Nanjido Ecological Park

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1. Timeline

Nanjido was the only large waste landfill of Seoul to bury approx. 92 million m³ of domestic, construction, and industrial wastes for 15 years from 1978 to 1992. In the 1970s, Seoul experienced rapid economic and exponential population growth. As the result, waste levels sharply increased forcing the city to designate the location around Nanjido (540, Seongsan-dong, Mapo-gu, Seoul) as an urban planning facility in 1978: "Waste Disposal Facility". Nanjido was a perfect landfill site for Seoul because of its accessibility, location on the outskirts and vast size. Horizontal burying was performed from 1978 to 1985 while vertical burying was performed at the primary and secondary landfills from 1986 to 1992.



Figure 1. Vehicles heading for Nanjido on the Jayuro (source : http://worldcuppark.seoul.go.kr)

But the insanitary burying caused leachate during the entire burying period which led to serious land and water pollution. The landfill gas was also prone to catching fire at times. The environmental arrangement of the landfill was politically highlighted in 1990. The basic master

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plan of the 'Seoul, Capitalization 600 Yyears-old capital city project' was established in 1992 for the strategic development of Yeouido, Yongsan, Sangam, Tukseom, and the Magok area. A special urban development plan was prepared for Sangam, where Nanjido was located, reflecting that it was a gateway of both globalization and the unification of the South and North as the key area of Northwestern Seoul. In addition, there was a need to fix the local environment in order to build a world-cup stadium following the decision to build the 2002 Korea-Japan World-Cup stadium in Sangam in May, 1998. Moreover, the 'New Seoul, Our Han River' project that included the basic millennium park plan of Seoul in 1999 also included the Nanjido landfill stabilization and park construction plans.

The Nanjido landfill stabilization and park construction plans were quickly implemented for the World Cup. The landfill stabilization project was initiated in January, 1998 and finished in October, 2002 after 4 years and 10 months. The construction company was selected and started work within 3 months of finishing the design so as to shorten the construction period. An ecological park was also constructed from October, 2000 to June, 2002 alongside the stabilization project (KSP, 2014). The waste buried under Nanjido is still being biodegraded, and Seoul estimates that the stabilization will continue until 2020.

2. Situation: Background

'Nanji' of Nanjido is a combination of orchied (Nan) and gromwell (Jichi) meaning extreme beauty. Indeed, it was a beautiful island where peanuts and sorghum were grown and a place that students visited for picnics despite the frequent floods. However, Seoul buried about 20,000 tons of waste in Nanjido following its designation as a waste landfill site as well as a solid waste handling area in 1977. With the 15 years of landfill, about 9,200 million tons of waste was piled up in mountainous forms of around 812,800 pyeong (about 246,303 m2). It was originally planned to use Nanjido as a landfill for a mere 6 years from 1978 to 1984 considering the extent of the work done there. But it was difficult to find an alternative, so most of the waste of Seoul was dumped there and Nanjido eventually had a 100m high mountain of waste standing on it.



Figure 2. Geumseongpyeongsa in Geyonggyomyeongseungcheop: Gyeomjae Jeongseon 1676-1759 (Source: http://worldcuppark.seoul.go.kr)

Nanjido landfill was operated in typically insanitary ways – without any solution for gas generation, leachate, flying waste, or the harmful insects. The excessive volume of waste caused many problems. More importantly, the insanitary operation caused land, water, and air pollution with the leachate and landfill gas while the unplanned and excessive landfill caused safety issues including ground subsidence and slope collapse. The leachate had very high Biological Oxygen Demand (BOD) of 72mg/l, Chemical Oxygen Demand (COD) of 605mg/l, and Total Nitrogen (T-N) of 1,416mg/l, which can have adverse effects on neighboring streams, The Han River is connected to the streams, and this underground water is directly connected to the health of citizens. The landfill gas generated by the waste degradation process is mainly composed of greenhouse gases such as methane and carbon dioxide; the former is very flammable and explosive so Nanjido experienced several fire accidents. At the same time, unbalanced subsidence during the degradation and the massive weight of the waste layers gradually removed space so the leachate level and possibility of slope collapse increased. In addition, the waste trucks caused serious pollution including dust and noise.



