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Analysis on Indoor Garden Technology Trends Based on Patent Search

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Abstract

Indoor gardens tailored to suit individual tastes offer a place to enjoy plants and to relax to city dwellers to relieve stress from city life. However, there are technical issues to build such indoor gardens. To offer solutions to technical issues, this study aims to analyze development phases of indoor garden-related technologies by studying available patents in detail. Also, the study aims to understand current status and future direction of technologies by examining technological trends for introduction of indoor gardens.

Brainstorming method was used to understand technology trends and as a result, two groups were identified for technical features of indoor gardens: indoor greening technology and rest area for users. An analysis on selected patents showed that the number of patents increased until 2010 and declined gradually afterwards. Korea ranked the highest in the number of patents grant followed by USA, Japan and Europe. Similar order was observed with the number of patents granted by nationality of applicants. The number of patents granted by nationality was the highest for Korean nationals. For indoor greening technologies, patents related to structure from 2007 were mostly concentrated in the areas of irrigation control and environment control for plants and vegetation. For rest area related technologies, patent related to structure showed a repetitive pattern of increasing and decreasing, but overall, on downtrend. For further development and dissemination of indoor gardening technology, more R&D work is needed with focus on environmental control technology for designing suitable environment for both human and plant.

Keywords: Indoor Garden, Indoor Greening Technology, Rest Area, Patent, Technology growth phase

1. INTRODUCTION

Environmental issues are no longer distant problems in modern society. Environmental issues have direct impact on our daily lives. Social systems are being developed to find ways to coexist with environment which, accordingly, brings significant change to patters of human life. Especially, urban cities, nowadays are quite overcrowded as living space and require transformation to more environment friendly structure and space. Moreover, modern cities have experienced reduction of green space which led to environmental aggravation such as global warming, desiccation, flood, pollution by fine dust, etc.

Urban city is a space for city dweller's livelihood and especially in Korea, majority of population is concentrated in cities and the metropolitan area. Therefore, such space as urban city is in absolute need of green space, but given current circumstances of modern city, securing and maintaining green space is almost impossible. Furthermore, most people these days spend more than 90% of the time inside buildings away from outdoor and we live in an era where artificial environment is almost completely replacing humans' basic living environment[1]. In such environment, garden is probably the easiest access to nature. Garden is a

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special space of relatively small size compared to a park or forest, yet with the most impact. In fact, gardens can be built to suit individual taste with minimum cost. Also, there are green technologies developed nowadays to build gardens in spaces with certain conditions such as indoor, walls, rooftops or any leftover space.

However, most city dwellers in Korea live in apartments which makes it difficult to own personal space outdoor. People usually have small kitchen garden in the veranda of their apartments or grow some plants inside on flowerpots, but having a garden is not realistically possible in apartments. Even if people live in a house, spaces are used for parking and storage and it is not common to build and maintain a garden given limited space of housing. However, recently, there has been a growing interest in building gardens for better quality of life or to utilize one's free time in Korea. With the Suncheon Bay Garden Expo 2013 as a start, Seoul Garden Show and Kyung-gi Garden Exhibition were held and these shows introduced positive effects of garden to the public. As a result, there is a growing demand to build and own a garden[2, 3].

This study aims to analyze technical trends and growing stages of indoor garden technology with focus on patent search. Also, the study examined domestic and international technical trends of indoor garden technology to understand current status and direction for future development of indoor garden technology.

2. RESEARCH METHOD

2.1 Extract of keywords by brainstorming

Brainstorming was conducted with experts in landscape engineering and construction in order to examine technical problems to introducing indoor garden and to understand current status of technological trends.

