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A Study of Walkable Spaces with Natural Elements for Urban Regeneration: A Focus on Cases in Seoul, South Korea

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Abstract: environmental protection issues and the monitoring of pollution, especially for the largest cities in Asia, are becoming increasingly prominent factors for inclusive urban planning of public open spaces. Recently, a walkability concept was implemented in many cities, and in 2016 it became a campaign direction for development in Seoul. This paper considers conditions of implementation for the walkability concept, using examples of pedestrian walkway-making initiatives, and regeneration of existing walkways along water streams in urban case studies in Seoul, South Korea. The role of nature-based solutions was considered in relation to aesthetics, and social and environmental characteristics (e.g., air pollution, oxygenation through greenery) obtained through literature reviews for the case studies. Considering the complexity of the situation, with factors such as Air Quality Index (AQI) warning conditions, and the general positive impact of walkability on enhancing a healthy life style and social interaction and on reducing congestion, this study contributes to the discussion on walkability, and the importance of nature-based urban regeneration projects for densely populated areas in cities. The results of particular cases in this paper suggest the need for careful monitoring and consideration of various factors for urban regeneration walkable design projects.

Keywords: walkable city; urban regeneration; walkability; water streams; pedestrian walkways; Seoul; Air Quality Index

1. Introduction

With increasing urban growth in large cities, environmental protection measures and pollution monitoring are becoming important issues that need to be taken into account. Particularly, in the largest cities in Asia, the notions of environmental and air pollution have increased in importance, as they affect human health and well-being. For instance, Baldasano et al. state that urbanization concentration in densely populated areas causes air pollution emissions, and emphasize that the SO_2 average values calculated for Asia exceed the World Health Organization (WHO) guidelines. Particulate matter is also a crucial problem in the majority of Asian cities, exceeding 300 $\mu g/m^3$ in some places [1].

Since environmental pollution in cities is caused by many factors influencing the daily urban life of residents, not all of the impacts of environment pollution can be easily reduced or eradicated. For example, it is possible for a citizen to buy clean bottled water to drink from any convenience store or supermarket in a city. But it is not possible to choose the air to breathe on the street (even if the air pollution may vary in different districts in a city). Therefore, the monitoring and measurement of AQI is an important procedure in relation to controlling and obtaining information about air pollution. Generally, government institutions use the AQI to inform and communicate about the current air

pollution status, and future forecasts. Frequently, this information is critical to certain sensitive groups of residents, such as people prone to asthma, or the elderly [2,3].

The AQI calculation depends on national standards, and different countries have their own indexes: for example, the Air Quality Health Index (AQHI) (Canada, [4]), the Air Quality Index developed by the United States Environmental Protection Agency (USA, [5]), the Daily Air Quality Index (UK, [6]), the Air Pollution Index (Malaysia, [7]), the Air Pollution Index measured by China's Ministry of Environmental Protection (China, [8]), the Pollutant Standards Index (Singapore, [9]), and the Comprehensive Air-quality Index (South Korea, [10]). For European cities, the Common Air Quality Index (CAQI) is applied. For the worldwide real-time air pollution monitoring, the World Air Quality Index project [11] provides air quality information for large cities in more than 70 countries in the world. As the air quality information is significant for the daily life of people, [11] describes the typical health implications and cautions to be taken for various air pollution levels.

According to [12,13], the largest Asian cities recently demonstrated one of the worst AQI. Illustrating that, Table 1 presents the average AQI for several large cities in 2016. According to a number of publications, Seoul is one of the most polluted cities from the 13 selected cities in terms of air quality [14,15]. For nitrogen dioxide, particulate matter and air quality, as [15] outlines, in Asia, Seoul and Hong Kong have the worst values, while in Europe, London and Paris exceed the WHO guidelines for daytime pollution. The situation in American cities is relatively better due to the less common use of diesel fuel.

Table 2 shows some urban characteristics for the six largest cities from the top of the previous table. The urban characteristics are as follows: (1) city land area (km^2); (2) percentage of green area; (3) population; (4) urban density (people per km^2); (5) famous examples of walkable city projects/open spaces/or green spaces (according to [16,17]). Among the six cities selected for Table 2, Seoul has the highest density of residents per km^2 (which is 16,700 people per km^2). In comparison with other selected cities, the existing percentage of public green space (parks and gardens) in Seoul is quite average, and constitutes 26.6% of the city area based on Seoul Metropolitan Government (2015) data. From this, it seems that increasing the quality of urban green spaces, as well as the amount of green spaces (for example, through conducting urban regeneration projects), is an important problem for cities with high urban population density.

