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Towards a Smarter Urban Park: Busan Citizens Park

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Abstract: Among various types of external space, a park, which is a critical urban public infrastructure, must be planned and redeveloped as a smart park that can reflect new technologies rather than being designed and managed in a traditional way. This study sets Busan Citizens Park, a representative urban park of Busan in Korea, as a case study site and presents guidelines for transforming the existing park into a smart park. To set the direction for presenting the guideline for park smartization, the role and function of desirable urban park in the 4th industrial age are defined. After that, smart technologies concerning park management are comprehensively organized through precedent project studies and literature research to examine the applicability of smart technologies. Based on the information obtained through field surveys, manager interviews, specialist interviews, and literature review, the management and usage status of Busan Citizens Park are identified. In order to improve Busan Citizens Park into a smart urban park, we propose smart technologies that can be applied to five components of the park: furnishings and facilities, water, green space, pavement and roads, and users. This study also suggests ways to distinguish management as urban and local dimensions by categorizing the hierarchy of technologies as urban, park, and facility scale. In conclusion, this presents guidelines for the introduction of next-generation technologies that can be applied to urban parks as a way to actively respond to changes that have already begun.

Keywords: smart park; urban park; Busan Citizens Park; smart technologies; park management

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1. Introduction

Currently, major cities around the world are experiencing unprecedented economic and social changes with rapid urbanization, and at the same time are confronting the huge crisis of climate change. In the case of Korea, the urbanization rate exceeded 80% twenty years ago, and unusual phenomena, such as heat waves, extreme cold, and heavy rain events, are gradually being accepted as normal [1]. Smart cities are attracting attention as a way to solve such a situation with technology, and to highlight the potential value of cities. To solve the problems of overcrowded cities and provide better services to users, the technologies of the 4th industrial age are being applied to the process of urban design and management, and these technologies provide ways to respond to climate change while reducing carbon emissions and maximizing energy efficiency.

However, while research to apply such cutting-edge technologies to the urban and architectural fields is actively being conducted, research on methods that can be used for the design and management of open spaces is still in its infancy. The importance of external space in overcrowded cities has become more prominent after the outbreak of coronavirus disease 2019 (COVID-19). Additionally, the possibility that open spaces, including parks, can become a basis for adaptation and mitigation to climate change has been studied through various research efforts. This suggests that the field of landscape design and management also needs to respond quickly to the changes in technology [2]. Therefore, among the various types of external space, the park, which has the most prominent character as public urban infrastructure, should be planned and redeveloped as a smart park that actively reflects smart technology, rather than being designed and managed in a traditional way. The construction of the smart park can be categorized into the construction of a new

park, and the improvement of an existing park. Currently, new smart parks of national pilot cities in Korea, such as Lake Park in Sejong City, and a landmark park in Eco Delta City, are about to be built. In the case of existing parks, upgrades are being planned in several places, starting with the National Debt Compensation Movement Memorial Park (NDCMM Park), to provide better services. Kim et al. observes that in the case of the NDCMM Park, the grafting of information and communication technology fails to express the essential value of an urban park in terms of aesthetics and usability [3]. In the case of newly created parks, the application of new technologies is relatively flexible, while the smartization of existing parks requires careful consideration of the given condition. The management and upgrading of existing parks play very important roles in improving the overall quality of the city from the fact that the area of existing parks is much larger than the area of new parks in a high-density city, such as Busan.

Busan Citizens Park, a representative urban park of Busan city, is set as a case study. Busan Citizens Park is a former Japanese Army base and United States Army camp located in Jin-gu of the city of Busan, South Korea. The U.S. military base Camp Hialeah occupied 540,000 m^2 of the center of the city, and on 10 August 2006, the land was returned to the Busan city government. The land was designated as an urban park, and opened on 1 May 2014.

In this study, the smart technologies that can enhance the functions and values of the smart urban park are critically reviewed and applied to the specific site to present practical guidelines for the introduction of next-generation of park management technologies.

2. Methods

Firstly, the concept of the smart city park will be defined, and desirable conditions for the contemporary city park will be set to establish guidelines for the smartization of the city park. Since there is no universally shared definition of the smart park yet, the essential concept of the smart park is extracted through reviewing precedent research, and the role and function of a desirable urban park in the 4th industrial age is defined to set the direction for upgrading the existing park to the smart park.

The 4th industrial age technologies that can be applied to park management, design, and construction are comprehensively summarized by literature review and precedent study. Smart park-related technologies scheduled to be applied or already applied in a project, such as the smart park in Eco Delta City in Busan [4], are investigated, and literature materials, including the Luskin Center's 'Smart Parks: A Tool kit' [5], are reviewed.

The case site is Busan Citizens Park. Field surveys and park manager interviews were conducted to analyze the use and management status of the park. The on-site survey was conducted to investigate the frequency of use of each space in the park. A number of investigators conducted four surveys of users in August 2021 and April 2022, during the summer and spring seasons, divided into weekdays and weekends. The manager interviews were conducted four times in total with park officials and management experts to enquire about the management status concerning smartization, smartization plan, role of smart command center, and administrative issues (Table 1).

Table 1. Interviewee information.

ID	Age/Sex	Affiliation
1	40's/Male	Associate Professor of 'A' Univ., Dept. of Landscape architecture
2	40's/Male	Professor of 'B' Univ., Dept. of Architecture
3	50's/Male	Researcher of 'A' research institute
4	40's/Male	Official of Busan Infrastructure Corporation
5	50's/Male	Official of Busan Infrastructure Corporation
6	40's/Male	Field manager of Busan Infrastructure Corporation

Lastly, based on the surveyed user data and management status of the park, the demand for new technology is inferred, and the components of the park are categorized into facility and furnishing, green areas, water, paving and roadways, and users, to propose technologies that are applicable to Busan Citizens Park.

