Landscaping Trees under the Impacts of Climate Changes: Construction Professionals' Perceptions in the Field of Landscape Architecture in South Korea

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Abstract: This study examines the relationship between landscaping trees and climate changes in the Korean context through a questionnaire designed to elicit the perceptions of construction professionals in South Korea. The questionnaire results show that these professionals are well aware of the various climate change phenomena. Based on this analysis, three noteworthy implications are identified: (1) drought and heat wave as major climate change phenomena that affect tree defects in Korea, (2) building a tree planting environment reflecting climate change prediction, and (3) additions for sustainable tree planting in the Korean context. In the answers to the questions pertaining to professionals' perceptions of the impact of climate change on tree defects, most respondents felt that climate change has already had a decisive impact on trees, and that impact needs to be reflected in tree-planting standards for securing the sustainability of urban trees.

1. INTRODUCTION

The reasons for climate changes such as warming and sea level rises, which have been realized globally since the 20th century, are widely believed to be caused by both natural and human factors, which are called "climate forcers" (Government of Canada, 2015). Regardless of opinions on its origin, we all recognize the fact that climates are changing, and that reality is an important social issue (Moon et al., 2017).

The Korean peninsula is not free from the globally emerging climate change phenomenon. According to the Korea Meteorological Administration (KMA), between 1921 and 2008, the average temperature on the Korean Peninsula rose by about 1.7°C (Korea Meteorological Administration (KMA), 2015b). This average temperature increase on the Korean Peninsula became noticeable starting in the 1950s. In detail, the average annual temperature of the Korean Peninsula increased by 0.23°C every 10 years between 1954 and 1999, by 0.41°C every 10 years between 1981 and 2010, and by 0.5°C between 2001 and 2010. Thus, this trend shows that the warming of the Korean Peninsula is continually increasing. Even though the average global warming

trend has become lower since 1998, the increase in average temperature of the Korean Peninsula has become higher, and the warming trend of the Korean Peninsula is expected to continue to increase in the future (Ibid.). In addition to warming, various phenomena related to climate change, such as changes in water circulation, extreme weather, changes in atmospheric circulation and fluctuation patterns, and rising sea level and water temperature on and around the Korean Peninsula, are continuously reported today (Korea Meteorological Administration (KMA), 2015a, 2015b); thus, various types of climate change, including warming, are expected to affect the Korean Peninsula more and more in the near future.

As a living creature, fixed to the ground, a tree is closely related to climate and its changes. Landscaping trees are especially sensitive to climate change more so than natural forests and wildwood because they are artificially implanted in man-made grounds that are not considered optimal for their growth and development. On the other hand, landscaping trees are important to urban environments, because trees serve as one of several solutions to various environmental problems of the urban environment, including abnormal climate. Therefore, climate changes can influence landscaping trees, but landscaping trees can also have a positive effect on climate changes. Many countries, agencies, and private organizations have acknowledged the positive impacts of tree planting in urban areas on climate changes, and encourage cities to plant street trees and urban forests (Lukac et al., 2010; Glick, 2007; Aspect Studios, 2011; Forestry Commission England, 2017; US Environmental Protection Agency, 2016; US Forest Service, 2017).

On the other hand, studies on climate changes' impacts on landscaping trees are still very limited, and the impacts are not fully verified. Additionally, the precise impacts on landscaping trees are hard to verify, because there are various elements that make landscaping trees vulnerable in urban spaces, such as defects—withering and rotting—in a tree itself, poor regional relevance, soil conditions (like artificial soil), and various management problems after planting. Nevertheless, if the landscaping trees' defect rates become unexpectedly higher in the same situation, such as when trees of the same species are planted in the same area, it is possible to conclude that climate change could be one of the reasons for the increasing defect rates. In 2015, for instance, about 300 trees of *Stewartia pseudocamellia* abruptly withered in Sejong City—a newly created special administrative city of South Korea near Daejeon which first settled in 2012. This species comprised almost half the street trees planted when the administrative district was rebuilt in 2012; 632 *Stewartia pseudocamellia* and 203 *Metasequoia glyptostroboides* were planted on the city streets (Kown (2017)). *Stewartia pseudocamellia* is a very common tree species in Sejong and its neighbourhood areas, and it is often used as a landscaping tree. However, this kind of large-scale defect was the first time it was seen in these areas and all over the country. Extreme drought and blistering heat, which are aspects of climate changes, were blamed for the situation. Additionally, there is another opinion that the tree species was not suitable for the area (Ibid.). According to the opinions from professionals, the *Stewartia pseudocamellia* was suitable for the area but the climate today is not suitable for this species anymore, so this opinion is also based on climate changes. As shown in the case of Sejong, it is important that landscape architects, urban planners, and related field professionals understand climate change in the area they target, and they must select adaptable tree species in those areas under climate changes in order to provide a suitable environment for the growth of planted trees.