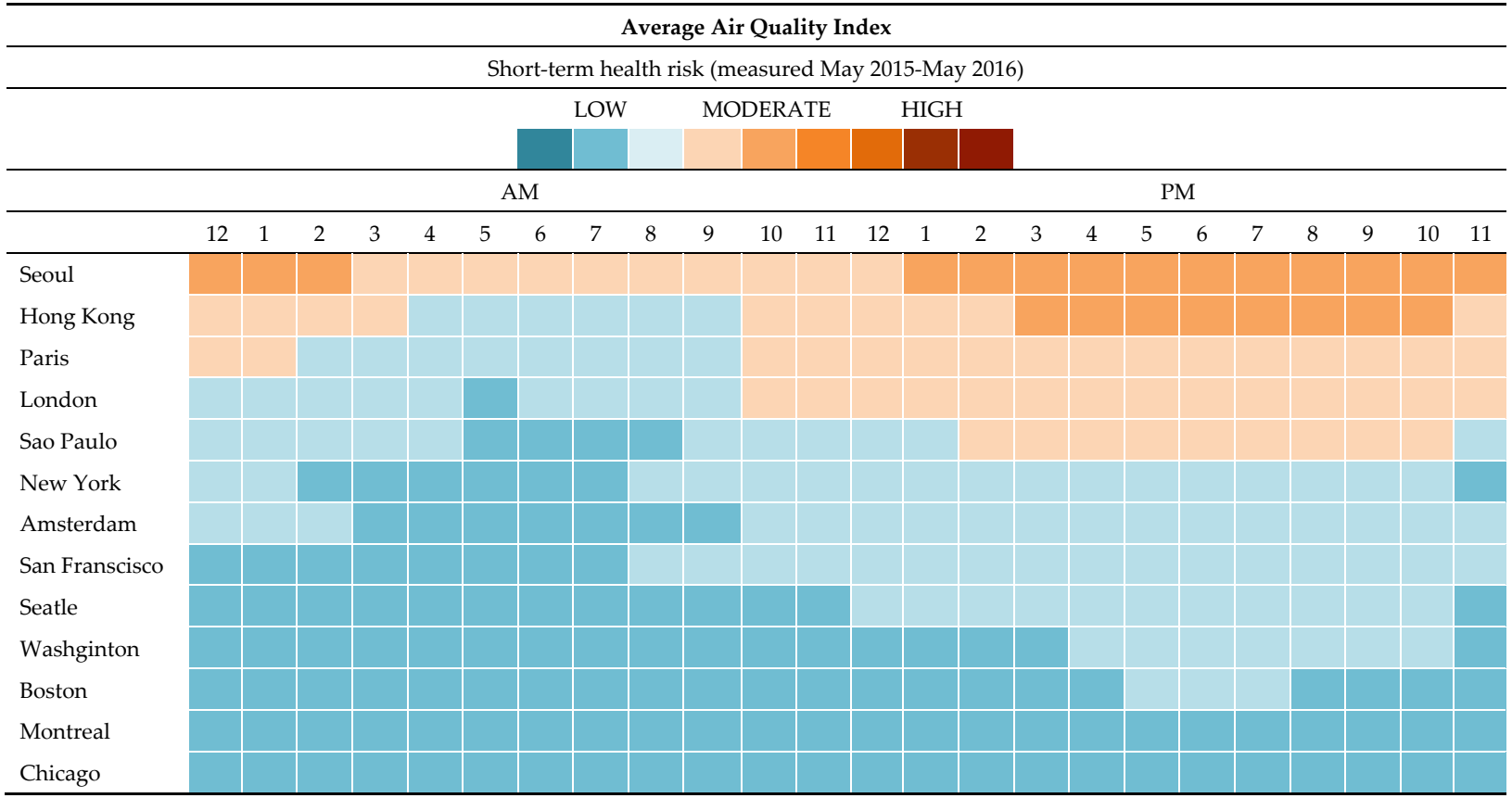
Taking into consideration one of the worst AQI conditions along with high population density in Seoul, this paper aims to study urban regeneration projects (using the example of creating walkable spaces) with natural green elements, and their potential for improving a city.

Previously, the importance of urban green spaces as a part of urban regeneration has been discussed in several papers [18–20]. For example, Dunnett et al. outline four levels of integration for urban renewal of urban green spaces, such as attracting inward economic investment, unforeseen spin-offs of grassroots initiatives, parks as flagships in neighborhood renewal, and strategic, multi-agency area based regeneration consideration of the environment and economy [18]. Force et al. suggest the creation of green belts and valuable urban green spaces as part of urban regeneration in England [19]. Tallon, describing the urban regeneration in UK, emphasizes the importance of urban green spaces for sustainability [20]. Despite the wide use of private transportation vehicles, traditionally the walking mode share is still high in Asian cities [21].

Recent urban trends suggest that a walkable city concept has become one of the relevant approaches of an urban revitalization [2,22,23]. The Seoul Metropolitan Government (SMG) has also set up "Making a Walkable City" as a campaign for Seoul's redevelopment in 2016, with high-budget urban regeneration projects [24].

In general, the positive arguments for the implementation of a walkable city concept are shown in Table 3. Negative factors caused by air pollution can significantly diminish the benefits from walking in the city. The negative arguments are summarized in Table 3.

Table 1. Air Quality Index (AQI) in selected cities, December 2016.



Sources: Plume Labs; The Economist * Using the formula of Canada's AQHI (Air Quality Health Index). Comparing urban air pollution, The Economist (2016) [15].

Table 2. Urban Characteristics of Selected Global Cities.

#	Seoul	Hong Kong	Paris
1	1049	8040	2723
2	26.6%	40.0%	9.5%
3	17,500,000	7,374,900	9,645,000
4	16,700	6690	3550
5	Cheonggyecheon; Yeouido Hangang park; Namsan park; Seoul 7017	Tram & pedestrian precinct in Central; Kowloon East; Choi Hung; Mong Kok; Kwun Tong	Promenade Plantée; La Plague; a riverside stroll along the Seine
#	**London**	**São Paulo**	**New York**
1	1623	1521	8683
2	33.0%	21.0%	27.0%
3	8,278,000	17,700,000	17,800,000
4	5100	9000	2050
5	London Olympic Park; West London's Bushy Park	Minhocao highway part-time park; city promotes bicycles routes, parklets, etc.	The High Line; Governors Island; Central Park

Notes: 1: City Land Area (sq. km); 2: Percentage of Green Area; 3: Population; 4: Urban density (people per sq. km); 5: Examples of Urban Green spaces & Walkable city projects Source: City Mayors Statistics (2007) [16]. Percentage of public green space (parks and gardens), World Cities Culture Forum [17].

Table 3. Positive arguments and negative arguments.

Positive Arguments	
(+) Reduction of congestion and car dependency in terms of transportation, although it is difficult to retrofit existing built-up areas	Southworth (2005) [2];
(+) Enhancement of a healthy life style by facilitating outdoor walking & exercise	Smith et al. (2008) [25]; Leslie et al. (2007) [26]; Lee & Moudon (2008) [27];
(+) Promotion of social interaction through "face-to-face collaboration"	Speck (2012) [23]
Negative Arguments	
(−) Physical activity in polluted air has a negative impact on health condition associated with several adverse health outcomes;	Marshall et al. (2015) [28]; Saelens (2003) [29],
(−) Low visibility (caused by smog, yellow dust, etc.) reduces the visual quality of place; reduced pleasure from walking	"ecological aesthetics" Gobster et al. (2007) [30];
(−) Long-term exposure and multi-factorial relationships	Shin (2007) [31]

Nature-based elements and features that are important for urban walkable places in this paper are presented as follows (see Table 4):

Table 4. Nature-based elements and features that are important for urban walkable places.