3. Definition of the Smart Park

3.1. The Traditinal City Park

Although the improvement of park functions through cutting-edge technology is the main issue of smartization of the park, the original functions and values of parks must be maintained, and the ultimate goal of smartization can be achieved when a clear direction is established based on this. The functions and values of urban parks have changed while maintaining their intrinsic part, since the creation of urban parks to solve the problems of the overcrowded city. To set the direction for the smartization of parks and to set a framework for analysis of the technologies, it is necessary to review the functions and values of urban parks that should be aimed for.

New York's Central Park, designed in 1857 and still functioning well to this day, is rooted in the naturalistic idea of seeing cities as evil and nature as good. Therefore, although the design at the time was carried out based on the social functions of the park, it is somewhat different from the current view, which regards the city as a living organism, and views the park as a part of it. Currently, urban parks are recognized as the core social overhead capital of the city, which both protect the ecosystem and improve the urban environment, but also provide comfortable resting places and determine the quality of life of city residents [6].

Walker notes that, as the perspective on the relationship between nature and the city changes, the function of parks as a tool that can contribute to the achievement of policy goals, such as job creation, education, public health, and community formation, are highlighted [7]. Richardson et al. focus more on individual users by emphasizing the function of urban parks that can contribute to the psychological, physical, and social health of urban residents [8]. Ellis and Schwartz set the value of city parks as a solution to the urban problem by stating that 'city parks play a very important role in achieving the goals of public domains such as culture, leisure, community, history, economy, health and welfare, natural environment, education, and transportation' [9].

3.2. The Smart City Park

Regarding the new role of parks in the background of rapid urbanization, climate change, and technological development, Qin and Kang emphasize the sustainability of contemporary parks that can be achieved through advanced technology, compared to the values of traditional parks. They argue that cities can no longer continue to solve complex and diverse problems in the traditional way, and that the field of landscape design and management must propose solutions to urban problems based on new technologies [10]. To set the direction for improving the existing urban park into the smart park, it is necessary to review the definitions of previous studies on smart parks, along with the functions and values of traditional urban parks.

Kazemersky and Winters define the smart park as an innovative model that can manage the inflow and outflow of energy, water resources, and waste in a sustainable way by focusing on the urban functions of smart parks [11]. Yoon analyzes the problems of urban parks, and proposes a holistic management and operation system [12]. The study emphasizes the importance of platform services for park users, and defines the smart park as an urban public green space using IT technology, that can continuously strengthen the function by providing user-centered services in the interaction between city residents and the park. On the other hand, Qin and Kang propose new generation public parks by using new technologies including cloud computing and artificial intelligence, and define a smart park as 'a park where various entities interact through richer smart services' [10]. In addition, Kim et al. define smart parks as 'a park that can respond smartly

to environmental and social changes by using smart technologies and designs, such as low impact development (LID), eco-friendly energy, Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), and stormwater management techniques [4]. Truch and Sutanto define the smart park as 'a park where the IoT is effectively utilized to properly respond to the needs of managers and users', by focusing on the functions of advanced technology [13]. Loukaitou-Sideris et al. view the urban park as a space of possibility to solve various urban problems, and define the smart park as 'a park that can solve various social and environmental problems in the city using cutting-edge technology' [14]. Kim et al. define the smart park as a public green space that contributes to securing the social, economic, and environmental sustainability of cities and local communities by supporting citizens' safe and pleasant use of parks, and improving the efficiency of management and operation by using digital, environmental, and material technologies [3]. Additionally, Lee et al. view the smart park as an extension of the smart city concept, not as an independent concept, and define the smart park as 'a park that supports operation, maintenance, and management by using various advanced technologies, and that contributes to solving the social and environmental problems of the city in terms of sustainability' [15]. Elsayed and Ashrry observe that it is impossible to define the basic standards of the smart park, because there are obvious limitations in measuring the performance of the space, but they define smart park as 'a park using technology', by comparison with traditional parks [16]. Suryotrisongko et al. assert an importance of a standard in the development of smart city with friendly design for disability. Instead of defining the smart city, they have smart city standards tailored to the conditions and disability needs. The four standards, they define to make smart city designs right for the disabled, are accessibility, safety, problem solving, and flexibility [17].

The definitions of previous studies of the smart park generally include the keywords 'new technology', 'sustainability', and 'user-centered'. The difference depends on whether the research topic focuses on 'user', or 'city and environment', but the main basis is the same, that the smart park can achieve a sustainable balance of demand (users) and supply (park services) through technology. Since the birth of the urban park, which was created to provide refuge from the city, rapid urbanization has progressed, and the role of the park has expanded to a wide range of fields, such as ecology, urban regeneration, economy, health, community, education, culture, and history. In the smart park, based on technology, attempts are made to further expand their functions and values through the efficient use of energy, the provision of user-centered services, and the advancement of management and operation.

In this study, by synthesizing the traditional and contemporary roles of the urban park discussed above, the smart park is defined as 'a park that improves the social and ecological environment of the city by using cutting-edge technology, a park that realizes sustainability through the efficient use of resources, and a user-centered park that provides better services by making smart decisions based on the demand of users'.

4. Smart Technologies

Through a study of smart park design/construction cases and literature review, technologies currently applied or applicable to a park are summarized. The major components of the park are divided into five categories: facility and furnishing, water, green space, pavement and roads, and users.