This research, as an early stage climate changes impact study on landscaping trees, attempts to verify the relationship between landscaping trees and climate changes through the perceptions of related professionals, who work on the ground, literally, in the South Korean landscaping industry. Clearly, this study tries to identify the recognition of the direct impact of climate change through field professionals' perceptions. Hypothetically, climate change could already be affecting planted trees, so field professionals may already be recognizing the impact, and this recognition can be an important clue to predict the future impact of climate change on tree planting environments. Based on the results of this study and future research to analyse the detailed relationship between climate changes and landscaping tree species selection, the researchers endeavour to find ways to develop a suitable tree-growth environment under climate changes. The impact of climate change varies by region even in one small country, thus, plans for landscaping trees for climate changes have to be based on detailed analyses of local climate change impacts of the region(s) in question.

1.1   Landscaping Trees and Climate Change

Trees, which are one of the major materials of landscape architecture and one main component of urban environments, are closely related to climate and its changes. Trees will thrive when they are provided suitable environments for growth and development, thus, changes in climate mean changes in their survival rates.

In 2008, the Landscape Institute of the United Kingdom (LI) published "Landscape Architecture and the Challenges of Climate Change: Landscape Institute Position Statement." In this statement, the LI declares that landscape architects need to recognize the seriousness of climate changes and continually try to minimize climate changes. As an attempt to do so, LI states tree species selection as one means for adapting to climate change, such as: "Plant species selection: Landscape architects understand what species to plant, where to plant them and the conditions different species require in order to thrive. This knowledge is invaluable in the face of changing climatic conditions, particularly arising from the impacts on the quality and availability of water and the potential increase in pests and disease" (Landscape Institute, 2008).

Even though trees are one of most significant materials for landscape architecture, as mentioned above, there is not much research about climate change impacts focusing only on landscaping trees yet. Almost all research related to the topic of climate change impacts on trees focuses on wildwoods or natural forests and their tree species (Aitken et al., 2008; Allen et al., 2010; Austin & Van Niel, 2011; Condit, Hubbell, & Foster, 1996; Gehrig-Fasel, Guisan, & Zimmermann, 2007; Hamann & Wang, 2006; Iverson & Prasad, 1998, 2001). In 2016, an interesting study related to climate change and trees was published in Canada. The research verified the next 50 years of sustainability of Vancouver's forests, including both natural and artificial, under climate change (Needoba et al., 2016). However, this research only provides a prediction, so there is a lack of coping with this change in the tree-planting industry.

In the case of Korea, almost all research about the relationship between climate change and trees focuses on natural forests and native habitats, especially related to the changing distribution of some specific species like *Pinus* and *Quercus* (Lee, S.-C. et al., 2011; Kim, B. D., 2016; Kim, Y. G., 2012). However, there is still no research focused on landscaping trees in

Korea. Climate change could have huge impacts on trees, not only natural forests but also artificially-planted trees. Thus, it is urgent that the preparation for how to cope with climate change in the tree planting field socially, legally, and institutionally is needed. And for this, this study tries to identify the necessities of this type of future research as a foundation.

1.2   Landscaping Tree Planting in Korea

The commonly used Korean standards related to planting landscaping trees are the landscape architecture construction standard specification from the Ministry of Land, Infrastructure and Transport (MOLIT) and the design guidelines (landscape architecture) from the Korea Land and Housing Company (KLHC). Table 1 shows the regionally suitable date standards for tree planting regulated by MOLIT, and Table 2 identifies regionally recommended tree species for landscape architecture construction, regulated by KLHC.