	Location Near Water: *Availability:* River/Water stream/Lake/etc.
	Increased Area of Greenery: *Availability:* Landscape and evergreen trees/Landscape shrubs/Perennials/Annuals/etc.
	Far Distance from Industrial Production & Transport Pollution: *Availability:* Urban points of attraction located far from hazardous industries/etc.
	Technical Protection Measures: *Availability:* Cleaning of drains/Air quality control/Protection of ecology and fauna/etc.

In Seoul, considering the compact and highly dense built-up environment and urban land use, a pedestrian-oriented design for a walkable city in urban regeneration projects is directly related to the following issues (see Table 5):

Table 5. Features of Pedestrian-Oriented Design.

	Public Transit Organization Connecting the Urban Points of Attraction; *Availability:* Linear/Non-linear/Network infrastructure between points of attraction/etc.
	Creating a Pedestrian Welcoming Environment *Availability:* Various public art/ Landscape elements stimulating walkability/ etc.
	Trigger for the Urban Neighborhood Change and Regeneration *Availability:* Land Value Change/ Increase of successful businesses/etc.

This paper seeks to consider the complex aspects of implementation of walkability concepts that incorporate nature-based elements, using examples of regeneration projects in Seoul in South Korea. It presents case studies of pedestrian walkways and walkway-making initiatives with natural elements in residential neighborhoods, with a special attention to the air quality conditions.

The next section presents the general study flow and methods for this study.

2. Study Flow and Study Methods

This paper uses multisite qualitative case studies and obtains information through literature review, various project descriptions, or site observations. Several sites were chosen to increase the generalizability in qualitative research [32]. Also, considering recent initiatives of SMG for creating urban regeneration projects with pedestrian networks (such as "Seoul Station 7017" or "Remaking Seung Sangga: Shopping Mall Regeneration" [24]), this study compares them with the completed Cheonggyecheon restoration project.

The case studies introduced large-scale urban regeneration projects (A) Cheonggyecheon water stream, (B) the ongoing Seoul 7017 project nearby Seoul Station in Yongsan-gu district, and (C) a small park ("pocket park") with the example of Dongdaemun district, which is in close proximity to

Cheonggyecheon. Sites are further described in Section 4 within the case study: Walkable Spaces with Natural Elements for Urban Regeneration in Seoul.

From one perspective, this paper considers the positive impacts of designing walkable projects that involve natural green elements. From another perspective, it discusses the implications for urban regeneration, with attention to AQI conditions in the city.

The study flow is presented in Table 6. With a focus on the impact of different quality indicators for the implementation of walkable projects with natural elements for urban regeneration, this paper uses particular case studies in Seoul to describe the impact of various characteristics of implementing walkable projects. The paper provides a qualitative analysis of the case studies; it discusses the selection of indicators, and advocates for deeper assessment of indicators for planning purposes.

Table 6. General Study Flow.

Type	Position	Description	Details
Theoretical background (Literature Review)			
Main Issue and Aspects	1	Relation between walkable city concept and Air Quality Index (AQI)	Existing methods for analysis
	2	Designs & projects in Seoul using walkable city concept	Review of existing urban trends
Case Study Area Selection			
Area Type and Particular Cases	A	Pedestrian walkway along water stream	Cheonggyecheon with its tributaries (Seoul)
	B	Pedestrian walkway with green elements	Seoullo near Seoul Station ongoing project (Seoul)
	C	Small park ("Pocket park") in residential area	On the example of Dongdaemun-gu (Seoul)
Case Study Analysis			
Characteristics and Quality indicators	1	Aesthetic characteristics	(i_1) Urban Landscape Design (i_2) Accessibility (i_3) Land Value Change (i_4) Social Interaction (i_5) Air Pollution Change (i_6) Oxygenation Through Greenery
	2	Socio-economic characteristics	
	3	Environmental characteristics	
Assessment of Walkable Spaces for Urban Regeneration in Seoul			
Main Issue and Aspects	1	AQI when implementing walkable city projects, and possibilities for air condition improvement	Results & Discussion
	2	Impact of the greenery in walkable city projects evaluation	Results & Discussion

Source: Authors (2017).

As each urban regeneration project incorporates many complex factors, the integral quality assessment for a project occasionally becomes difficult to determine, but it is a good way for the formalization of benefits and warrants for a project. Therefore, the role of nature-based solutions for walkability in urban regeneration in Seoul will be considered in relation to (1) aesthetic; (2) socio-economic; and (3) environmental characteristics.

Aesthetic characteristics for the walkable projects have previously been addressed in several studies. According to Saelens et al., aesthetic characteristics for walkable projects can be useful for obtaining measures of perceived neighborhood environment (e.g., perceived connectivity and aesthetics) [29]. However, they suggest the inclusion of both objective and subjective modes of environmental assessment. Despite the high level of subjectivity, the formalization of aesthetic characteristics for streetscapes that contribute to a pleasurable feeling from walkability is necessary, according to Timms & Tight [33]. In another work, Leslie et al. provide a description of aesthetic

characteristics that they used for analysis, such as attractive buildings or homes in a local area, pleasant natural features in a local area, or many interesting things to look at while walking [34].

Socio-economic characteristics for walkable projects, as for other urban regeneration projects, are commonly presented in terms of community engagement and economic benefits from the projects. Developing a "global walkability index", Krambeck claims that walkability itself is not yet fully understood, and paves the way for widespread interpretations [35]. Krambeck suggests the use of (1): safety and security; (2) convenience and attractiveness; and (3) policy support as "global walkability index" components for the analysis of walking conditions and pedestrian environment. Forsyth also points out the ubiquity and multidimensional character of "walkability" [36]. Lo suggests the consideration of "sense of place and aesthetics", "civic engagement", and "public health and active living" to evaluate walkability or pedestrian quality of environment [37]. Further, for civic engagement, Lo notes the importance of "equity and democracy, cost effectiveness, community interaction, and civic engagement".