Among the five components of the park, facility-related technologies are divided into general features, play features, lighting, and air control facilities. Unlike traditional furnishings, smart furnishings can produce and supply electricity as needed, detect the offline condition with Internet of Things (IoT) technology, and provide appropriate services. Water-related technologies are categorized into irrigation and stormwater management, and these include technology that enables supply in response to changing demand through diverse types of sensors, technology that efficiently distributes and recycles water resources, and uses ecological solutions—such as bioswales and raingardens—rather than civil engi-

neering methods. Technology related to green space can be categorized into construction and management, which can be used to reduce the number of times of maintenance of green space to increase the efficiency of manpower allocation, to reduce carbon emissions, and to reduce the energy consumption of buildings through vegetation plantings. In the technology related to paving and roadways, the spectrum of technologies varies from the passive to the active level, from the permeable block, which is still commonly used, to the piezoelectric power generation pavement that can produce energy. Additionally, new transportation systems that should be viewed from urban scale, are included in this category, such as personal mobility. Lastly, user-related technology is categorized into user analysis and user support technology. Technologies such as big-data and cloud-computing can be introduced for user analysis, and through AR/VR, Wi-Fi, and diverse display facilities, a smart park can provide a richer spatial experience to users. Table 2 shows a category of smart technologies that can be applied to park management.

Table 2. Smart technologies that can be applied to park management.

Categories		Facilities	Technologies
Facility and furnishing	General features	Smart bench/Smart shelter, Smart pole/Smart cctv, Smart signage	Solar heat collector and storage, Charging system, Interactive panel, Motion sensing
		Smart restroom	Motion sensing, Occupancy counter, Display panel
		Solar-Powered Trash Compactors	Weight sensing, Solar heat collector and storage
	Play features	Interactive Play Structures Energy-generating Exercise Equipment	Motion sensing, Interactive panel, Energy storage system, Charging system
	Lighting	Smart lighting	Motion activated sensors, LEDs & Fiber Optics, Off-grid Light Fixtures
	Air control	Cooling mist, Air purifier tower	Air quality sensing
Water	Irrigation	Smart Water Controllers (w/Soil moisture sensing), Low-pressure and Rotating Sprinklers, Subsurface Drip Irrigation, Smart Water Metering, Greywater Recycling system	
	Stormwater, Water management	Bioswale, Rain garden, Engineered Soils, Rainwater Harvesting (Underground Storage Basins), Stormwater Continuous Monitoring and Adaptive Control (CMAC), Smart metering system, Water buffer zone, Pool Ozonation, Drone as a transportation device for water space monitoring camera	
Green space	Construction and design	Air-Pruning Plant Containers, Native species, Xeriscaping, Low maintenance species, Rain garden, Green Roofs, Green Walls	
	Maintenance	Automatic Lawn Mowers, Near-Infrared Photography (Image sensing), Drone as a transportation device for greenspace image sensing camera	
Paving and roadway		Pervious Paving, Smart traffic control system, PM circulation system, Smart parking (car), Piezoelectric Energy, Harvesting Tiles, PM/bike charging/parking station, Daylight Fluorescent Aggregate	
Users	User analysis	Big data, Cloud computing, Geographic Information Systems and Services, Drone as a transportation device for user behavior monitoring camera, Geographic Information Systems and Services	
	User support	Wearable information/education system (AR, VR), Application software (Provide park information, reservation system), Wi-fi	

5. Busan Citizens Park

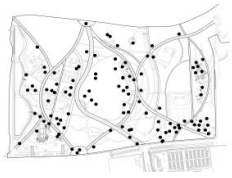
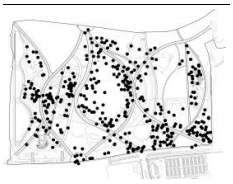
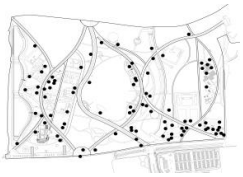
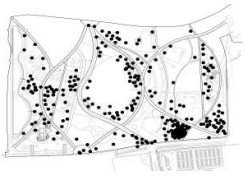
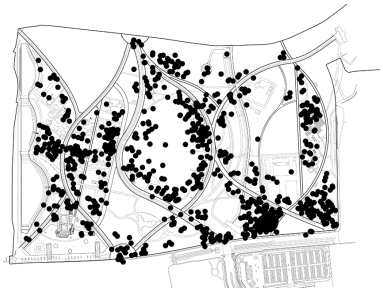
To screen out smart technologies that can be applied to or are necessary for Busan Citizens Park, the use and management status of the park is analyzed through on-site surveys and interviews with managers and park management experts

5.1. Use of Spaces in Busan Citizens Park

A field survey was conducted to determine the use of each space in Busan Citizens Park, and a number of investigators implemented a total of four surveys to measure the space utilization density in August 2021 and April 2022, during the summer and spring seasons, and weekdays and weekends. Figure 1 shows that the number of users of the space was measured at 36 survey points along the seven north–south routes (Figure 1b), while Table 3 shows the results.

Figure 1. (**a**) Main spaces and context of the park. (**b**) Survey routes.

Table 3. The number of users of main spaces of the park.

	Weekdays	Weekends
April		
August		
Total		

For the use of the park in spring (April), major facilities, such as the Maze Garden, open space around the Park History Center, the play features, the Lawn Plaza, the Participation Garden, the Culture and Art village, the Urban Sand beach, and the Pillars of Memory are used relatively evenly. The utilization is high in the case of a space that provides an open landscape, such as the Pillar of Memory or the Forest of Memories, is adequately surrounded by trees, or where furnishings are concentrated. On the other hand, it was observed that the utilization of the Woomulteo, the Forest of Participation, the Wall of Participation, and the area around the Dasomgwan was relatively low. In the case of summer (August), the density of use of the spaces where there is adequate shade of trees or where the space has specific target users, such as the Forest of Memory, the Water playground, and the play features, was prominent. In the case of the entrance, the largest number of users used the South Gate during the summer and spring season, weekends and weekdays, and it is observed that visitors using the underground parking lot enter the park directly through the visitor center.

As a result of synthesizing the density of use during the spring and summer seasons, and weekends and weekdays, the most popular attractions in terms of users in descending order: the Urban Beach, the Forest of Memories, the Lawn Plaza, the playground, the Participation Plaza, the Park History Center, the Children's Library, the Pillar of Memory, and the South Gate. Figure 2 shows existing park condition.