Figure 3. Nanjido Landfill Source: World-cup Park Management Office (2006) Nanjido recovers the scent)

Besides the environmental issues, the Nanjido landfill caused social issues. The Nanjido landfill was a living foundation for the urban poor who made their living with goods found from the waste. They suffered from the odors, dust, insects, birds, and air pollutants from the trucks every day. They also lived in very poor brick housing around the waste piles provided by the Seoul City Government. In a word, they were exposed to risks of environment, health, and safety.



Figure 4. Nanjido people collecting waste (Source: http://worldcuppark.seoul.go.kr)

From the end of 1992, Seoul began to dump its waste at the Sudokown Landfill and finally stopped using Nanjido from 1994. Nanjido had been used as Seoul landfill for 15 years from 1978 to 1993. But the environmental issues of landfill did not suddenly disappear. As the landfill ceased, social issues appeared – including jobs and housing for the urban poor. Furthermore, Seoul had to discuss how to use the once-landfill land. Academia and various industries had different ideas regarding the early development and long-term development following the stabilization of Nanjido. The 'Early Development' was to relocate the buried waste to coastal landfill sites or other locations and then redevelop it as a housing or business site. On the other hand, the 'Long-term Development following Stabilization' was to develop it in the long term when the conditions were established after installing pollution prevention facilities for landfill gas and leachate, stabilizing the land, and finally building an environmental and ecological park on the ground. After analyzing the different aspects, Seoul decided "to maintain the current situation and postpone the development while preventing environmental pollution and stabilizing it."

3. The Importance of the Policy

The Nanjido Ecological Park Development policy has had a positive role in the eco-friendly management of Seoul in many aspects.

Firstly, the Nanjido Stabilization project was a case in which Seoul took the lead in managing the waste landfill instead of the central government. In 1993, when the Nanjido landfill had ceased being used, there were no follow-up management regulations in Korea. Post-landfill management regulations were found in the Waste Management Act in 1996 for the first time in Korea focusing on "establishing engineering solutions for appropriate follow-up management of landfills to be closed after 1998 and obliging environmental management for over 20 years." In 2010, the follow-up management regulations were reinforced to extend the follow-up environment management period to 30 years. Nanjido stopped being used for the burial of waste in 1993 so it was not subject to those regulations. However, Seoul predicted political changes of sustainable waste management in Korea and overseas countries and preemptively opted for landfill stabilization and thus creating a good example of post-landfill management.

Secondly, the Nanjido Ecological Park is connected to surrounding green areas and an ecology stream for self-sustainable recovery of the ecological functions. The Nanjido Ecological Park meets the Han River, Bulkwang Stream, Hongje Stream, and Hyangdong Stream while the grass fields on their watersides is connected to that of Nanjido Ecological Park. Even though Seoul is not home to much in the way of artificial features or design, except for some food plants and improvement of the habitat around the Nanjido park, the number of animals and plants have increased around the surrounding ecological space after developing the park.



Figure 5. Green field and streams around Nanjido Ecological Park Source: Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park")

Thirdly, the landfill gas obtained as part of the stabilization is used for district heating contributions to the 'resource cycling' city development policy of Seoul. Methane is one of the most valuable fuels, and about 232,572K m³ of landfill gas had been used at the Nanjido Ecological Park from 2002 to December, 2013, which amounts to about 8.2 billion KRW of economic value. The collected landfill gas is supplied to a district heating facility located in the Nanjido Ecological Park. The park has an incineration facility (capacity of 750 tons) for handling the domestic waste of neighbors while the heat is collected and then supplied to the district heating facility. It is a unique and rare occurrence to have landfill gas collection, domestic waste incineration, and district heating facilities all in one ecological park.



Figure 6. Mapo Resource Recollection Facility (Source: https://seoulsolution.kr)

Fourthly, the awareness of citizens regarding waste management has changed as the abandoned landfill has been transformed into a park. The Nanjido landfill site was constantly negatively seen as a source of both environmental pollution and odor. But the waste handling facility was

transformed into a resting place for citizens, which is now widely known as a shining example of excellent representative environment management on the part of Seoul.

4. Relevance with Other Policies

The Nanjido Ecological Park project was connected with the Sangam New Millennium Town project and New Han River Development projects.