Table 1. Regionally suitable date for tree planting (Ministry of Land, Infrastructure and Transport (MOLIT), 2016)

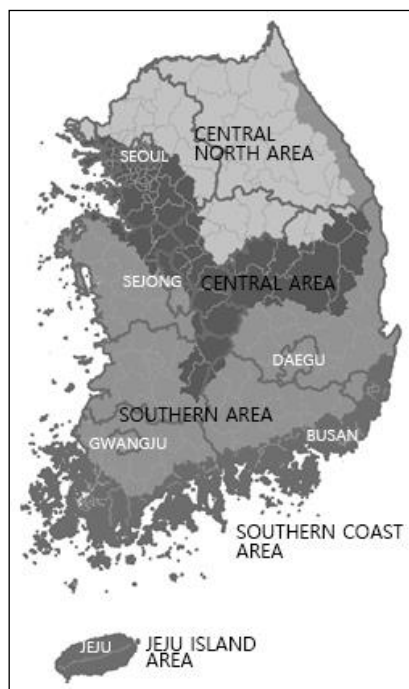| Region	Suitable date for tree planting	
	Spring	Fall
Central north area	20 March-25 May	25 September-20 November
Central area	10 March-20 May	1 October-30 November
Southern area	1 March-15 May	5 October-10 December
Southern coast area	20 February-10 May	10 October-20 December
Jeju island area	10 February-5 May	20 October-10 January

Figure 1. Regional division for tree planting in South Korea (reproduced based on information from Korea Land and Housing Company (KLHC) (2015))

Table 2. Regionally recommended tree species (Korea Land and Housing Company (KLHC), 2015)

Region	Recommended Tree Species
Central north area	*Pinus koraiensis, Abies holophylla, Pinus strobus, Acer buergerianum, Acer palmatum Thunb, Malus prunifolia, Platanus orientalis, Ginkgo biloba, Zelkova serrata, Betula platyphylla, Cornus officinalis,*

	Syringa oblate, Rhododendron schlippenbachii, Chaenomeles speciose, Weigela subsessilis, Cornus alba, Berberis poiretii, Prunus domestica, Acer triflorum
Central area	*Pinus koraiensis, Picea abies, Pinus strobus, Metasequoia glyptostroboides, Acer buergerianum, Liriodendron tulipifera, Magnolia Kobus, Malus prunifolia, Acer palmatum Thunb, Acer saccharinum, Platanus orientalis, Zelkova serrata, Prunus yedoensis, Zizyphus, Styphnolobium japonicum, Chaenomeles speciose, Syringa oblate, Spiraea prunifolia, Rhododendron yedoense, Weigela subsessilis, Prunus tomentosa, Cornus controversa, Acer platanoides, Juniperus chinensis, Pinus densiflora, Quercus acutissima, Vitis vinifera, Cercidiphyllum japonicum, Ailanthus altissima, Ulmus davidiana var. japonica, Cornus kousa, Chionanthus retusus, Albizia julibrissin, Styrax obassia, Cercis chinensis, Euonymus alatus, Kerria japonica, Prunus mume, Castanea crenata, Juglans regia, Pyrus pyrifolia, Malus domestica, Prunus persica*
Southern area	*Pinus koraiensis, Cedrus deodara, Picea abies, Pinus strobus, Liriodendron tulipifera, Acer palmatum Thunb, Acer buergerianum, Malus prunifolia, Prunus yedoensis, Prunus armeniaca, Diospyros kaki, Ginkgo biloba, Zelkova serrata, Platanus orientalis, Aesculus turbinate, Euonymus japonicus, Rhododendron indicum, Chaenomeles speciose, Syringa oblate, Callicarpa dichotoma, Lagerstroemia indica, Celtis sinensis, Punica granatum, Ficus carica*
Southern coast area	*Camellia japonica, Viburnum odoratissimum, Cedrus deodara, Pinus thunbergii, Chamaecyparis pisifera, Acer buergerianum, Malus prunifolia, Prunus yedoensis, Firmiana simplex, Zelkova serrata, Platanus orientalis, Pseudocydonia sinensis, Ligustrum japonicum, Euonymus japonicus, Rhododendron indicum, Viburnum sargentii for. Sterile, Pyracantha angustifolia schneid, Lagerstroemia indica, Machilus thunbergii, Gardenia jasminoides, Ilex crenata*
Specialized for sheath and cover	*Platycladus orientalis, Juniperus chinensis, Forsythia koreana, Hibiscus syriacus, Buxus koreana, Ligustrum obtusifolium, Parthenocissus tricuspidata, Rosa multiflora Thunb. var. platyphylla, Wisteria floribunda, Pueraria montana, Amorpha fruticose, Phyllostachys bambusoides, Zephyranthes carinata*

The Korean Peninsula is geographically located in a middle latitude temperate zone, thus, it experiences four distinct seasons: spring, summer, fall, and winter. The summer is hot and humid, which is influenced by North Pacific anticyclones. On the other hand, the winter is cold and dry because of continental high pressure. The regional divisions for tree planting are based on the average lowest temperature in January. In 2009, when the design guideline was first established, the regional divisions were adapted and have not changed until today. However, the average lowest temperature in January today is significantly different from these division lines, so the divisions look like they were never revised after their first adaptation. Thus, the regional divisions (and all standards specified above including date and species) for tree planting need to be revised to reflect warming trends and other climate change symptoms today.

