate change, damage caused by natural disaster has increased in urban areas. Densely populated cities are more seriously affected by meteorological disaster than rural areas inevitably. Recently, damage by heat waves has been increased remarkably among other natural disaster types. It is seen that among the fifteen hottest years on earth, the fourteen years belong to the 21st century, and this tendency is expected to continue.

This study proposes two things. Firstly it suggests a safe and healthy urban model that can respond to abnormal climate phenomena resulted from climate change and threat of meteorological disasters. Then, it suggests planning techniques applicable to urban development projects.

II. Understanding Climate Change Adaptation

For the climate change era, urban planning paradigms, theories, concepts and models have been appeared. City planning approaches in the climate change era can be categorized into two types: One is mitigation-oriented planning to cut off causes of climate change, and the other is adaptation-oriented city planning to counteract impacts by already changed climate. Planning theories that are applied exemplary urban practices responding to climate change are summarized by 'resilience' and 'urban metabolism' which recognize a city as an organism.

The city adaptive to climate change means that a city possesses resilience, which holds a system that can be recovered to its original state by absorbing the external impact rapidly. In other words, the city can minimize unavoidable negative impacts resulted from climate change by confronting risk factors flexibly.

Among various meteorological disaster types, heat waves, heavy rain and drought are typical phenomena that cause a lot of damage to urban areas.

III. Case Study

This paper chose two types of urban cases to draw out planning-design elements and application techniques to adapt climate change. The first type of case is cities in the United States that devised adaptation plan as a solution to effect of increasing climate change. The second case is cities in Europe that represents urban planning paradigm that has the same context with climate change. The method of the case study is progressed by investigation-analysis of literatures and field survey-analysis the cases.

TABLE I: Overview of Cases

City	US		
	Seattle, WA	Chicago, IL	Philadelphia, PA
Area	369.2sq.km	606.1sq.km	369sq.km
Population (approx..)	621,000	2,707,000	1,526,000
Main Plan & Project	2013 Climate Action Plan 2030 Vision SEA Streets project	Chicago Climate Action Plan Urban Forest Agenda Green Alleys Program	Local Action Plan for Climate Change Green Works Plan

Project	Germany				Netherlands
	Riem, Munich	Krons Berg, Hannover	Jenfelder Au, Hamburg	Haulander Weg, Hamburg	EVA-Lanxmeer, Culemborg
Area	556ha	160ha	35ha	20ha	24ha
Population	16,000	15,000	-	-	250 households
Construction period	1990~ 2013	1990~ 2010	2013~ 2016	-	1994~ 2009
Main features	Preparing for future flood abundant natural environment	Preparing for flood and heat waves □ Escarpment shapes	Waterfront Abundant green area Conservation of natural environment	Preparing for heat waves Introduction of water cycle management system	Preparing for heat waves Integrated strategies for climate change

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TABLE Ⅱ : SYNTHESIS PLANNIING TECHNIQUE OF CASES

Planning Technique	Europe					US		
	K	R	E	J	H	S	C	P
☐ Soil improvement						●		
☐ Restoration and management of urban forest						●	●	
☐ Conservation of existing topography	●	●	●					
☐ Urban structure considering wind corridor	●	●						
☐ Site plan considering elevation angle of the sun	●	●						
☐ Site plan considering heavy rain and strong wind	●	●						
☐ Multifunctional arrangement and mixed-use				●	●			
☐ Urban farming			●		●			
☐ Planting trees in park and green space	●	●		●		●	●	●
☐ Garden and small green space	●	●	●	●			●	
☐ Landscaping similar to nature			●				●	
☐ Ecological wetlands			●		●		●	●
☐ Creation and management of Waterfront	●	●	●	●				
☐ Restoration and conservation of river and stream			●					
☐ Waterscape for natural detention						●	●	●
☐ Reusing rainwater and wastewater			●	●	●			
☐ Ecological sewage/rainwater system and drainage facility			●	●	●	●	●	
☐ Rainwater management system	●	●	●	●	●	●	●	●
☐ Integrating road design with water cycle system	●	●		●		●		●
☐Permeable paving in road and parking space	●	●	●			●	●	●
☐ Greening railroad and sidewalk for cooling	●	●		●		●	●	●
☐ Installation of wooden planter box for rainwater infiltration	●	●		●		●	●	●
☐ Using high albedo materials on the road and roof							●	●
☐ Green parking area	●	●	●					●
☐ Greening roof and balcony								●
☐ Passive building design			●		●	●	●	
☐ Solar heating system	●	●	●	●	●	●	●	
☐ Applying ecological design to building adjacent to wind corridor		●						
☐ Renewable energy			●	●	●			