(**a**) (**b**) (**c**) (**d**)

Figure 2. (**a**) The lawn plaza on weekends. (**b**) General paving condition of the park. (**c**) The south gate of the park. (**d**) A water feature of the mirror pond of the park.

5.2. Management of Busan Citizens Park

The current status of facilities and management of the park was identified through interviews with managers, management experts, and literature research, and Table 4 shows the current use of smart facilities and technologies applied to the park.

Table 4. The current use of smart facilities and technologies applied to the park.

Categories		Facilities and Technologies
Facility and furnishing	General facility	Smart bench: 2 × 1 kw square pergola type bench integrated with emergency button & call, and thermo barometer sensor
	Security facility	Operating 24 h operation center, General cctv: 50. Smart cctv: 42: Notify operation center, police station, and fire station of emergency situation when it is detected by motion sensor of cctv
	Play feature	4D theater
Water	Irrigation	Lawn square: Sprinkler irrigation Tree: watered through irrigation valves that are installed every 40 m on avg.
	Stormwater, water management	Bio-swales are installed around most of the green spaces, except sloped or vegetated area
Green space		Species information is available through QR code that is attached to trees Some important trees are monitored and managed through RFID technology
Paving and roadway		Grass block permeable paving is installed on outdoor parking lots
Users		Wi-fi is available in limited spaces Online reservation is available for park programs and facilities through park website
Other		All features powered by electricity; water features, lightings, and play features are controlled by command center Operation hours of lighting and water features are automatically controlled in accordance with seasonal change Most of the machinery equipment is possessed (two types of lawn mowers, tractors, and mini excavators)

Busan Citizens Park is systematically managed according to the management method of the Busan Facilities Corporation. Seasonal tree and hydroponic facility management are controlled through a specific manual suitable for the condition of the park, and the manual is continuously supplemented and updated.

Play features are inspected daily by a legal safety manager, while pavements, green spaces, and general facilities are frequently checked by resident management personnel.

Busan Citizens Park boasts a high security rate, and no violent crime has so far occurred there. When an emergency situation is detected by smart cctv or emergency bell call, the system allows the defense personnel to be immediately dispatched.

In the case of green areas, except for slopes and shrub planting areas, a natural waterway is installed around all green areas, so an eco-friendly design that allows rainwater to penetrate underground is introduced. The lawn is automatically irrigated through a sprinkler, and the entire green area can be irrigated relatively fluidly through QC valves installed at intervals of about 40 m. In the case of the facility and furnishing, two smart benches of the square pergola type equipped with temperature/humidity sensors, emergency bells and emergency call devices are installed.

The current stage of the smartization of Busan Citizens Park is at a very early level, as some passive technologies, such as natural water way, are introduced, and limited active technologies, such as smart benches, are introduced.

The management status of Busan Citizens Park can be reviewed based on the definition of the smart park of this study: 'a park that improves the social and ecological environment of the city by using cutting-edge technology, a park that realizes sustainability through efficient use of resources, and a user-centered park that provides better services by making smart decisions based on the demand of users'.

First, Busan Citizen's Park has already achieved some portion of its goals, in that the park contributes to improving the social and ecological environment of the city using advanced technology. However, since the management is limited to the park management system, there is no active intervention for the urban role of the park, such as transportation that will change in relation to access to parks, demand forecasting from an urban perspective, water resource management at the macro scale watershed level, and a management system linked to the diverse levels of management and administrative organizations.

Second, the current management method is rather passive, in that an urban park must secure sustainability through the efficient use of energy. The emergence of numerous technologies aiming for sustainability is gradually adding to the validity of the introduction of new methods that have taken a step further from the current electricity and water resource management systems of the park. In Busan Citizens Park, it is necessary to supplement the current water supply system, which relies on tap water and groundwater from a subway tunnel, by effectively recycling stormwater or greywater. Additionally, there is a need to reduce unnecessary labor through new green and water space monitoring techniques, and energy can be managed in a more efficient way through various greening methods, power management devices, and the use of new eco-friendly materials.

Lastly, the smart city park uses cutting-edge technology to understand the needs of users and provide adequate services, so the system for data collection, analysis, and service provision is still incomplete. Currently, among the facilities installed in Busan Citizens Park, the only device that can collect user information is closed-circuit television (cctv), and through this, real-time information of the user can be grasped, but a device or system that can collect the macroscopic user pattern has not been implemented.

6. Proposal of Technology Application for the Smartization of Busan Citizens Park

To realize the functions and values of the smart city park mentioned above, this study proposes the application of technology for the smartization of Busan Citizens Park. The application stage can be broadly divided into the technology introduction stage, and the system completion stage. Technologies that can be applied in the initial stage can be arranged based on the density of use of the space investigated above. Completion of the system must be accompanied by both the introduction of technologies, and the arrangement of management entity from a long-term and urban perspective, and linkage with other urban facilities.

This study proposes smart technology that can be applied by categorizing the components of the park into five categories: facility and furnishing, water, green space, paving and roads, and users. It was established by reflecting the landscape design standards and landscaping construction specifications according to Article 44 of the 'Construction Technology Promotion Act (CTPA)' [18], and the 'Urban Parks and Green Areas Act (UPGAA)' [19] of south Korea, and 'Landscape Architecture Documentation Standards: Principles, Guidelines and Best Practices (LADS)' [20] of American Society of Landscape Architects (ASLA). LADS recommends that construction documentation for landscape architecture design be divided into grading and drainage, furnishing, tree, groundcover, shrub, and materials (paving) sections. CTPA categorizes park areas into green area, water facilities area, street and square, and landscape facility to apply management systems and regulations. UPGAA divides the components of landscape space into drainage, planting, structure, pavement, and facilities. The five categories of this study cover all elements except for the grading of LADS, and include all elements constituting urban park. The newly added user category is an item that is not included in the general park component classification method, and represents smart park-related technologies, which are mostly focused on users.