Another piece of evidence to show the necessity for revision of the standards above is the defect rate of landscaping trees after construction. According to the results of the latest investigation, the defect rates of landscaping trees were 17.54% in 2011 (Park, 2017), 16.75% in 2013, and 12.7% in 2016 (Lafent, 2017). The rate decreased after it peaked in 2013, but the rate is consistently over 10%. As stated above, defects of landscaping trees can be influenced by several variables besides climate changes. However, it is reasonable to presume that climate change is one of the major causes of defects of landscaping trees today for two reasons: (1) a rapid increase of the rate of defects—originally the defect rate of landscaping trees was estimated under 5%, but latest numbers continually show over 10% (Lafent, 2017; Park, 2017), and (2) an emergence of large-scale defects in landscaping trees—as stated

above, in 2015, almost half the numbers of street trees (*Stewartia pseudocamellia*) in Sejong abruptly withered (Kwon, 2017).

2. MATERIALS AND METHODS

A questionnaire was used as the major research method for this study. The questionnaire contains 27 questions to measure professionals' perceptions regarding landscaping tree defects. In detail, 23 questions are designed to discover professionals' perceptions toward major causes of tree defects, and the others ask professionals' perceptions toward the duration of tree defects, monthly frequency of the occurrence of tree defects, dates for rapid increases of tree defects, and causes of the rapid increase of tree defects.

For selecting respondents for the study, stratified sampling was used. The perceptions of tree defects under climate change can differ depending on the role of a respondent in the landscape architecture construction process. Thus, the respondents of the questionnaire were largely categorized into three types according to roles of their affiliation characteristics: 1) a public construction enterprise, 2) a private construction firm, and 3) a small private landscape architecture construction firm.

A total number of 299 professionals responded to the questionnaire. The answers varied depending on respondents' affiliation characteristics, like a public construction enterprise, a private construction firm, or a small private landscape architecture construction firm. Thus, researchers tried to contact professionals at various levels of affiliation, to obtain a diversity of opinion. The demographic profiles of the survey respondents are presented in Table 3.

Table 3. Demographic profiles of survey respondents.

Demographic Characteristics (n=299)		Frequency	Percentage (%)
Age	20-29	30	10.0
	30-39	106	35.5
	40-49	118	39.5
	50-59	39	13.0
	60 and over	6	2.0
Affiliation characteristics	A public construction enterprise	133	44.5
	A private construction firm	90	30.1
	A small private landscape architecture construction firm	65	21.7
	Other	11	3.7
Work experience in the field of landscape architecture construction	1-10	94	31.4
	11-20	77	25.8
	21-30	39	13.0
	30 and over	4	1.4
	No response	85	28.4

The field survey, using the questionnaire, was conducted between December 2016 and January 2017. The collected data were analysed using the IBM Statistical Package for Social Science Statistics on Cloud. All trees, mentioned after in this article without separate representation, refer to a tree as a material for landscape architecture construction.

3. RESULTS AND DISCUSSIONS

The result of the questions regarding professionals' perceptions toward causes of tree defects are shown in Tables 4 and 5. Additionally, the following tables show the results of the questions regarding professionals' perceptions

of the duration of major occurrences of tree defects (Table 6), professionals' perceptions of the monthly frequency of tree defects (Table 7), professionals' perceptions of dates of the rapid increase of tree defects (Table 8), and professionals' perceptions of causes of the rapid increase of tree defects (Table 9). Of all the perceptions verified in this research, three noteworthy issues were discussed regarding sustainable tree planting under climate changes: (1) drought and heat waves as major climate change phenomena that affect tree defects in Korea; (2) building a tree planting environment reflecting climate change prediction; and (3) additions for sustainable tree planting in Korea.