* K: Kronsberg, R: Riem, E: EVA-Lanxmeer, J: Jenfelder Au, H: Haulander Weg, S: Seattle, C: Chicago, P: Philadelphia

Ⅳ. A CITY MODEL FOR CLIMATE CHANGE ADAPTATION

The model of the city for adaptation to climate change counteracts to risk factors caused by climate change flexibly, and possesses resilience. The purpose of the model is to establish a safe and healthy city by minimizing effect of climate change. The basic structure of the model is an integrated strategic plan that contains physical aspect including land use of a city, transportation, energy, architecture and management of green zone and water resource, and non-physical aspect including demand for lifestyle change, management of vulnerable social group, disaster management and healthcare service.

To augment adaptability in respect of climate change, diversity of social-biological system should be secured along with capability to analyze and predict risk factors of urban space.

The bottom line of the model of the city for adaptation to climate change is to improve potentiality and resilience that are able to counter climate change based on the climate change response system. To realize it, it is essential to develop planning-design system, process and planning factors.

Ⅴ. APPLICATION TECHNIQUES TO ADAPT CITIES TO CLIMATE CHANGE

This paper carried out following methods to draw out planning-design factors and technique. 1) Organization of planning factors and technique that are suggested theoretically with domestic and foreign literatures as the

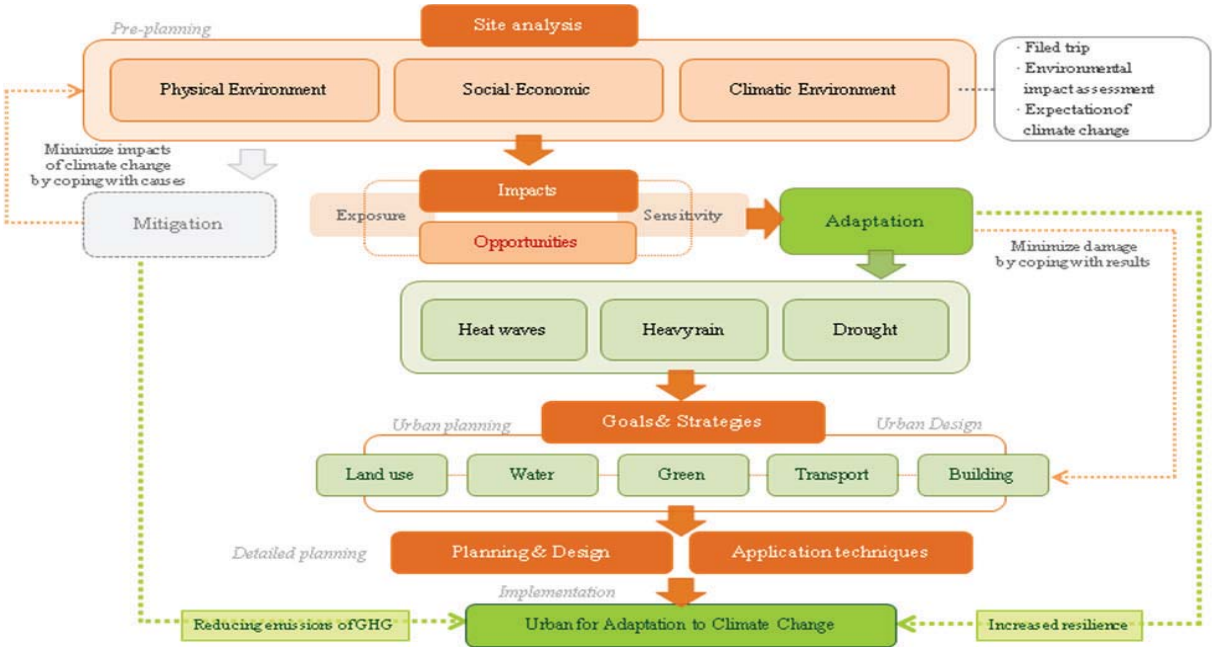

Figure 1. A Planning Process for Climate Change Adptation

central figure, 2) Literature review of exemplary cases, 3) Field survey at case regions, 4) Interview with the person concerned and visit institutes. Through the methods, this paper 1) figures out planning condition and standard, 2) investigates and analyzes planning factors and technique that is applicable in practice. Then brainstorming is conducted by research staffs, working group and planners with synthesizing results of the study.

TABLE Ⅲ : APPLICATION OF TECHNIQUES BY SECTOR

Sector	Techniques	Climate Change Impacts		
		Heat Waves	Heavy Rain	Drought
L-1	Construction and protection of region generating fresh air and wind corridor	●	◎	○
L-2	Building design considering ventilation and flow of cooling air	●	◎	○
L-3	Site plan considering sunlight and wind direction	●	◎	○
L-4	Park and green space planning for shading in public space	●	◎	○
L-5	Urban forest to keep city cooler	●	◎	○
L-6	Habitat preservation of native flora and fauna and creation of leisure space for human	●	◎	◎
L-7	Limited development of vulnerable region to natural disaster	○	●	◎