The work of King and Clarke, tracing the relation of walkability and community clustering of poverty and racial minorities, finds that tracts with more residents in poverty were more walkable, but that there was less open space [38]. Frank et al. measured the net residential density, retail floor area ratio, connectivity of street network, and entropy score of land and used a mix of these values to propose a walkability index for urban districts [39].

Environmental characteristics for walkable projects often deal with air quality, estimating regional pollutants and their influence on walkability performance. For example, Marshall et al. evaluated the concentrations of nitric oxide (NO) (which is an indicator of traffic exhaust), and of O_3, for the Vancouver Metro area, to outline the impact of these on spatial patterns and walkability [28]. The relation of AQI and walkability from previous studies will be regarded in Section 3.1.

After consideration of the previous studies, this paper uses the following quality indicators: (i_1) urban landscape design and (i_2) accessibility, (i_3) land value change, (i_4) social interaction, (i_5) air pollution, and (i_6) oxygenation through greenery, for aesthetic, social, and environmental characteristics respectfully (Figure 1). For the purposes of quantitative analysis, the quality indicators (i_n) can be further defined as values with range.

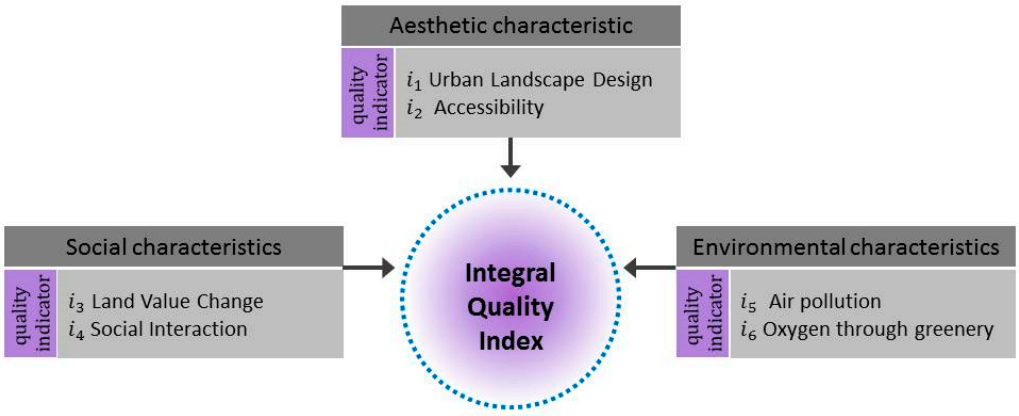


Figure 1. Integral Quality Index for a Case Study. Source: Authors (2017).

Outlining the relation between a walkable city concept and AQI from the previous literature review in general, and the situation in Seoul in particular, the theoretical background for this paper is presented in the next section.

3. Theoretical Background

3.1. Relation between a Walkable City Concept and Air Quality Index

As cities are always based on each other for innovations, the approaches for renovation of public spaces towards creating a walkable environment in many cities are similar. With regard to walkable public spaces, widely known spaces with natural elements include "High Line" park in New York, boulevards in Paris, picturesque Straatjes streets in Amsterdam's canal belt, the Luchtsingel pedestrian bridge in Rotterdam—a crowd funded public infrastructure project, and many others [40–44]. Gaining popularity walking initiatives, such as "Walk (Your City)", the "Walk (Raleigh) campaign" in US, "Jane's walk" for a community-based city building in US and European cities, "Walk21" in Hong Kong, "From Gwanghwamun to Hangan: Seoul walk and bike festival", aim to discover the walking possibilities within cities [45–48].

At the same time, taking into consideration the trend for creating a healthy urban environment, urban planning has to involve environmental issues. For example, Lehmann explores the major environmental trends towards a low-carbon city for Shanghai [49], while Kim & Choe present their vision for the evolution of the Seoul Metropolitan Region (SMR) with urban planning and sustainability directions [50]. However, environmental issues, such as air pollution evaluation, low carbon emission, waste recycling, and impact of built environment influence to health, are different for particular locations.

This section provides a literature review in terms of the relation between the walkability concept and AQI as one of the environmental characteristics, in order to reveal existing approaches for their relationships (see Table 7). The AQI assessment in relation to the urban design of walkable spaces is approached differently by various authors, using both qualitative and quantitative methods. With qualitative approaches, Soni & Soni summarize the benefits and warrants for "pedestrianization" [51]. Although that work utilizes a point-scale for particular factors (such as AQI for India or level of service (LOS) for pedestrians), the overall summary for benefits and warrants for "pedestrianization" has a qualitative character [51]. Samet qualitatively analyzes the relation of air pollution to health risks in urban design and describes cases related to improving air quality as performed by city governments in London and in Bogota [52].

Using quantitative methods, Marshall et al. measured the spatial intersection between walkability and air pollution for Vancouver [28]. Walkability is understood to be the proximity between functionally complementary land uses and the degree of route directness, while air pollution is estimated with annual average concentrations of NO and O_3 using land-use regression and spatial interpolation. The comparison of walkability and air pollution revealed different spatial patterns and their joint effect of health outcomes. Using regression models, Frank et al. analyzed the walkability in King County region in Washington in relation to various variables, such as active transportation, body mass index, and air quality (e.g., grams of transportation-related NO_x and volatile organic compounds emissions per capita) [53]. The Walkability index [53] is defined as a composite measure for intersection density, land use mix, retail floor area ratio (FAR), and street connectivity.

Lee & Moudon emphasized the importance of health problems related to physical inactivity, and suggested interventions to improve urban neighborhood walkability [27]. Lee & Moudon used both personal and environmental variables to analyze the selected areas in Seattle and the urbanized areas in King County of Washington State in US. Their research draws valuable implications for increasing walkability in existing urban neighborhoods.