1) Sangam New Millennium Town Project

Sangam New Millenium Town Project was a plan focused on developing the Sangam district from 1998 to 2000. It contained long-term plans to shape Sangam as a future city as well as a new sub-center of Seoul. The first phase connects the Nanjido landfill stabilization and redevelopment with surrounding facilities and development plans. The slogans and ideas behind the plan include 'Gateway City for reunified Korea', 'Information City for 21st century', and 'Eco City for coexistence of humans and the environment'. The objectives included planned development for transfer station construction and sphere development of the Gyeongui line, Yeongjongdo New Airport Railway, and Subway Line No.6; scenario developments and stage plan settings for the Nanjido landfill stabilization and future use; establishment of organization plans aligned with the city development for a successful World Cup; suggestion of ecological city design guidelines for Samgam Millennium City; and planned responses to high-speed trains.



Figure 7. Sangam New Millennium Town and Nanjido Ecological Park (Source: https://seoulsolution.kr/)

Additionally, the land was divided into various sections (Digital Media City, an eco-friendly housing complex, and World-cup Park) to help shape Sangam as a new city combining downtown functions, distribution, housing, with parks and green fields.

2) New Han River Development

This project aimed at developing a space for the coexistence of humans and the environment: where the Han River is made fascinating with water purification, ecosystem recovery, and leisure facilities for citizens and tourists alike. Located along the Han River, the Nanjido Ecological Park was developed for landscape and water quality improvement of the Han River. The Nanji-Han River Park is the second biggest park around the Han River and provides natural purification and leisure to the citizens using the wetland developed for 2002 World Cup. For the New Han River Development, the framework plans were developed in the first half of 1999 and it got underway in 2000 with the addition and maintenance of facilities, preservation and recovery of historic sites as well as the development and promotion of green fields.

5. Policy Objectives

The millennium park framework plan for the Nanjido Ecological Park development consisted of the following political objectives: (1) to recreate the landfill as an eco-friendly space; (2) to shape the surroundings of the 2002 World Cup stadium; and (3) to contribute to developing an eco-friendly city with the open space and park functions of the Sangam New Millennium Town Arrangement project.

Nanjido, however, raised different issues – including air and water pollution, odor, harmful insects, and safety for the surroundings as an insanitary landfill for 15 years. As addressed before, discussions took place to relocate the waste and use the land for new purposes, or stabilize the waste and avoid its short-term use for the future. Finally though, a decision was made to build the Nanjido Ecological Park. By developing the ecological park, the abandoned land was recycled as an eco-friendly space for the new millennium suggesting future-oriented environmental alternatives and representing proud cultural characteristics.

The second political objective was to improve the surroundings of the Sangam World-cup Stadium by developing the Nanjido Ecological Park. Korea was selected as a host for the 2002 World Cup and Sangam was the site for main World-cup stadium in Seoul. But the surroundings were poor. It was vital to address the mountains of waste at the Nanjido landfill site, polluted streams, and housing for the poor. So, the ecological park development project was responsible for the large-scale environment rearrangements for the surroundings.

Thirdly, Seoul tried to transform Sangam into an eco-friendly town in order to to address the rapidly increasing demand for housing in the 1990s. Seoul actively developed housing sites because of the increasing demand for development and housing in the 1990s. Sangam was no= exception as it had detached houses, settlements, and faming land. Thus, it was planned to build housing to transform Sangam into a sub-center while developing a large park in Nanjido to improve the life quality of citizens and build the Sangam New Millennium Town as an eco-friendly city serving as a supporting green field.

6. Main Policy Contents

Seoul concentrated its full organizational capabilities so as to finish the Nanjido Ecological Park Development project before the World Cup. To shorten the project period, 8 projects - landfill stabilization. Pyeonghwa Park, Haneul Park, greening of surroundings, Heemang Forest, Noeul Park, Nanjicheon Park, and Najni Han River Park - were carried out at the same time. 6 departments of Seoul were engaged in the design while 5 departments took part in order placement and supervision. Moreover, many private businesses participated: 9 designers, 23 constructors, and 6 supervisors.

The Nanjido Ecological Park development consists of the landfill stabilization and park development and cost 232.2 billion KRW (140.5 billion KRW for the stabilization and 82.7 billion KRW for the park development). The expenditures were covered with the general funds of Seoul.