Brainstorming, as a way of promoting creative thinking, is a method to encourage imagination through creative atmosphere and review different ideas including somewhat uncommon or bold ideas if it can be a solution to a problem[4, 5]. This method allows participants to freely come up with ideas instead of using logical thinking and is a way of learning techniques of thinking on how to refrain from criticizing others which is mostly widely used in many countries. Also, this method was introduced to gain more creative ideas in a short period of time and is proved through Osborn's study[6] and many other researches/presentation of scholars to be more effective than conventional meeting or idea collection methods[7]. Innovative ideas that are also successful is a result of many trials and errors of collective action of many people's ideas coming together and brainstorming is a mandatory process for such result which allows ideas to develop further through interaction and collaboration with other people. This is why brainstorming was selected as the most appropriate method to understand technological trends. Creative and constructive innovation is not about abandoning your knowledge, but it is about making what you partially know into abstract concept and into valuable combination. Thus, opinions from various experts were collected and combined through brainstorming[8, 9]. The purpose of this study is to examine technological trends of indoor garden with ornamental and relaxing effect, thus 10 participants of various ages discussed freely about status or technical aspects of building indoor gardens and keywords were extracted from the discussion.

2.2 Scope of search for patents and technology

In modern society which is represented by global and knowledge based economy, knowledge and information have become the source of wealth instead of means of wealth. Also, intangible intellectual property such as technology, brand, and design, instead of tangible assets such as land and capital, have become core elements of competitiveness for enterprises or nations[10]. Especially, a patent which is the most representative intellectual property of intangible assets, is used as important and objective measure to the technology level and innovative capability of individuals, enterprises and nations[11]. Also, patent information is utilized as significant index for technological innovation for continuous growth[12, 13] and this study with a purpose of understanding technological level and status, examined and analyzed patents granted on indoor garden technology.

Target countries for patent search include major industrial nations such as Korea, USA, Japan and Europe and patent documents that are open to public access or registered from 1997 until now.

2.3 Analyzing technological trends and market affordability

Trends per country, applicants, CPP (Cites per Patent) and FPS (Family Patent Size) were analyzed and data since 1997 were analyzed to understand trends by year.

CPP is an index describing the impact of patent of target subject(Country, enterprise, etc.) on technology innovation activities after patent registration. CPP provides information on the technological impact of value of patent portfolio owned by certain entity. The bigger the value of CPP, the more of major or original technology an entity has and an entity or a person with much cited patents, naturally has an upper edge in technological competition[14, 15]. Patent family is a set of patents protecting an invention made by one or a group of patent applicants[16]. FPS directly represents geographical protection scope of a patent and indirectly, provides information on technological importance of a patent and its value as innovative achievement. When considering cost and effort required for forming a patent family, one can expect that the bigger the family size, the more technological importance, the higher market value, thus the bigger market affordability of the patent.

2.4 Analysis on Technology development phase

Analysis on technology development phase was conducted by examining changes in the number of patents and understanding which phase of the growth graph patents belong to[18]. There are 5 development phases as below.

Table 1. Technology development phase

Technology Development phase	Content
Initiation Period(I)	With the advent of new technology, a number of patents granted and patent applicants increase slightly.
Growth Period(II)	Sharp increase in R&D activities and more intense competition. A number of patents granted and applicants increase rapidly.
Maturity Period(III)	R&D activities continue. Some companies will fall behind causing a decrease in the number of patents granted or patent applicants.
Declining Period(IV)	With the advent of alternative technology, old technologies reach a discontinuity point causing a decrease or halt in the number of patents granted or patent applicant.
Revival Period(V)	The usefulness of technologies is re-discovered along with a decline of alternative technology. A number of patents granted and applicants is again on a growing trend.

3. RESULTS

3.1 Extract of keywords by brainstorming

10 experts in landscape engineering and construction participated in brainstorming and they were 2 university professors, 3 researchers from universities and research institutions and 5 from landscape construction companies.