Additionally, to allocate management tasks to an adequate management entity from local to urban dimensions, we classified the hierarchy of technologies into three scales: individual element-level technologies and facilities, medium scale (Park scale) system and technologies, and Macro scale (city scale) system (Table 5).

Table 5. Category of the park components.

Research/ Document	**Categories**				
Five categories of this study	Facility and furnishing	Water	Green space	Paving and roads	Users
Construction Technology Promotion Act	Landscape facility	Water facilities area	Green area	Street and square	-
Urban Parks and Green Areas Act	Structure, Facility	Drainage	Planting	Paving	-
Landscape Architecture Documentation Standards: Principles, Guidelines and Best Practices	Furnishing	Grading and drainage	Tree, Groundcover, Shrub,	Materials	-

6.1. Facility and Furnishing

As the facility and furnishing is the most directly supporting element for park users, it is the most closely related park component to users' satisfaction, and at the same time, it can be used as a device that measures user behavior information. Currently, smart cctv and smart benches that measure atmospheric information and supply electricity are installed in the park. This can be seen as a local prescription introduced on a trial basis where it is expected to be most efficiently used, rather than promoting smartization at the level of the entire park or the city. To realize smartization on a broader level in terms of facility and furnishing, the expansion of smart furniture installation and the introduction of smart play facilities can be considered in Busan Citizens Park.

Firstly, among the various spaces in the park, one of the most important considerations from the user's point of view is to manage the amusement facilities to maintain the current function, and prevent accidents. However, compared to other facilities, the trend of play features is changing frequently, and the facilities rapidly age, due to high utilization. Therefore, it is necessary to think about alternative amusement facilities that can replace the current playground in the future. Smart interactive play features are very diverse in types and functions, but basically, sustainability through energy self-generation, device management and update through network, accessibility for the disabled, and flexible variety of play can be provided by most of the smart play features. For example, the 'Sutu ball wall' by Yalp Interactive provides a variety of games, including soccer games, linked to a smartphone application. The collected play information is transmitted to the manager, and through the data, the manager can analyze user demand. Above all, the Yalp smart play facilities were designed to be utilized by users of various classes, such as the elderly and the disabled, by providing a wide variety of alternative play through the combination of online and offline [14]. The introduction of the next-generation play space needs to be actively considered, as the current play spaces of Busan Citizens Park are extremely limited to infants, toddlers, and the disabled.

In addition, the introduction of smart furnishings, such as smart benches and smart pergola, should be considered, based on user demand. For this, it is necessary to measure the density of space use, which can be divided into the traditional method by systematic observation as conducted in this study, and the next-generation method using the Internet of Things, sensors, and drones. The counter, which is the simplest device for measuring usage patterns or density, is a tool that can collect user's movement information using a motion sensor. Motion sensors can be installed in facilities such as smart poles, smart cctv, lightings, and kiosks, or they can be linked with other objects to collect more diverse levels of information. The collected information can be analyzed in various ways, and based on

this, customized services can be provided to determine the relocation of park furnishings and facilities, deciding the size and location of park programs, and so forth.

In addition, smart toilets equipped with a greywater system, self-powered lighting equipped with motion detection sensors, and solar waste compactors are also appropriately utilized in Busan Citizens Park in terms of minimizing energy and cost consumption, and providing better convenience to users.

6.2. Green Space

For more efficient green management, low-maintenance planting, green walls, and management technology through drones can be applied to Busan Citizens Park.

First, low-maintenance planting can be expanded from places with relatively little use, such as open space around the Woomulteo and the Forest of Participation, rather than places where frequent management is inevitable, such as the entrance to a park or a space where major facilities are concentrated.

The introduction of low-maintenance species can reduce the number of tree management activities, such as pruning, and save water resources for irrigation, thereby fundamentally reducing carbon emissions in terms of tree management [21]. In particular, xeriscaping, which is difficult to find in Korea that does not have a dry climate, can efficiently use water through the mulching and selection of suitable species, as well as reduce the use of fertilizers and pesticides, and reduce the number of weeding/pruning activities [22].

In addition, much research has been conducted into the correlation between vertical greening (green walls) and energy saving through the control of water and thermal circulation. Among the various types of vertical greening methods, self-climbing type, auxiliary climbing type, and hanging-down type are suitable to be introduced into the structures of Busan Citizens Park in terms of cost and environment. In particular, application of the self-climbing type of wall greening has the advantages of easy adsorption, low-cost installation, and short-term initial greening, because the surface of the elevation is porous, such as concrete blocks or bricks with joints [23]. This approach can be applied to the Park History Center, the Dasomgwan, and the Busan Citizens Sarangchea with a large surface area of the building wall.

Information regarding a wide range of green surfaces can be collected through infrared photography using a drone to make green space management more efficient. In Busan Citizens Park, there is a lawn plaza with an area of more than 50,000 square meters. If drone images are used for weed screening, it is possible to effectively prevent the spread of soil exposure by quickly and easily identifying the distribution and growth status of weeds, which have a faster growth activity than lawn grass, and exacerbate damage by interfering with the photosynthesis of lawn grass [24]. In addition, in the case of trees, shrubs, and other herbs, it is possible to predict plant pest detection and tree shape change by comparing and analyzing data taken close-up by drones, and by analyzing the difference in reflectance in the visible and near-infrared bands of plants, so that the growth status can be systematically and accurately managed [15].

In addition, smart automatic lawn mowers that can be introduced to the management of lawn plazas in the park can reduce the generation of additional green waste by pulverizing the lawn, so that it can directly contact the soil for biodegradation. The use of Air-Pruning Plant Containers can reduce the cost of plant management in an environmentally friendly way by strengthening the root structure of plants [5]. Additionally, the construction of vegetated waterways and rain gardens, where there are no underground facilities and which does not affect the accessibility of users, aims to realize a sustainable water circulation system through restoration of a nature-friendly drainage system, and can contribute to water conservation, water purification, and flood prevention, and enhance biodiversity [25].