	New 100 Year Preparation Committee		Mayor • Primary Deputy Mayer • Secondary Deputy Mayor		Seoul Institute (Planning & Design)	
Landfill stabilization	Pyeonghwa Park development	Haneul Park development	Slope greening & Heemang Forest development	Noeul Park development	Nanjicheon Park development	Nanji-Han River development
Designed by: Waste Facility Department Ordered by: Construction Safety Management Headquarters	Designed by: Park Green Field Project Office, Han River Project Planning Group Ordered by: Park Green Field Project Office	Designed by: Landscaping Department Ordered by: Park Green Field Project Office	Designed by: Landscaping Department Ordered by: Park Green Field Project Office	Designed by: Landscaping Department Ordered by: Landscaping Department	Designed by: City Development Corporation Ordered by: Park Department, City Development Corporation	Designed by: Construction Safety Headquarters Ordered by: Construction Safety Headquarters
Designed by: 1 supplier Supervised by: 1 supplier Constructed by: 2 suppliers	Designed by: 2 suppliers Supervised by: 2 suppliers Constructed by: 4 suppliers	Designed by: 3 suppliers Supervised by: 1 supplier Constructed by: 4 suppliers	Designed by: 3 suppliers Supervised by: 1 supplier Constructed by: 3 suppliers	Designed by: 1 supplier Supervised by: 1 supplier Constructed by: 1 supplier	Designed by: 1 supplier Constructed by: 3 suppliers	Designed by: 2 suppliers Supervised by: 1 supplier Constructed by: 5 suppliers
Advice from experts	Advice from experts	Advice from experts	Advice from experts	Advice from experts	Advice from experts	Advice from experts

Figure 8. Organization for Nanjido Ecological Park Development project

Source: Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"

1) Nanjido stabilization

With the landfill finished, Nanjido is expected to be stabilized until 2020. The landfill stabilization is a process in which the organic matter is degraded for a long time and discharged as landfill gases or leachate; inorganic matter and heavy metals are leachated with the ground subsiding. Finally, it returns to its original state. The insanitary landfill was carried out for a long time so Nanjido produced leachate, odord, and harmful gases resulting in water and ground pollution around the Han River and thus serious destruction of the local ecosystem. The Nanjido stabilization aimed at addressing the environmental pollution and preparing for eco-friendly park development. The stabilization consists of leachate handling by installing barrier walls for the leachate, top molding processes to develop grass fields; gas collection and handling; and slope stabilization to prevent collapse by adjusting its incline and developing the area for the return of green space.

2) Ecological park development

The Nanjido Ecological Park has 5 parks - Pyeonghwa Park, Nanjicheon Park, Haneul Park of Landfill No.1, Noeul Park of Landfill No.2, and Nanji-Han River Park - covering approximately 1.05 million pyeong (about 318.182 m2). They were designed to be integrated and organized while having independent characteristics. The planning concept was the 'Mutual Coexistence and Symbiosis' for the coexistence of nature and human culture; a symbiotic relationship between environment preservation and human development, and a harmony of artificial structures and natural landscapes. In addition, the drainage and earthwork plans were reflected to prepare for the subsidence of landfill layers and observe them.



Figure 9. Bird's-eye view of Nanjido Ecological Park Source: http://worldcuppark.seoul.go.kr

3) Sustainable waste management

Along with the Nanjido Ecological Park development, the Mapo Resources Recollection Facility was built between the Noeul Park and Haneul Park. It is an incineration facility that handles 750 tons of domestic waste daily from Mapo, Yongsan, and Junggu. It was built from June, 2000 to December, 2003. The Nanjido Ecological Park came to have comprehensive resource recycling functions with the newly-built resources recollection facility, district heating facility, leachate treatment plant, and landfill gas collecting facility. In addition, the resources recollection facility is serving as an environmental education space by operating site visit programs for citizens and designing symbolical building for the futuristic ecological city.



Figure 10. Resources collecting and related facilities Source: http://worldcuppark.seoul.go.kr

7. Technical Details

The Nanjido ecology recovery project consists of landfill stabilization and ecological park development.

1) Stabilization



The stabilization aims at isolating the waste accumulated for 15 years and thus restoring the surrounding environment. The stabilization consists of barrier wall installation and leachate processing to prevent water pollution, landfill gas collection and processing, stabilization of the slope, and top molding for grass fields.

The leachate facility has intercepting and processing equipment. The intercepting equipment (barrier walls and collecting wells) isolates the leachate and keeps stable levels of leachate in the landfill to prevent collapse of the slope. 31 horizontal-drainage collecting wells were installed to 3m depth of the bottom layer with the Caisson method. This method is especially good with underground water level control and low costs. The barrier wall isolates the leachate and was installed at a depth of 19-48m at 6,235m distance by combining the S.S.P Wall and C.B.S Wall. The leachate is stored in the collecting wells; from there it is sent to the leachate treatment station and the Nanji Sewage Treatment Plan using pumps. Finally, it is discharged into the Han River.