Overall, although the relation between walkability in the urban environment and AQI has been analyzed by various authors, the understanding of walkability itself and formalization of principles of its description still have room for discussion.

The next subsection views designs and projects for walkability, particularly in Seoul.

Table 7. Selected Literature Review: Relation between a Walkability Concept and Air Quality Index.

Authors, Year	City	Walkable City Concept	Air Quality Index (AQI)	Description/Applied Method	Key Findings
			Qualitative methods		
Soni & Soni [51]	In general; Case of New Delhi, India	Introduced the "pedestrianization" concept	Benefits: Air pollution reduction as a part of "Environmental Benefits" Warrants: AQI unacceptable range	• Qualitative analysis; literature reviews; • Summarized the benefits and warrants of "pedestrianization"	Justification to pedestrianize an area
Samet [52]	In general; Case studies of London and Bogota	Micro-environment model (personal exposure) & built environment	Defined a personal exposure to air pollution in urban environment; analyzedl major pollutants and health risks	• Qualitatively analyzed the relation of air pollution to health risks • Presented case studies to improve the air quality	Air pollution is an ever greater threat to public health, smart growth strategies
			Quantitative methods		
Marshall et al. (2015) [28]	Metro Vancouver	Walkability is defined as a proximity between functionally complementary land uses and the degree of route directness or connectivity between destinations	Air quality: Measured annual average concentrations of two pollutants: NO concentrations and O_3 concentrations with spatial interpolation of monitoring data	• Quantitative assessment of spatial intersection between walkability and air pollution • Analyzed the health impacts of spatial exposure to the built environment	Calculated pollution values for low-income and high-income communities; costs and benefits for activities in urban settings
Frank et al. [53]	King County in Washilngton	Walkability index is a composite measure for intersection density, land use mix, retail floor area ratio (FAR), and street connectivity	Air quality: Estimated grams of transportation-related NO_x and volatile organic compounds (VOC) emissions per capita for vehicle emissions; nvironmental Protection Agency's emission rate model	• Quantitative (regression analysis) • Evaluated the association between a single index of walkability and health-related issues (including air pollution)	Connected development patterns (e.g., auto dependency/walkability; single-use/mixed-use, etc.) with health impact factors
Lee & Moudon [27]	Seattle and the urbanized areas in King County of Washington State in US	Analyzed walkability using personal and environmental variables	Seemed not to focus on AQI in particular, but considered health related factors	• Quantitative (independent and dependent variables)	Traffic and lack of destinations as barriers to walking; value of personal factors

Source: Authors (2017).

3.2. Existing and New Designs in Seoul Using the Walkability Concept

SMG implemented the "Walkable City, Seoul" concept for urban regeneration projects aimed at a pedestrian-oriented environment in 2016/17 [54]. The walkability campaign directions included the forming of a people-oriented traffic environment, improving the quality of citizens' lives, and the revitalization of the urban environment (Table 8).

Table 8. Walkability Campaign by the Seoul Metropolitan Government.

Direction	Objective	Campaign
Form a People-oriented Environment	• Creating a city free from discrimination by implementing a pedestrian-oriented traffic environment	걷자,서울
Improve the Quality of Citizens' Lives	• Reducing the social costs of environmental pollution through reduced use of cars; • Improving public health by encouraging relaxation, and preventing age-related illnesses with walking	* "Walkable City, Seoul"
Revitalize the Urban Environment	• Revitalizing the nearby regions, fueled by an increase in mobile populations • Inducing economic activities, including buying and selling of goods and services	

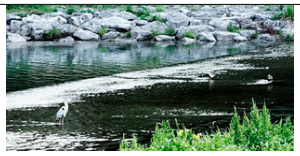
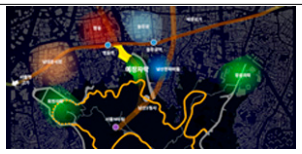
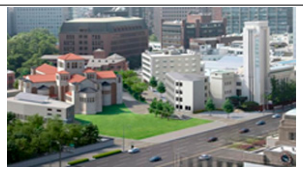
Source: Seoul Metropolitan Government [54], Image source: http://news.mt.co.kr/mtview.php?no=2016060515438224467 [55].

The existing and newly proposed walkable places and initiatives in Seoul are shown in Table 9. Among the existing walkable routes in Seoul, the most widely known is the Cheonggyecheon water stream. For the Cheonggyecheon restoration project, the elevated highway structure was removed and the urban stream was restored in its natural state, a human-friendly and environmentally friendly space with a waterfront and walks along its banks [56]. The project began in 2003 and was completed in 2005. It is now a modern, 10 km long public recreational space in the downtown area of Seoul. Restoration works were also performed on the Cheonggyecheon tributaries and other water streams [57]. The tributaries serve as connection ways and have great value for the local district communities. The Hangang River Park is another walking and cycling area in the city, equipped with bicycle sharing stations along the river. The park provides many kilometers of bicycle and walking trail, incorporating beautiful scenery and landscape [58].

Besides existing walking routes, SMG is currently implementing new walking initiatives in terms of urban regeneration, to make pedestrian connection routes between the urban points of attraction. Five Walking trails will be implemented as follows: the "Connecting Trail", "Jongno Unjong Trail", "Cheonggyeo Water Trail", "Old Scenery Trail", and the "Forever-young Trail" [54]. The Seoullo ("Seoul 7017") will be designed according to the MVRDV Winy Maas proposal, which won the international competition. SMG is also developing a bicycle-sharing system, "Seoul Bike", in the major public spaces of a city. Overall, these new projects for restoration and walkable routes are scheduled to be completed in 2017–2018.

The impact of the completed and newly implemented projects with environment-oriented design solutions is an important issue. Existing large-scale regeneration projects, such as Cheonggyechon water stream restoration, can be considered successful, but have received a lot of public discussion after completion. For example, Lee and Jung claimed that the benefits from the project were lower than anticipated, because of underestimated traffic problems, and because the finished project did not look like the natural stream [59]. Decision-making for the projects needs more participatory discussions and public awareness through all stages of analysis and design.