6.3. Water

The mean annual precipitation of Korea is (1200–1500) mm, and it belongs to a region where precipitation is quite abundant in the world, but it is seasonally biased. In the dry season of spring and autumn, water shortage frequently occurs, and heavy irrigation is often required; while in the rainy season, there is too much rain, which causes considerable management difficulties [26]. The importance of water resource management is increasing as the Water Poverty Index (WPI) ranks 20th out of 29 OECD countries, due to a large loss of stormwater, and a significant increase in water use, due to the recent occurrence of locally heavy rainfall by climate change [27]. Water resource management technology for a sustainable system can be largely divided into stormwater management and irrigation system management. Technologies such as a rainwater harvesting system, subsurface drip irrigation, greywater system, and smart water controllers can be introduced to the smartization of Busan Citizens Park.

The installation of stormwater storage tanks is a measure to circulate rainwater smoothly and efficiently use the water resource at the urban level. In the case of Busan, especially where there are many tributaries and the capacity of the downstream drainage pumping station is small, it can be of great help to install the facilities. Bucheoncheon Stream at the western boundary of the park merges with Dongcheon Stream and the water flow to Busan Bay. Bucheoncheon Stream, which belongs to the upstream part, is rebuilt as a kind of ecological water storage tank, and can be linked with new underground water harvesting tanks that can maximize total water harvesting capacity. In the lawn field near the north gate of the park, a water harvesting system can be introduced in connection with the construction of the Busan International Art Center scheduled to open in 2023, or it can be added in places where there are no underground structures, such as the Lawn Plaza, and the lower part of the Dasom Madang [28].

In addition to the rainwater collecting system, the use of greywater for toilet, street cooling system, irrigation, and cleaning water is emerging as a means of reducing water demand. Currently, water supplied to buildings, water features, and irrigation for green areas of Busan Citizens Park is dependent on tap water. In the park, in particular, a greywater irrigation system can be introduced to cover a wide range of green surface of the lawn plaza of over 50,000 square meters, on which a lot is spent on water irrigation by sprinklers. Current research shows that the effect of the chemical properties in greywater on both human and vegetation is negligible [29]. The technology can be selectively applied where the efficiency is expected to be high in consideration of the high initial installation cost, and of the entire area or part of the Lawn Plaza [30].

Additionally, subsurface drip irrigation is a technology that has been used for decades, but the potential of this technology is being re-evaluated, along with the greywater system and the Smart Water Controlling System. Since this irrigation method does not generate fine water particles, it is easy to use greywater; and in some cases, it can be installed over existing irrigation pipes and pumps, so it has the advantage in construction [31].

In addition, the smart water controller is a tool that enables automatic irrigation through the subsurface drip irrigation and low-pressure rotating sprinklers based on weather information, soil humidity information from sensors, and infrared imaging data [5]. This is a key device that can collectively manage irrigation water in Busan Citizens Park, along with the smart metering system that enables automatic water use controls by measuring usage, and providing metering information through a communication network in real time [32].

6.4. User

User-related technologies are largely categorized into technologies for providing services to users, and technologies for collecting user information. Online services, AR and VR service, and Wi-fi belong to the former, and through big data, cloud computing, and drones, better service can be provided by collecting and analyzing user data.

SNS is both a representative medium that can easily provide information about facilities and programs to users along with a website, and is being used as a major means for information collection. By using big data accumulated through portal sites and SNS, user interest in park spaces, issues, activity, and facility usage can be analyzed. In particular, text mining through big data has the advantage of being able to analyze user behavior from a long-term perspective, because it can collect past data [33]. Busan Citizens Park is an urban landmark that is visited by more than 10 million city residents annually, and is an appropriate place to collect meaningful big data. Since new activities and values can be measured with keywords derived using text mining, this technology can play an important role in both the short-term facility planning of the park, and in the reconstruction of a desirable park environment in the future.

In addition, the survey method using drones (unmanned aerial vehicles) has the advantage of being able to observe a wider area compared to the traditional observation techniques, and being suitable for precise surveys on the number of users and their usage patterns. The device can be used to reduce time and cost consumption, and to analyze more objectively. The collected data can be used as evidence for the improvement of park spaces and the introduction of new facilities in a smarter way [34].

Lastly, Virtual reality (VR) and Augmented reality (AR) are technologies that allow users to experience more diverse park spaces and programs beyond reality. Busan Citizens Park is a site where significant historical events took place during the Japanese colonial period and the Korean War. The types and formats of content that can be provided through AR and VR are very diverse, and this has the potential to complement the limitations of existing park programs. AR is often more realistic than VR, and the number of cases where AR is applied to tourism and education is increasing [35]. AR is suitable for application to open public spaces such as parks, and is particularly suitable for publicizing the historicity of the park in various ways.

6.5. Paving and Roadways

For the paving and roadway-related technologies applicable to Busan Citizens Park, piezoelectric energy harvesting tiles, permeable pavement, daylight fluorescent aggregate, and systems for personal mobility circulation can be introduced.

The piezoelectric power generation method, piezoelectric energy harvesting, is an eco-friendly power generation system that converts unused mechanical energy, such as pressure, shock, and vibration, into electrical energy. Since the output of the piezoelectric element itself is insufficient to produce macro-scale energy, most studies have focused on energy harvesting for driveways [36]. However, recent studies and practices show that the small amount of energy that can be produced using walking pressure is suitable for driving low-power electric devices [37]. The paving system was installed in a subway station in Tokyo in 2008, and in 2017, was installed in Bird Street, London for the first time as an outdoor space. Although piezoelectric power generation is not yet high in efficiency in terms of installation cost, it has great significance as a sustainable energy source that does not generate carbon, and does not deplete natural resources. The location of the pavement installation in Busan Citizens Park should be considered selectively, and it should be located where the most crowded circulation occurs. To maximize the cost-effectiveness of the piezoelectric power generation in Busan Citizens Park, the installation can start from the south gate on a trial basis, which has the highest traffic loads, and can then be expanded to the lawn plaza, along the circulation from the south gate.