The landfill gas produced with the biodegradation of waste is collected and then processed. The average production of Nanjido landfill gas is 432KNm³/day, which is mainly composed of methane (51%) and carbon dioxide (46%). To prevent odor diffusion and any risk of explosion of landfill gases, the top of landfill was covered with a blocking layer. The landfill gas processing collects and processes harmful gases in a safe manner and provides habitats for plants. The reflected collection of landfill gas was 300Nm³/min through 55 and 51 vertical collecting wells installed at 120m intervals on both the top and slope, respectively. The gas is collected at the landfill gas processing facility for district heating while the remaining is burnt. The landfill gas collecting and processing facilities are managed by the Korea District Heating Corporation.



Figure 10. Design concept of slop stabilizing facility for Nanjido Landfill Stabilization Source: Yeong Kuk Lim, 2006, Nanjido Landfill Stabilization

The slope stabilization is to prevent its collapse while minimizing rainwater penetration. Any slope with a inclination under 1:2 was maintained while those over 1:2 were adjusted with a 9m protection installed. The maintenance stage performs continuous slope inspection, waterway repairing, and maintenance to prevent slope loss. Lawn and Leafy lespedeza was planted on any

vegetation-vulnerable slope for better stability. Any potentially collapsing slope was covered with tent fabrics to prevent further damage from occurring. Additionally, regular safety inspections were performed biennially by external experts, including professional engineers.

The top arranging and molding work installed water shields (HDPE) to prevent rainwater penetration and covered the top with earth to encourage the growth of plants. The molding consists of a 50cm supporting layer, 1.5mm shield layer (HDPE), a 30cm drainage layer, filtering felt, a 30cm vegetation layer, and a 30cm surface layer in the order to create a 1.4m depth on average. The top is arranged to have an approximately 4% slope to easily avoid rainwater and encourage plant growth. The future subsidence was estimated with the hyperbolic method of the Gibson &Lo Model and Power Creep Law and then reflected on the top arranging and molding. Maximum subsidence was estimated in the center by over 3.6m for 20 years.

Classification	Project details			
A. Top arranging and m	nolding			
1) Purpose	•Top: Minimized rainwater penetration and thus leachate production, prevention of surface gas leakage, and vegetation •Slope: Maintenance of currently stable slopes while recovering vegetation and installing protection on surrounding sections and banking around the outskirts and slope maintenance roads			
2) Arranged inclination on top	·About 4% of arranged inclination for good rainwater avoidance			
3) Cross section of top molding layer	•Top molding layer (1.4m): Surface (30cm), vegetation (30cm), drainage (protection, 30cm), blocking (HDPE 1.5mm), and supporting (50cm) layers •Dynamic compaction for landfill gas collecting well, pipelines, and roads			
B. Blocking of leachate				
1) Purpose	•To prevent diffused leachate pollution in the adjacent Nanji Stream, Bulkwang Stream, Han River, and others			
2)Installation section & method	·Barrier walls were fully-installed around the landfill with Coment Bentonite Slurry Wall and Steel Sheet Pile.			
3)Installation depth & distance	·Depth: Penetration of 1m and 0.5m into weathered rock and soft rock, respectively ·Distance: 6,235m (S.S.P : 3,320m, C.B.S : 2,915m)			
C. Intercepting and prod	cessing of leachate			
1) Purpose	$\cdot Optimized$ intercepting and processing of leachate from the slope and foundations			
2) Slope collecting facility	•Slope collecting pipe: 6,003m, MAT type pipe: 3,622m •Horizontal drain: 667 holes			