Table 9. Designs and Projects in Seoul Utilizing the Walkability Concept.

Name	Objective	View
Existing Walkable Routes		
Cheonggyecheon water stream (Jongno-gu)	• Revitalization of the surrounding area • Focus on cultural, artistic, and ecological activities • Cleaning of water, water flood prevention, restoration of flora & fauna	
Cheonggyecheon- connected water tributaries & other waterways (ex. Jungnangcheon)	• Improved connectivity and bicycle/pedestrian transit • Cleaning of water, water flood prevention, restoration of flora & fauna	
Hangang River Park & bicycle/walking routes (ex. Yeouido, Ttukseom)	• Providing sport and leisure facilities, "Hangang River Comprehensive; Development Project" created in the 1980s • Major bicycle and walking routes	
New Walkable Initiatives (scheduled for 2016–2018)		
Seoul Station 2017 Project	• Promoting the revitalization of the local economy and improving the pedestrian environment by converting the overpass into a walking trail • Linking Seoul Station Square with the surrounding area	
Sewoon Shopping Mall Regeneration Project	• Establishing well-designed walking trails by repairing the old pedestrian deck • Making a connection with Cheonggyeoncheon stream by building an above-ground pedestrian bridge	
Namsan Yejangjarak Regeneration Project	• Transforming the isolated Namsan Yejangjarak into a park for walking and a hub of urban tour courses • Building a link to the overpass of Seoul Station, Namsan, and Hanok Village	
Sejongro Historical and Cultural Special Space Project	• Connecting the underground space to Gwangwhamun • Restoring the traditional appearance of Deoksugung Palace	
Operation of Ddareungi, Seoul bike sharing system	• Operating a Seoul public bike sharing system • Expanding bike infrastructure to encourage the use of bicycles	

Source: Seoul Metropolitan Government [54], Han River Park's Top 3 Walking Routes [58].

In summary, nowadays the idea of increasing city walkability is one of the priorities of SMG. However, these initiatives, as large-scale area regeneration projects, incorporate various complex factors and conflicts of interests, causing public reflection and discussion [60,61]. Additionally, decision-making for large-scale area regeneration projects with sustainable designs lacks publicity and citizen participation to a certain extent [61,62].

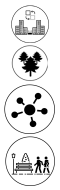
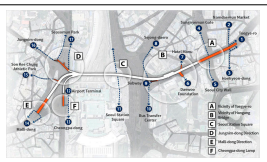
The next section presents case studies of walkable routes and spaces with natural elements in the residential neighborhoods in Seoul in South Korea.

4. Case Study: Walkable Spaces with Natural Elements for Urban Regeneration in Seoul

4.1. Areas Selection for the Case Studies

This section provides a description of the areas selected for each case study in Seoul. Two locations serving as walking routes were selected—the Cheonggyecheon water stream, and the "Seoullo" walkway, which is designated to be transformed into a walkable space with area regeneration. They represent large-scale redevelopment projects. The third case is a small park in one of the districts in Seoul. This is an example of small urban green area. The areas selected for the case studies are shown in Table 10.

Table 10. Case Study Areas in Seoul.

Name	Feature	Location	View
Large-scale Infrastructure Projects for Urban Regeneration with Nature-Based Elements			
Case A Pedestrian walkway along water stream Cheonggyecheon (completed project)		 Length: 5.84 km (total 10.92 km) Width: 20–85 m. Basin Area: 50.96 km^2	 Existing condition (Completed: 2003–2005)
Case B Pedestrian walkway with green elements "Seoullo" near Seoul Station (ongoing project)		 Length: 938 m long pedestrian passage Width: 2.5~3.5 m	 Ongoing project (Expected completion date: 2014–2017)
Small-Scale Green Space with Urban Regeneration (Example)			
Case C Small Park ("Pocket Park") in Residential Area Yongdu Park, Dongdaemun-gu, (completed project)		 Length: ~250 m Width: ~40 m Area: 0.011 km^2 (north of Cheongyocheon)	 Existing condition (Completed: 2007–2009)

Sources: "Seoullo" or "Seoul 7017" project: Image and Data Source: SMG [54]; Naver maps (2017); Authors (2017).

Cases A and B present large-scale and high-cost regeneration projects involving natural elements. They also can be considered as a status projects for Seoul as an Asian global city. The Cheonggyecheon regeneration project has proven to be successful for a city. Its realization significantly affected all of the surrounding areas, and improved its economic and environmental characteristics [63,64].

The Seoullo project is expected to bring positive changes to the surrounding area [65]. It is expected to connect historic and cultural assets, create a clean vehicle parking lot at Jungnim-dong, vitalize Jungnim market, and create a cafe street. However, when compared to High Line Park in New York, the Seoullo overpass is too high and isolated from the ground [66]. Additionally, merchants are worried about the traffic jams that the project will cause [66].

The area for the case C, although it is relatively larger than a pocket park in US, can be compared to a "pocket park" green space. Yongdu Park was constructed at the northern end of Cheonggyecheon Gosanjyo Bridge in Dongdaemun-gu in 2007–2009. As a "pocket park" [67] is usually accessed by the general public, the small triangular park has an exit from Yongdu subway station, near the "Homeplus" supermarket and the Naebu expressway. This park was selected as an example for Case study C. The maximum length of the park itself is approximately 250 m; the average width is approximately 40 m. According to [68], it is used for various events with the participation of residents.

The creation of "pocket parks", or parklets (a green space created from a car parking lot or a small vacant site) has not gained popularity in Seoul yet. However, making pocket parks of various sizes as a tool of urban regeneration that incorporates nature-based elements is popular in other large cities such as New York [69]. Typically, for new construction developments, the ratio for the landscape area is required by a project assignment. However, for the existing built environment of a city, as land prices are very high, a pocket park is frequently the only viable means of creating a new public space without large-scale redevelopment and large financial investment.

The next subsection will present the analysis for the case studies in relation to aesthetic, social, and environmental characteristics.