The result of brainstorming by 10 experts showed that technologies related to indoor gardens for ornamental and relaxation effect can be divided into 2 groups. First of all, indoor gardens are built in disclosed space from outdoor, thus technologies are divided into indoor greening technology and rest area technology. Keywords extracted regarding indoor greening technology are categorized into 3 groups. The first group of keywords is related to expressing special structure such as indoor, inside, unit and module. The second group represents water system such as water, irrigation, and nozzle. The third group represents vegetation environment control which includes greening method, environment control, temperature, etc. Keywords on rest area technology are categorized into 4 groups. The first group of keywords includes target subjects such as human body and city dwellers. The second group represents space such as pergola and bench. The third group is about environment control system such as air quality, air conditioner, and heater. The fourth group of keywords represent means of measuring stress level such as autonomic nervous system, blood pressure and heart rate.

Further study into 2 technology groups to understand details showed that indoor greening technology includes structure related technology such as green wall, housing, module and unit, irrigation control related technology such as nozzle, pump, and tank, and lastly vegetation environment control technology such as light, luminance, temperature, and humidity. For rest area technology, there were structure related keywords such as module, housing, and assembly and indoor environment control related keywords such as light, temperature, and humidity.

After combining keywords groups at high level and sub-level, the following tech. tree as table 2[6,7] below was completed. Keywords used in this tech. tree was used to understand technological trends.

Table 2. Tech Tree of Indoor Gardens

Category	Sub-Category	Feature
Greening Technology	Structure	Indoor Greening System (Vertical Garden, Green Wall)
	Irrigation	Irrigation System for Indoor Garden
	Vegetation Environment Control	Indoor Vegetation Environment Control System
Rest Area	Structure	Structure as Rest Area
	Indoor Environment Control	Indoor Environment Control System for Enjoying plant and Relaxation

3.2 Scope of patent search

The population of 24,823 patents granted was searched which included 21,403 patents granted on indoor green technology and 3,420 patents granted on rest area technology. However, the population needs to be filtered for duplication and noise of low relevance in order to come up with only effective patent population. Cautions to filter for duplication and noise are exclusion of planting experiment conducted outdoor or methods of construction for rooftop structures and only to focus on include patents on technologies of vegetation indoor. Also, technologies related to indoor greening methods and rest areas were selected.

Table 3. Category Classification

Category	Sub-Category	KR	JP	US	EP	Total	Before Noise Cancellation
Greening Technology	Structure	98	58	190	53	399	6,372
	Irrigation	256	78	142	36	512	11,074
	Vegetation Environment Control	201	90	192	29	512	3,957

	Sub Total	555	226	524	118	1,423	21,403
Rest Area	Structure	28	45	19	2	94	2,091
	Indoor Environment Control	60	50	37	5	152	1,329
	Sub Total	88	95	56	7	246	3,420
	Total	643	321	580	125	1,669	24,823

3.3 Results of technological trends and market affordability

Looking at each country, Korea had the highest number of patent granted with 643 and showed the most active patent application activities compared to other countries since 2007. USA had the second highest number of patents with 580 (approx. 35%) followed by Japan with 321 patents (19%) and Europe with 125 patents (7%). When looking at target technologies for analysis, patents were granted mostly in native country by citizens of the country. In USA, more patent were registered by foreigners than natives, but no significant variance was observed.

Table 4. Number of patent, FPS and CPP

Country	# of Patent	Rate (%)	FPS	CPP
Korea	643	38	1.23	1.59
US	580	27	6.69	6.03
Japan	321	20	1.50	3.34
Netherland	44	3	7.00	2.64
Germany	33	2	5.55	8.43
Taiwan	25	2	2.76	1.33
China	24	1	4.33	0.56
France	19	1	10.42	2.00
Others	92	6	Mean Value	
Total	1,781	100	3.43	2.86