W-1	Separation between sewage and rainwater pipe and regular management	○	●	◎
W-2	Rainwater detention system	◎	●	◎
W-3	Creation and maintenance of diverse waterfront	●	◎	○
W-4	Restoration of waterways from shapes obstructing flow of water to natural shapes	○	●	◎
W-5	Securement of space to install tree filter box for rainwater infiltration and storage	○	◎	●
W-6	Bio-retention for using waste water	◎	●	◎
G-1	Three-Dimensional greenery system	●	◎	●
G-2	Continuous street trees management	●	●	○
G-3	planting and maintenance of deep-rooted species	◎	●	○
G-4	Management of plant community and selection of weather resistant tree species	◎	○	●
G-5	Greening for microclimate control in urban block	●	◎	○
G-6	Irrigation of green space to prevent aridity and maintain cooling	◎	○	●
T-1	Prevent overheating through greening railway and road	●	◎	◎
T-2	High albedo paving materials	●	◎	○
T-3	Road design Integrated with water cycle system	●	●	◎
T-4	Design of road and parking area including rainwater infiltration and storage facility	◎	●	◎
T-5	Use of heat-resisting and permeable paving materials	●	●	◎
T-6	Improving bus stop environment from extreme hot and cold weather	●	●	○
B-1	Maintaining optimal indoor temperature by controlling insulation and ventilation	●	○	○
B-2	Shading system of building for sunshine and insolation control	●	○	○
B-3	Green roof and balcony to cooling building	●	●	◎
B-4	Climate-friendly building structure and exterior materials	●	●	○
B-5	High albedo building's envelopes	●	○	○
B-6	Application of water management techniques for water saving	○	○	●

* Relevance: ● Very High, ◎ High, ○ Normal

VI. CONCLUSION

This study can be differentiated from existing researches conducted at policy and strategic level. Changing trend of city planning paradigms for climate change adaptation was addressed and concepts and local policies to provide adaptation measures to climate change were summarized. Focusing on the meteorological disaster types which can take serious damage in urban areas, a planning model which enables cities to respond to risks caused by climate change was proposed. Planning and design factors to strengthen resilience of built environment were also drawn out.

The urban planning model and application technique of planning-design elements in this study still need to be verified in the context of practice. By applying the proposed process and techniques of climate-adaptive city planning to drafting and establishing urban development projects or local action plans for climate change adaptation, this approach can become more systematized and concrete.

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