4.2. Case Study Analysis

In this subsection, the case studies are qualitatively described using aesthetic, social, and environmental characteristics. The limitations are related to purposeful site selections. However, this paper aimed to raise awareness of environment protection and air quality issues. Therefore the case studies of open walkable spaces as urban regeneration projects with green elements were selected as examples.

Further, the evaluation of different characteristics was proposed to be performed through the collection of expert opinions. This appeared to be a good method for formalizing the discussion on particular projects under conditions of uncertainty and complexity that often accompany large-scale infrastructure and regeneration projects.

Table 11 summarizes the case studies with the selected quality indicators.

4.2.1. Aesthetic Characteristics

For this paper, the aesthetic characteristics included the following quality indicators:

- (i_1) Urban Landscape Design
- (i_2) Accessibility

In terms of the aesthetic characteristics for the case studies, each case study urban design was unique and addressed different purposes. For each case, the natural elements were actively involved in the urban regeneration and played an important role for attracting visitors.

In particular, for Case A (Cheonggyecheon), the landscape design emphasized the value of the water stream and the increase biodiversity (flora & fauna) in the natural environment. The Seoullo project (Case B) landscape design focused on creating a pedestrian route with natural elements, such as circular-shaped tree pots at the overpass. Yongdu Park (Case C), which is located in a close proximity to Cheonggyecheon water stream infrastructure, itself incorporates various types of greenery, trees, and sculptural forms. Cheonggyechon and "Seoullo" can be easily accessed from the city center and can be regarded as city pedestrian infrastructure.

4.2.2. Socio-Economic Characteristics

For this paper, the social characteristics included the following quality indicators:

- (i_3) Land Value Change
- (i_4) Social Interaction

Socio-economic characteristics and feasibility study constitute an important part for the implementation of projects. For instance, the Cheongyecheon restoration project has led to an increase of land value by 30–50% for properties within 50 m of the restoration project. As a large-scale pedestrian infrastructure project, Seoullo appears to resemble the Cheonggyecheon project, and is expected to increase the value of the land and revitalize the surrounding area. For the small-scale project (Case C), although definitive information on a land value change was not available, the project implementation seemed to be important for social interaction in the local area.

Table 11. Quality Indicators for the Case Studies.

Characteristics	Case A	Case B	Case C
View			
Type of project	• Restoration of Natural Environment	• A Road for People (Walking Tourism Network)	• Yongdu Park: Northern end of Cheonggyecheon stream
Aesthetic Quality indicator: (i_1) Urban Landscape Design	• Created ecological biotope and environment: number of plant species increasing from 62 to 308, fish species from 4 to 25, bird species from 6 to 36, aquatic species from 5 to 53, etc. • Thematic places: waterfall and fountains	• Will install the circular type of planting ports at the overpass/684 kinds in 72 type in total • Display in the Korean alphabet order/215 types in 50 family/23,195 trees in total • Create a city forest with tall trees on the natural soil	• Green space (small park) • Focused on "rainbow gate" and "art wall" compositions
Quality indicator: (i_2) Accessibility	• Easy accessibility, project of the city value	• Easy accessibility, project of the city value	• Easy accessibility, park (itself) project of the local district value
	• Contributed to 15.1% increase in bus ridership and 3.3% in subway ridership in Seoul between 2003 and 2008	• Will create and link trails and theme streets: connecting the pedestrian roads considering the situation of each place	• Connected with Cheonggyecheon stream and subway station; a place for citizen participation and local residents
Socio-economic Quality indicators: (i_3) Land Value Change	• Increased the price of land by 30–50% for properties within 50 m of the restoration project. (double the rate of property increases in other areas of Seoul) • Increased number of businesses by 3.5% in Cheonggyecheon area during 2002–2003 (double the rate of business growth in downtown Seoul) • Increased the number of working people at the area by 0.8%	• Expected to serve as a new tourist attraction in the Seoul Station area • Expected expansion of international business and tourism at the area near Seoul Station • Expected to revitalize the surrounding area (especially Jungnim Malli-dong, and Namdemun market)	• N/A
Quality indicators: (i_4) Social Interaction	• Attracts an average of 64,000 visitors daily; (1408 of them are foreign tourists)	• Expected to attract tourists (domestic and international)	• Place is used for local resident and citizen participation
Environmental Quality indicators: (i_5) Air pollution change	• Reduced small-particle air pollution by 35% from 74 $\mu g/m^3$ to 48 $\mu g/m^3$. Before the restoration, residents of the area were more than twice as likely to suffer from respiratory disease as those in other parts of the city.	• Expected to reduce air pollution	• Reduced air pollution
Quality indicators: (i_6) Oxygenation through greenery	• Absorb pollutants and particulate matter in the air and release oxygen	• Expected to improve the air condition (expected to plant 23,195 trees in total)	• N/A

Sources: [65,66,68,70–72], Authors (2017).

4.2.3. Environmental Characteristics

For this paper, the environmental characteristics included the following quality indicators:

- (i_5) Air pollution change (e.g., reduction of carbon emissions)
- (i_6) Oxygenation through greenery

The natural elements integrated into the projects had a significant value for the improvement of environment conditions. For instance, the realization of the Cheonggyecheon restoration project resulted in a decrease of air pollution at the area by 35% [70]. The Seoullo project was expected to reduce air quality in the neighborhood area. The total number of trees to be planted for the Seoullo urban regeneration project was estimated at 23,195 trees in total, planted in circular planting ports on the upper part of the overpass [72]. The Yongdu park project implementation locally improved the environmental quality, although an overall calculation for the local air pollution change was not performed in previous studies.

The overall air quality in South Korea, plus several ways to improve air quality with the use of natural elements is shown in Tables 12 and 13 respectively. South Korea was ranked 173rd out of 180 countries in outdoor air quality by the Environmental Performance Index (EPI) 2016, and Seoul has a quite a low outdoor AQI [73]. In the overall EPI rankings, South Korea received 80th out of the 180 countries [73].

Table 12. Overall Air Quality in Korea.