Table 4. Professionals' perceptions toward major causes of tree defects (n=299)

Impact Variables*	Mean	SD	% Agree
Climate Change	5.77	1.1	88.3
Tree/Planting	6.20	0.9	94.6
Construction	5.14	1.2	68.9
Soil	5.79	1.1	88.3
Management	5.85	1.1	88.0
Construction Process	4.86	1.2	60.2

*Measured on a seven-point scale: 1=strongly disagree, 4=neutral, 7=strongly agree. SD: standard deviation.

Table 5. Professionals' perceptions toward detailed causes of tree defects (n=299)

Impact Variables*	Mean	SD	% Agree
Climate Change			
Drought	6.38	0.9	96.0
Heavy rain	4.52	1.2	84.3
Heat wave	6.15	0.9	97.3
Increasing average temperature	5.08	1.2	71.2
Cold wave/Heavy snow	4.91	1.1	64.9
Tree/Planting			
Defect of a tree itself	4.97	1.4	64.5
Unsuitable species	5.15	1.2	70.2
Species vulnerable to blight and harmful insects	4.61	1.2	51.8
Planting at unsuitable time	6.05	1.0	92.6
Construction			
Deep planting	5.08	1.1	69.6
Planting delay	5.54	1.2	81.6
Soil			
Soil defects	5.69	1.1	85.6
Artificial soil	5.94	1.0	92.0
Management			
Poor irrigation	5.77	1.2	86.6
Poor management of blight and harmful insects	5.20	1.2	72.6
Construction Processes			
Collaboration with other construction processes	4.79	1.1	58.9
Previous construction processes	4.79	1.2	60.2

*Measured on a seven-point scale: 1=strongly disagree, 4=neutral, 7=strongly agree. SD: standard deviation.

Table 6. Professionals' perceptions toward duration of major occurrence tree defects (n=288)

Duration	Frequency	Percentage (%)
During construction	25	8.7
Within a year after construction	201	69.8
Within two years after construction	48	16.7
After two years from construction	11	3.8
Other	3	1.0

Table 7. Professionals' perceptions toward monthly frequency of tree defects occurrence (n=286)

Month	Frequency	Percentage (%)
February-March	19	6.6
March-April	14	4.9
April-May	11	3.8
May-June	32	11.2
August-September	169	59.1
September-October	9	3.1
October-November	21	7.3
Other (November-February, July-August)	11	3.8

Table 8. Professionals' perceptions toward date for rapid increase of tree defects (n=287)

Date	Frequency	Percentage (%)
Last five years	148	51.6
Five-ten years	76	26.5
Ten-fifteen years	8	2.8
More than fifteen years	2	0.7
No rapid increase in tree defect	53	18.5

Table 9. Professionals' perceptions toward causes for rapid increase of tree defects (n=288)

Causes	Frequency	Percentage (%)
Climate changes	127	44.1
Quality of trees	24	8.3
Artificial soil	53	18.4
Planning	14	4.9
Built environment	46	16.0
Insufficient management	1	0.3
No rapid increase in tree defect	23	8.0

3.1 Drought and Heat Wave as Major Climate Change Phenomena that Affect Tree Defects in Korea

Of the questionnaire respondents, 78.1% think the rapid increase of tree defects emerged within the last 10 years (Table 8). In addition, the most selected reason (44.1%) for this rapid increase is climate change (Table 9). These results suggest that most professionals who plant and manage trees in the field of landscape architecture in Korea believe that climate change phenomena have emerged in Korea within the last decade, and these phenomena have bad effects on trees. According to KMA, phenomena such as warming, water circulation changes, extreme weather (heat wave, droughts, and heavy rains), atmospheric circulation and fluctuation patterns changes, rising sea level, and increasing water temperature are appearing in the Korean Peninsula (Korea Meteorological Administration (KMA), 2015a). And understandably, these various phenomena could have a decisive influence on trees.

The questionnaire results show that climate change is perceived as not only a reason for the sudden increase of tree defects within the last decade, but also as a major continuous source leading to negative impacts causing tree defects by professionals. For the question that asked about the major cause of tree defects, 88.3% of the respondents answered that climate change is a major cause of tree defects, while only 3% disagreed with climate change's impact on tree defects (Table 4). Today, much research identifying climate change impacts on wildwood has been released in the academic world of Korea (Kim, S. A. et al., 2009; Kim, Y.-K. et al., 2012; Ko et al., 2014; Lee, S.-H., Choi,

& Lee, 2011; Lee, Y. et al., 2014; Tae-Geun, Cho, & Oh, 2015; Shin, 2016).
In a similar context, climate change can have influence on trees in urban
environments. This study explores climate change as a challenge not only for
wildwoods, but also for trees in urban environments through professionals'
perceptions.