Analysis on nationality of patent applicants revealed that the most number of patent granted was by Korean nationals followed by American and Japanese. Other nationalities include European countries such as Netherland, Germany, France and also Taiwan and China. Utilizing CPP and FPS, an analysis to understand the quality and market affordability of technology was also carried out and the result showed that target technologies had an average of 2.86 for CPP and 3.43 for FPS respectively. In other words, target technologies, on average, are active in 3-4 countries. On the other hand, Korean applicants have the higher number of patents granted, but an average CPP was 1.59 which implies that technology level is relatively low and utilization of technology is mostly domestic. Thus, there is a need for technology development that can be utilized internationally. On the contrary, patent applicants in USA had the second higher number of patents granted, and also had higher CPP and FPS than the overall average which implies that they have more advanced technology level and market affordability. Germany had a small number of patents, but patents were of high quality and market affordability. Patents from Netherland and France are active in more than 6 countries which implies that patent quality is relatively high.

A majority of 85% of patents granted was related to indoor greening technology. There was a gradual increase of patents granted related to indoor greening technology up until 2008 followed by a sharp increase until 2010 and slow decrease afterwards. For rest area technology, a total of 246 patents are found.

Regarding indoor greening technology, Korea had the most number of patents of 555 (39%) showing more active patent application than other countries especially since 2008. USA had the second highest number of patents with 534 cases (37%) and had high number of patents granted Prior to 2007, but Korea outpaced USA in the number of patents granted afterwards. In Japan, there are 226 patents(16%) and Europe had 118 patents(85).

Looking at details of patents on indoor greening technology, there are 512 patents granted in irrigation control and plant vegetation. 339 patents are granted related to structure which represents 28% of total indoor garden technology patents. The number of patents granted was similar among structure, irrigation control and vegetation environment control until 2007. However, since 2008, more patents was granted to irrigation control and vegetation environment control technology.

The quality of technology and market affordability were analyzed with CPP and FPS. The result was an average of 2.74 for CPP and 3.72 for FPS which implies that target technologies are active in 3-4 countries. Regarding structure related patents, average CPP and FPS were higher than the total average which means that technology is complete and fierce competition is expected in the market. On the contrary, patents related to vegetation environment control and irrigation control had lower average FPS than the overall average which implies that more effort is needed for technology development for further recognition and approval in the market.

Table 5. Indoor greening technology

Technology	Share(%)	Increase(%)	FPS	CPP
Structure	28.04	0.00	7.70	3.36
Irrigation	35.98	4.45	2.52	2.25
Vegetation Environment Control	35.98	5.83	1.82	2.79
Total / Mean Value	33.33	3.55	3.72	2.74

Regarding patents on rest area technology, Japan has the most number of patents with 95 patents. Patent registration related to rest area technology was most active in 2001 in Japan, but it is on a declining trend since then. Korea has 88 patents on rest area technology (38%) followed by USA with 56 patents (23%) and 7 patents by Europe (3%). In Korea, patent registration related to rest area technology was most active in 2007 which then turned to a declining trend afterwards. In 2013 and 2015, Patent registration was again on a growing trend.

The quality of technology and market affordability of patents were analyzed based on CPP and FPS. Average CPP was 3.65 and average FPS was 1.74 which means that target patents are active in 1-2 countries which are likely to be native countries. For patents related to indoor environment control, an average CPP was 3.65 which is higher than the average and this implies that there is fierce completion in the market.

Table 6. Rest area technology

Technology	Share(%)	Increase(%)	FPS	CPP
Structure	38.21	0.00	1.72	1.29
Indoor Environment Control	61.79	6.82	1.76	4.68
Total / Mean Value	50.00	3.55	1.74	3.65

4. TECHNOLOGY DEVELOPMENT PHASE

The number of patents granted and applicants related to indoor greening technology between 1997 and 2017 were analyzed to examine technical development phase of patent. The result showed that the number of patents granted and patent applicants are in growth period, but growth in period 4 is decreasing, so indoor greening technology is expected pass growth period and move into maturity period.

The number of patents granted and applicants related to rest area technology between 1997 and 2017 were analyzed to examine technical development phase of patent. The result showed that the number of patents granted and applicants are in maturity period where technology is in completion and expected to gradually fall behind in the market.