Table 1. Details of Nanjido Ecological Park project

3) Intercepting facility	·Horizontal draining type collecting well: 31 points, Horizontal strainer: 9,300m (186 holes)				
4) Transfer facility	•Non-pressure flow pipe (MDPE): 5,186m, Forced flow pipe (PEM): 2,035m •Intermediate pumping station: 3 points				
5) Processing facility	 On-demand pretreatment and then transfer to Nanji Sewage Treatment Station for the separate processing Process: Flow Control+Collection & Precipitation+Penton Oxidation Capacity: 1,860 tons/day 				
Classification	Project details				
D. Collection and proce	essing of produced gas				
1) Purpose	·Collecting and processing of gas (375N $\mbox{m}^3\mbox{/min})$ produced during degradation of wastes				
2) Collecting facility	·Extracting well: 106 points				
3) Transfer facility	·Transfer pipe (HDPE): 13,250m				
4) Processing facility	·Blower: 5 EA				
E. Slope stabilization					
1) Purpose	·To prevent collapse of slopes and minimize rainwater penetration				
2) Horizontal drain facility	·Length: 9m, Installation: 667 points				
F. Sewage sludge proce	ssing				
1) Purpose	Purpose \cdot To eliminate hazards by processing and disposing the landfill sluce (565,882 m ³) and thus increase the recycling and land utilization				
2) Method	 Banking material for landfill bottom arrangement: 202,210 m³ Utilization of sludge-mixed earth and sand as molding material: 16,890 m³ Method Supporting layer: 91,570 m³ Vegetation layer: 77,320 m³ (top+slope) Soil-like: 194,700 m³ 				

Source: Yeong Kuk Lim, 2006, "Nanjido Landfill Stabilization"

2) Ecological park project

① Pyeonghwa Park

The Pyeonghwa Park was built on a plane surface, which had an area of 440,000m², between the World-up Stadium and Gangbukgangbyeon-ro, at an altitude of 10-15m altitude on a 10m-high waste pile. Its concept is the peace that is related to the Mutual Coexistence and Symbiosis theme of the World Cup Park. It was specifically designed to reflect the themes of global harmony and peace kept in mind for the World Cup. The Pyeonghwa Park was designed by the

Han River Project Planning Group, and was working-designed and constructed by the World Cup Park Project Group, Park Green Field Management Office. It consists of the UNICEF Square, Nanji Pond, Pyeonghwa Garden, Picnic Square, and Nanjido Story (Exhibited in Worldcup Park). The waterside trail was developed on the water's edge using a 50cm-high wood deck. Water was brought from the Han River to the Nanji Pond in the center with cattails, baby lotuses, water lilies, scouring rush, and Russian irises planted for water purification.



Figure 13. Framework plan for Pyeonghwa Park Source: http://www.lafent.com

2 Haneul Park

This grass field park consists of a 190,000m² area on Landfill No.2. It has the poorest soil quality of the entire Nanjido Landfill site so it was designed to show how nature can still be reborn on poor land.

The master plan was established by the Master Plan Commission for Millennium Park; the landscaping and working design was performed by Yooshin Corporation Co., Ltd. and Pyeonghwa Engineering Co., Ltd.; the construction was performed by Bando Environment Development Co., Ltd., Imwon Development Co., Ltd., and Dongil Construction Co., Ltd. A total of 25.6 billion KRW was spent on the Haneul Park development. It was built with to a concept of a vast grass field and separated into 4 zones – with the ridge formed for drainage and the high grass field developed in the South-North section and low one in the East-West section. The South-North section had silver grass and the equivalent perennial grass field while the East-West section between them later. The entire area has drainage gradient of 4-8% with the cross management roads. For stabilization, the available vegetation depth was only 60cm on top of the water blocking layer and the ground was unstable so the planting of trees and installation of structures was prevented. Haneul Park has vast grass fields and the Silver Grass Festival is held there every October.

③ Noeul Park

This site was developed with about 340,000m² area at the location of Landfill No.1. Initially, there were plans to develop a public golf course with 57% of the area and civil leisure facilities and vegetation area with the rest. This initial plan was put forward but it, ultimately, did not succeed. There was serious disagreement concerning the golf course so the plan was changed to build family and sculpture parks in 2008 and 2009. Currently, it is used as a family park with cafes, playgrounds for children, park golf courses, and a family camping area.

(4) Nanjicheon Park

This location was built in the lowlands with a 70-250m width between the waste layer (Haneul and Noeul Parks) and Sangam Area. It had suffered from serious water pollution because of leachate from the Nanjido Landfill. Some of the waste had been buried in the center and the stream was affected severely. The plan, therefore, was to develop the Nanji Stream and park around it in order to show the ecological recovery of the polluted stream and transformation into a natural one.