Then, we must ask, of diverse climate change phenomena, which one(s)
has the biggest impact on trees? To answer this question, researchers asked
about detailed subsections of climate changes—drought, heavy rain, heat
waves, increasing average temperature, cold snaps, and heavy snow. Most
respondents agree that all of those subsections have decisive effects on tree
defects today. In the case of drought, 96% of the respondents deem that
drought has a bad influence on tree defects. In the case of heavy rain, 84.3%
of respondents believe that heavy rain is a major cause of tree defects today.
Most respondents (97.3%) think that heat waves seriously affect tree defects,
while only 1.3% disagreed with this statement. Additionally, of the
respondents, 71.2% for increasing average temperature and 64.9% for cold
snaps and heavy snow believe that these subsections of climate changes are
also major causes for tree defects today. One notable thing from these
professionals' perceptions is that drought and heat waves are especially
believed to be major causes of tree defects today. Thus, it is reasonable to
assume that drought and heat waves are the most influenced climate change
circumstances for trees in Korea. In a similar context, Brune (2016) also
remarks that heat waves and dry spells could be the most challenging climate
change phenomena for urban trees in Germany in the coming decades.
According to Allen et al. (2010), drought and heat stress associated with
climate change are major reasons for increasing tree mortality rates, even in
natural forests. Trees in urban environments could be more vulnerable to
drought and heat waves than natural forests because urban environments are
worse for trees' growth and development than living environments of natural
forests.

It is also important that in Korea, heat waves typically occur during the
summer, while droughts are most common in winter. Of all respondents, more
than half (59.1%) perceived that tree defects mostly occurred during August
and September. Thus, summer is significant for securing sustainability of
trees. During the summer days, how to reduce the impacts of heat waves is the
key to decreasing climate change impacts on trees in Korea today. However,
as stated above, the current standards for regional tree planting (Tables 1 and
2) are only designed considering the temperatures in winter (January). So the
trees on the regional list (Table 2) could endure during winter days with cold
snaps and drought, but could not withstand summer heat waves. Additionally,
based on global warming, heat waves are becoming more severe year after
year. Therefore, all standards with tree planting in Korea need to be updated
to reflect this climate change data, considering not only winter data for cold
and drought but also the summer climate phenomena, including heat waves.

3.2   Building a Tree Planting Environment that Reflects Climate Change Predictions

Through the professionals' questionnaire analysis, we could identify that
climate change has a huge impact on trees. In particular, drought and heat
waves are perceived as primary causes for tree defects; thus, it seems to be
important to consider these climate change phenomena for sustainable tree
planting.

The results from the questionnaire imply that reflecting on climate change prediction models for tree planting is crucial for securing sustainability of urban trees. Above all things, a central characteristic of trees that is totally different from other materials in landscape architecture is that trees live their lives fixed in the ground and cannot move when their living conditions are or become sub-optimal, trees are also hard to repair or replace, thus it is important to provide suitable environments for tree growth and development. Growth and development of trees are closely related to climate and its changes, so to create suitable environments for trees' growth and development, planners, designers, and construction professionals must understand and reflect on expected climate change phenomena for their urban works.

In addition, the regionally recommended tree species list (Table 2) needs to be updated to reflect climate change predictions in order to secure the future sustainability of tree planting. The list includes species that are unsuitable under the current climate change-influenced conditions. Some studies (Ko et al., 2014; Choi & Kim, 2015), for example, examine the climate change impact on movement of *Pinus densiflora* habitats on the Korean Peninsula. *Pinus densiflora* is a commonly used landscaping tree all over the Korean Peninsula because this species was suited for the climate across all regions of Korea. However, because of climate change, the southern area of Korea is no longer suitable for *Pinus densiflora*'s growth and development, even for naturally settled *Pinus* habitats. These studies find that mass withering of pine trees has emerged in many pine habitats located in the southern area of Korea. These studies are focused on natural forests, but the context from these studies could be applicable to urban trees. Similar studies about *Quercus mongolica* (Lee, Y. et al., 2014) and *Pinus koraiensis* (Shin, 2016) also show movements of habitats under the impacts on climate change today. Native species, like *Pinus densiflora* and *Pinus koraiensis*, are commonly used as landscaping trees, because they are suitable for regional climate and easy to supply for construction. However, because of climate change, native species' potential ranges of growth and development are changed, modified, and decreased, thus the potential planting areas for each native species and non-native-but-commonly-used tree species could be adjusted to adapt to climate change predictions.