Overall Air Quality for South Korea	
Air Quality, EPI Results, 2016	
(Out of 100) Score 45.51	(Out of 180) Rank 173
Air Pollution—Average Exposure to $PM_{2.5}$	
Score 33.46	Rank 174
Air Pollution—$PM_{2.5}$ Exceedance	
Score 20.76	Rank 174
Air Pollution—Average Exposure to NO_2	
Score -	Rank -
Household Air Quality	
Score 97.50	Rank 1

Source: [73], Authors (2017).

Table 13. Ways to Improve Air Quality Locally with the Use of Natural Elements.

Ways to Improve Air Quality Locally
• Affecting microclimate: human comfort, building energy budgets, and heat islands [74]
• Young trees and mature trees absorb CO_2 (13 lbs/year and 48 lbs/year) and release oxygen (enough for two persons) [74–76]
• Trees alleviate the greenhouse effect by shading buildings (reducing the need for air-conditioning by 30%) [75]
• Trees remove other gaseous pollutants with normal air components, for example, sulfur dioxide (SO_2), ozone (O_3), nitrogen oxides (NO_x), and particulates [75]

Sources: [69–71], Authors (2017).

For local air quality improvement, the positive effect of applying natural green elements is summarized in Table 10. For instance, Miller et al. outlined benefits of urban trees and vegetation [74]. Particularly, according, urban trees have valuable impact on the urban mesoclimate and microclimate in three ways: human comfort, building energy budgets, and heat islands [69]. Several sources point out trees ability to absorb carbon dioxide and release enough oxygen back into the atmosphere [74–76].

According to [76], "A single mature tree can absorb carbon dioxide at a rate of 48 lbs/year and release enough oxygen back into the atmosphere to support two human beings".

In this way, all of these projects that involve natural green elements (such as trees and vegetation) help to improve the environmental conditions of a local area of the city, and stimulate walkability. However, the low overall air quality (caused by extensive air pollution) has to be critically considered by the government authority and related organizations. Generally, air quality is an important environmental indicator that has to be regarded as of increased importance for urban regeneration projects of walkable places.

In summary, the AQI in Seoul seems to be an important factor which requires consideration when designing walkable places. Urban regeneration projects involving natural green elements will improve the environmental conditions of a particular location of a city. Walkable activities in the city have to be thoroughly planned along with environmental improvements, with the use of green elements, and the application of safety and protection measures.

5. Results and Discussion

This study considered urban regeneration projects with a walkability concept that incorporated nature-based elements, using the example of several case studies in Seoul, South Korea. It emphasized the importance of environmental protection issues in the large cities, especially concerning air pollution, which tends to be high in large cities. Seoul, as a highly urbanized city with a high-density built environment, recently experienced acute air pollution problems. Particularly, the AQI for outdoor air in Seoul is low. Overall, AQI in Seoul seems to be a crucial factor requiring consideration when designing walkable places. Hence, the following factors are of great importance:

- The AQI condition when implementing walkable projects, and possibilities for air condition improvement
- Evaluation of the impact of green nature elements in walkable projects

Taking into account the importance of AQI for projects using walkability concepts, especially for outdoor places visited by many people such as open public spaces, there is a need for inclusive urban planning with a detailed consideration of environmental issues. Particularly, environmentally-oriented urban regeneration projects have an important significance for cities with high urban population density.

Walkability is one of the recent trends for urban regeneration. However, previous studies have shown that walkability has a multidimensional character and it is not fully understood. In 2016, the SMG developed a campaign to increase the walkability of Seoul. Therefore, there is a need for a way of evaluating of the impact of walkable projects with natural elements towards the air quality condition and possible improvement of environmental characteristics.

The paper viewed three case studies in Seoul in terms of aesthetic, social and environmental characteristics for walkable projects, including natural elements in urban regeneration. The case studies for two locations serving as walking routes were the Cheonggyecheon water stream, and the "Seoullo" walkway, which is designated to be transformed into a walkable space with regeneration of the area. These represent a large-scale redevelopment projects. The third case presented was Yongdu Park, an example of one of the Dongdaemun district in Seoul, located at the northern end of Cheonggycheon.

For the large-scale regeneration projects, nature-based elements (such as greenery and water) along with the replacement of car roads with pedestrian walkways in the selected case studies, have improved the air quality conditions in the particular locations of the city. From this, it can be seen that large scale pedestrian infrastructure projects require a large funding budget and are usually aimed at solving complex urban problems, and therefore have to manage other outcomes.

Small parks (for example, pocket parks) as a tool of urban regeneration can be installed in a relatively small space (such as several car parking lots or a small vacant site). For the existing built environment of a city, land prices for redevelopment are very high, and a pocket park is frequently the only method of creating a new public space without major redevelopment and large financial

investments. Pocket parks with green elements also improve the microclimate, and therefore their positive impact has to be carefully calculated. The design standards of pocket parks seem to have good potential for the existing built environment of Seoul.

In broader sense, urban regeneration projects can have valuable impacts for improving walkability and air quality in the city. It has been shown that green elements decrease local air pollution in the area, facilitate the restoration of the natural environment, and increase ecological species richness. The social impact of regeneration projects has to be evaluated in relation with cost-benefit analysis, land value change, and the nature of social interaction. Personal health impacts and aesthetic impacts for applying green elements are important factors for practical urban planning purposes.

Taking into consideration that Seoul recently received a low AQI for outdoor air, measures for improving air quality conditions are very relevant.

This paper suggests the need for further discussion considering the following agenda:

- Discussion on the need for an integral quality index for walkability projects
- Setup of framework guidelines for the improvement of the environmental characteristics of walkable spaces by applying natural green elements
- In Seoul, decision-making for large-scale area regeneration projects with sustainable designs, lacks publicity and citizen participation to a certain extent
- Consideration of local microclimate improvement for pocket park designs, rather than just for large-scale or status projects

Furthermore, walkable activities in the city need to be thoroughly planned along with environmental improvements by the use of recommended natural and green elements, and the application of safety and protection measures.

The study is to be extended with further consideration for walkability projects, including particular natural elements in urban regeneration.

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