In contrast to the piezoelectric energy harvesting system, the paving using daylight fluorescent aggregate can be applied mainly to places where the usage density is relatively low. Daylight fluorescent aggregates can collect energy from the sun during the day, emit light up to ten hours at night, and can be mixed with epoxy resin and used for bicycle paths or pedestrian pavements [14]. Such a dimming method is both environmentally friendly in that it can reduce the use of electricity, and is attractive, in that it provides a new experimental environment for users. In Busan Citizens Park, this pavement can be

applied to prevent violent crime and secure night vision, especially in places where there are relatively few users. It is desirable to install this pavement around a trail with a width of three meters or less, a place that is covered by trees or buildings, or a place that is separated from major facilities in terms of location, rather than in a place such as a main circulation or a crowded plaza.

One of the greatest changes in mobility in the 4th industrial age is the rapid increase in personal mobility. Personal mobility (PM) can be defined as a transportation method that is intended for use by one or two people and that is mainly powered by electricity [38]. As of October 2020, the number of domestic personal mobility users reached 1.8 million, a 314% increase from a year ago, and the market is also growing at an average annual rate of over 20% [39]. The characteristic of personal mobility is that it has much higher fluidity than the existing four-wheeled vehicle, and there is a risk that it may invade pedestrian circulation at any time. Currently, the city of Busan stipulates that personal mobility is, in principle, to be operated on a bicycle road; but if there is no bicycle road, the lane on the right edge of the roadway may be used. In addition, there are a total of 12 bicycle rental stations operated by Busan City, which are not intended to substantially improve the city's transportation system, but are part of a tourism and leisure program, and remain as a pilot facility. In other words, the current road system of Busan, which is simply divided into cars and pedestrians, cannot accommodate the rapidly increasing demand for personal transportation system, so the supply of infrastructure for personal mobility is urgently needed. Large urban infrastructure, such as Busan Citizens Park, needs to consider introducing new technologies and facilities in response to the rapidly changing traffic demand. The introduction of roads and stops for personal transportation should take into account the flow of surrounding traffic, existing bicycle paths, and the location of public transportation stops. Bicycles are allowed along the south and north gates of Busan Citizens Park. A road for personal transportation can be introduced on the premise that safety devices, such as signage, are installed around this circulation, and personal transportation stations can be installed in the South Gate Square and North Gate Square. A smart station equipped with a charging system, smart kiosk, and smart signage, rather than a simple station, can be used as a base to support a macro scale transportation system by placing it in the South Gate Plaza near subway stations and parking lots.

6.6. Hierarchy of Technology and Management

Urban parks in Korea tend to be recognized and used as green spaces detached from the city, due to the hasty space design during the rapid urbanization process, and clear separation from other land uses, but by improvement through new technology, can be closely linked with various living spaces in the city to increase synergy in park use, and to strengthen various communities.

Smartization of an urban park does not mean smartization of only places classified as a park for land use. Since Busan Citizens Park already occupies a very large part of the city's infrastructure, the perspective of promoting the smartization of Busan Citizens Park is meaningful when it includes an urban scale perspective. For the smart city park to operate in a complex manner with various city functions, institutional reorganization from a long-term perspective is necessary, and among these functions, reorganization of the management body is essential for the smooth introduction of new technologies.

Many of the technologies introduced above can be appropriately used when building a system in connection with other technologies, and different hierarchies can be assigned, depending on the technologies. For adequate management, administrative arrangements and allocation of management task can be considered based on the hierarchy of technologies.

The hierarchy of technologies and facilities can be broadly categorized into three: first, independent facilities and technologies that can be managed by the existing management entity; second, medium scale or park scale system and technologies that should be managed in connection with other facilities and technologies within the park; and third, the macro scale system that controls and supports all or part of the technologies and facilities of the

park or the city. Table 6 shows the hierarchies of technologies and facilities ranging from independent facility units to urban-level systems.

Table 6. Hierarchies of technologies and facilities.

Hierarchy of Technology/Facility	Technology and Facility
Individual element-level technologies and facilities	Smart restroom, Interactive Play Structures, Smart bench, Smart shelter, Air purifier tower, Solar-Powered Trash Compactors Use of Native species, Xeriscaping, low maintenance species, Raingarden, Green Roofs, Green Walls, Air-Pruning Plant Containers, Automatic Lawn Mowers, Bio swale, Raingarden Daylight Fluorescent Aggregate, Pervious Paving Wearable information/education system (AR, VR) Low-Pressure and Rotating Sprinklers, Subsurface Drip Irrigation, Cooling mist
Medium scale (Park scale) system, technologies, and facilities	Automatic Bicycle and Pedestrian Counters Drone for user analysis, green space image sensing, water space monitoring Application software (provide park information, reservation system) Wi-fi, Smart pole/Smart cctv, Energy-Generating Exercise Equipment SmartWater Controllers (w/Soil moisture sensing) Near-Infrared Photography (Image sensing) Greywater Recycling system, Smart Water Metering system Piezoelectric Energy Harvesting Tiles
Macro scale (city scale) system	Big data, Cloud computing, Geographic Information Systems and Services (GIS) PM circulation system/PM/bike charging/parking station Rainwater Harvesting (Underground Storage Basins) Stormwater Continuous Monitoring and Adaptive Control (CMAC)

Currently, the main management body of Busan Citizens Park is the Busan Facilities Corporation, not local government. However, for smart technology to be utilized properly at the urban level, management at the city level must be accompanied as mentioned above. In the case of Busan, the departments related to urban greenery are the Park Management Department and Forestry Green Department, and the department related to smart technology is the Smart City Team of the Future Innovation Technology Department. Each department belongs to different offices and bureaus, so it is difficult to make Busan Citizens Park smart at the urban level with the current administrative organization.