According to professionals' perceptions analysed by this study, diverse climate change phenomena are already influencing trees, and future intensified climate change phenomena will have more decisive impacts on trees. Therefore, understanding and adapting climate change prediction will be important variables for sustainable urban tree plantation, growth, and development. In this context, current tree planting standards in Korea need to be revised reflecting climate change predictions.

3.3   Additions for Sustainable Tree Planting in Korean Context

As stated above, according to construction professionals' perceptions, climate change predictions are significant for securing the sustainability of tree planting. However, additional implications are also found for ensuring the sustainability of urban trees. The construction professionals who responded to the questionnaire believe that improvements are needed regarding all other issues causing tree defects asked about in the questionnaire, such as defects caused by trees/planting, construction, soil, and management.

In detail, the majority of respondents (94.6%) perceived that the tree itself and the method of planting are one of reasons for tree defects. 68.9% also noted construction as a reason for tree defects. 88.3% selected soil problems, and 88% of respondents agreed that management could be one reason for tree defects. In addition, 60.2% perceived that construction processes also affect emerging tree defects today. More than half of respondents agreed that every subsection of the items above—defects of a tree itself (64.5%), unsuitable species (70.2%), species vulnerable to blight and harmful insects (51.8%), and planting at an unsuitable time (92.6%) for the tree/planting sections; deep planting (69.9%) and planting delay (81.6%) for the construction sections; soil defects (85.6%) and artificial soil (92%) for the soil section; poor irrigation (86.6%) and poor management of blight and harmful insects (72.6%) for the management section; and collaboration with other construction processes (58.9%) and previous construction projects (60.2%) for the construction process section—have an impact on tree defects. One notable thing is that causes the majority of respondents selected, such as unsuitable species, planting on an unsuitable date, soil defects, and poor irrigation, are closely related to climate changes, thus for improving all of these issues to reduce tree defects, both reflection on climate change prediction and other efforts for improvements might be needed together. Additionally, 70% of respondents mentioned that tree defects commonly occurred within a year after construction (Table 6). Based on this perception, urban trees need special care during that first year for their survival. To ensure the sustainability of urban trees, all tree-related processes, including not only construction, but also preparation and management, need improvements and reform.

4.   CONCLUSIONS

In this study, researchers examine the relationship between landscaping trees and climate changes in the Korean context through construction professionals' perceptions using a questionnaire. As a result of the analysis regarding professionals' perceptions of climate change impacts on tree defects, most respondents perceived that climate change already has a decisive impact on trees and needs to be reflected on regarding tree planting standards for securing the sustainability of urban trees.

As stated above, the reasons for climate change are not fully verified, but climate change has already influenced all creatures on earth. Trees, which are living creatures closely related to climate, need suitable environments for their growth and development as a construction material. Thus, for building living environments for trees climate change prediction is needed because trees remain in one place for their duration. With climate change prediction, additional improvements in all tree related processes are needed for reducing tree defects and securing the sustainability of trees.

The Korean Peninsula was divided into various zones for tree planting based on unique climates according to surrounding environments. However, today, these zones divided in the past are acquiring totally different climate characteristics and this change is directly affecting tree growing conditions. According to a result of this study, many construction professionals of South Korea recognize these climate changes and its impacts on planted trees, but there still be needs to be preparation toward how to cope with climate change in the tree planting field socially, legally, and institutionally. Such a situation is not only relevant to South Korea, but also most countries of the world. Thus,

more research about social, legal, and institutional handling of climate change in the tree planting field is urgent from an international point of view.

This study is an early stage study on building sustainable environments for urban trees. Additionally, more studies, such as how to measure local climate change phenomena and how to improve tree planting standards to reflect climate change prediction, are needed. In particular, climate change phenomena in each region could be different in their aspects, particularly in their forms and impacts. The detailed results of this study are only applicable for the Korean context. Therefore, locally focused studies for each region are needed for building sustainable tree planting environments. In this context, this study can arouse attention to the need for research of the relationship between climate change and landscaping trees, and provide information for an early approach to this type of study.

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