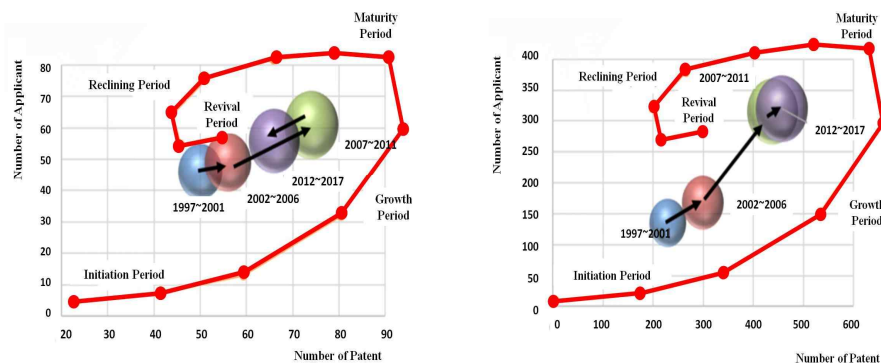


Figure1. Technology development phase

(Left : Indoor greening technology , Right : Rest area technology)

As mentioned above, indoor greening technology and rest area technology have already passed through a growth period and entered into a maturity period. These two technologies are not new technologies, thus not expected to cause indoor gardening market expansion. In fact, these technologies are expected to go into a declining period soon and a short term market outlook may not be so bright. However, in a long term perspective, there is a revival period which would bring further technology enhancement for possible market dominance and fairly good market outlook of indoor gardening.

5. CONCLUSION AND DISCUSSION

The purpose of this study is to resolve technological difficulties of building indoor garden and aims to analyze development phase of current technologies by examining types of patents granted. Also, by studying technological trends related to introduction of indoor garden, the study focused to understand current status of domestic technologies and future direction.

Brainstorming was conducted to understand current status and issues of current indoor garden technology. The result showed that there are two types of technologies needed for introduction of indoor garden which are indoor greening technology and rest area technology. Annual trends were studied to show that a number of patents increased until 2010 and gradually decreased afterwards. Patent trend per country showed that the most number of patents were granted in Korea, followed by USA, Japan and Europe and patents were granted mostly in native countries. One observation made is that technologies related to indoor gardening are mostly used domestically or only in neighboring countries and not internationally which is probably due to differences of natural environment.

For the number of patents by countries, Korea had the most number of patents. However, patents in Korea had relatively low CPP or FPS size when compared to patents registered in USA or European countries which means that the quality of technology or market affordability of patents in Korea are low. This implies that more R&D is needed to improve the quality of technology and market affordability.

Another observation made from studying types of indoor gardening technologies is that there was no technology found on irrigation related to environment control. Furthermore, there was no patent found regarding green wall technology or indoor garden technology which would allow building an environment suitable for both growth environment for plants and pleasant environment for humans. So, there is a need to develop such technology.

The study concluded that indoor greening technologies are currently in growth phase, but is expected to soon to enter maturity phase. Starting in 2007, more number of patents were granted on controlling vegetation environment and irrigation control which reflects growing interest of the society on controlling pollutants such as yellow dust or fine dust. Also, on average, indoor greening technologies are active in 3-4 countries whereas patents related to structure have higher quality and higher level of completion. But, with more focus on irrigation control and environment control for vegetation and plants, it is expected to change soon.

On the other hand, technologies on rest area are in maturity phase with a number of patents showing repetitive up and down trends. Currently, the number of patents on rest area is on a decreasing trend. Patents on rest area are active, on average, in 1-2 countries which implies that they are active mostly in domestic/native markets.

The study's result shows that indoor garden technologies have passed growth phase and entered maturity phase which means that these technologies are not new, but of continuous interest. Also along with current technology development on vegetation control or environment control system such as air quality control, there is much potential for further growth of indoor garden technology.

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