First, before making a park smart, it is necessary to pay more attention to the smartization of urban spaces at the city level, and to reorganize the smart city organization of Busan city. As of June 2019, the Ministry of Land, Infrastructure and Transport (2019) organized smart city organizations in 78 local governments nationwide (the trend of local government organizations: 10 in 2014 $\rightarrow$ 34 in 2018 $\rightarrow$ 78 in June 2019). Thanks to the policy implementation of the central government supporting the smartization projects, a total of 67 local governments are promoting the smart city [40]. In the case of Seoul, a relatively large organization called the Smart City Policy Officer is organized and operated as an entity that is capable of comprehensively introducing, operating, and managing smart technologies. However, in the case of Busan, an organization allocated to smart city is in operation with a team size under departmental scale, and it is insufficient to operate as a management body that can comprehensively cover from large to small issues of the city regarding smartization.

Second, an organization in charge of the smartization of an urban park and managing a smart city park should be operated at the city level. The jurisdiction of this organization is not limited to the Smart Busan Citizens Park, but it is involved in the establishment of smartization strategies and the smart management of green areas in Busan, and the management of systems at the city level, such as big data, cloud, and personal mobility system, by closely communicating with the smart city organization. In other words, the city-level organization plays the role of an integration manager, such as data building and

data hub for city parks, and operates by collecting, sharing, and linking information with organizations in each district (Gu) of Busan city and the Busan Facilities Corporation [12].

Lastly, facilities and technologies that can be managed independently, and the facilities and technologies of the park scale level can be managed by the existing management body, the Busan Facilities Corporation. The hasty introduction of technology can lead to a low level of understanding or lack of expertise. From a long-term perspective, smart management tasks can be systematically performed only when a dedicated organization is established by effectively distributing human resources of the organization, and securing the smart technology expertise of the members [40].

7. Result and Discussion

In this study, through comprehensive documentary research, the smart park is defined a park that achieves ecological improvement, energy sustainability, and user centeredness by using cutting-edge technologies. The guidelines for technology application proposed to orient the functions and values of the aforementioned smart city parks, and significant implications are as follows:

First, to upgrade the Busan Citizens Park into a park that can contribute to the social and ecological environment of the city using cutting-edge technology, this study suggest the introduction of a personal mobility transportation system, the use of stormwater harvesting system from the watershed-scale perspective, the formation of a smart management organization of Busan City and Busan Facilities Corporation, and the arrangement of management entities according to the hierarchy of the technologies.

This suggests that the operation and management of urban parks cannot be limited to the park scale. A smart park properly reflected in the city's context can have a positive influence on not only the city's green network system, but also other macro scale systems such as rainwater management and transportation system. Therefore, in this study, by applying smart technology to city parks, we propose a plan for parks to play an appropriate role as urban infrastructure and provide important references that can be used for upgrading other cities.

Second, to transform into a park that can achieve sustainability through the efficient use of energy, technologies to secure water resources by effectively recycling stormwater and greywater, effective use of irrigation management devices, greenery and water space management plan to use management manpower smarter, and a plan to achieve the efficient use of electricity through the use of new materials and technologies were presented.

This suggests that the smartization of parks has a strong relationship with carbon neutrality, which is attracting attention as the most important issue in contemporary society. All urban spaces, including parks, must prepare self-sufficient systems by producing energy or minimizing its use for sustainability. The energy-related smart technologies presented in this study provide examples of self-sufficient urban space operation/management through efficiency of energy use.

Third, to improve the space that can identify users' needs and provide appropriate services using advanced technology, this study suggested the use of big data and cloud, Internet of Things, and introduction of facilities that can collect user information and provide customized services.

This implies that urban parks are active service providers, not passive green spaces, and can furthermore become 'service proposers' that propose new facilities, activities, and lifestyles. When users do not know what they want, an expert can suggest it, and AI and other smart technologies can play the role of the expert. What this study presents is a city platform that can provide appropriate services almost in real time, which is of great significance as a draft version of a future space that can provide services to users in advance.

8. Conclusions

As such, the smartization of urban park is very meaningful in that it is closely linked to the growth of cities, is closely related to the global major task of carbon reduction, and generates a platform that provides advanced services to urban citizens. To this end, what is presented in this study is not a single method or technology, but dozens of different fields and hierarchical technologies that are applied individually or in a complementary relationship. From this point of view, this study reveals that the application of smart technology to the city's main infrastructure, a public urban park, is not a simple and linear intervention, but a complex and multi-dimensional process. Therefore, this study focuses on the role of a generalist who can coordinate and mediate complex situations, rather than a specialist who creates a single technology to achieve smartization of city parks. The significance of this study is to show which technologies can be applied to which areas of urban park from a generalist perspective.

New York's Central Park is one of the most famous traditional picturesque urban parks in the world, well over a century after it was first opened, and will remain a space that city residents and tourists will enjoy for hundreds of years to come. The change of technology will be applied to manage and maintain the idyllic landscape of the existing city park, rather than change it, and this study has intrinsic value in that it presents guidelines for the introduction of next-generation technologies that can be applied to urban parks as a way to actively adapt to changes that have already begun. However, some of the proposals have limitations in applying to the present reality, in that they mainly present future-oriented measures from a mid- to long-term perspective. For example, there is no disagreement among many experts that installation of a stormwater harvesting system is effective in preventing floods at the urban scale; but to use this as water for parks, it is necessary to secure the budget for the installation of another water purification system, and it is difficult to cover the cost-effectiveness of this with current status.

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