The Nanjicheon Park was developed for residents in the Sangam New Millennium Town especially the disabled, old and infirm, and youth. Thus, a lawn picnic field was built sloping down toward the pond with special and natural playgrounds using natural materials and topography. The trail and stepping stones were installed around the pond so that family visitors can have the opportunity to study the wetland ecology. Furthermore, the Nanjicheon Park has sports and game facilities for the residents. It caters especially for the disabled and old, with sports facilities arranged in small groups along the road in the forest to alleviate desolateness. Curved trails were installed between the sports facilities and stream to improve accessibility to the stream's edge and different types of wild plants.

(5) Nanji-Han River Park

This is the second biggest park among the 13 Han River parks. The Nanji-Han River Park is a neighborhood park for the recreation of residents offering sports and game facilities, picnic places, and trails and required functions for the smooth operation of the World Cup. Considering the site conditions, the land use plan of the Nanji-Han River Park was divided into a dock, camping, central square, sports facilities, and waterside ecological park zones.



Figure 14. Pyeonghwa Park Source: http://worldcuppark.seoul.go.kr



Figure 15. Haneul Park Source: http://www.lafent.com



Figure 16. Noeul Park Source: http://worldcuppark.seoul.go.kr



Figure 17. Nanjicheon Park Source: http://worldcuppark.seoul.go.kr



Figure 18. Nanji-Han River Park Source: http://hangang.seoul.go.kr/archives/3021

8.Policy Effects

1) Environmental effects

After the ecological park development project, the ecosystem and surroundings of Nanjido have considerably improved. Over 1 million trees and herbaceous plants have been planted. It was reported that there were 89 types of 24 families of plants in 1994, which is only 1 year after the last landfill had taken place. Within 3 years, grass and trees had covered the slopes of the waste piles and the plant species had extended to 271 types of 60 families compared to 1994. These continuously extended to 502 types of 95 families until 2010. The plant species were naturally extended with different types of naturalized plants. Naturalized plants were brought in and adapted to the poor environment during the landfilling so 50% of naturalized plants in Korea were found there. This formed a very unique and notable ecosystem. Currently, only 22% of naturalized species have survived because of succession. The inhabitation of birds, insects, amphibians, fishes, and mammals has also increased. Before the park was developed, 167 types of animals had been reported to live there; this was increased to 731 types after the Nanjido Ecological Park was developed, which is a sign of healthy ecology. A continuing increasing number of birds inhabit the Han River, Nanji Pond, Nanji Stream, and mountains. It was also found that endangered species are now living there: narrow-mouthed toads and wildcats.



Figure 19. Narrow-mouthed toads found in the Nanjido Source: http://worldcuppark.seoul.go.kr



Figure 20. Acacia flows found in the Nanjido Source: http://worldcuppark.seoul.go.kr

Moreover, the Nanjido Ecological Park development contributed greatly to improved biodiversity and water quality. Seoul investigates the environment around the Mapo Resources Recollection Facility at 3 year intervals. These have shown that all environmental criteria are met for the air quality, noise, water quality, and soil. There are no residents around the Mapo Resources Recollection Facility so the investigation range is extended to a 2km radius, which includes the entire Nanjido Ecological Park.

2) Economic effects

The stabilization and park development created economic effects through the landfill gas collection and housing site developments. The Nanjido Ecological Park installed landfill gas collecting wells on the top and slope of Haneul Park and Noeul Park and connected pipeline to collect it. This is then used as boiler fuel at the Korea District Heating Corporation. From 2002 to 2013, a total of 232,592,000m3 of landfill gas had been used for boilers amounting to 6.86 million KRW of annual savings. The Korea District Heating Corporation processes the landfill gas for heating the World-cup Stadium, neighboring apartments, and office buildings. The landfill gas production is decreasing as the landfill is stabilized.

The surroundings of Nanjido were left undeveloped before the World-cup Park was developed because there of odor and environmental pollution and thus the demand for housing was low. However, the surrounding ecosystem and environment were considerably improved with the ecological park development and Digital Media City plans and this resulted in increased land prices. The competition rate of subscription was very high for the Sangam Housing Site Development Zone in 1999 with a land price of 900,000 KRW per 1m² in 1996 increased to 1,200.000 KRW to 1,500,000 in 1999. This was aided by the announcement thatthe Sangam area would be transformed into a special housing area (21C New Seoul Town) with leisure, shopping, and cultural facilities, Nanjido Ecological Park and water park, as well as different types of amenities and sports facilities. The housing site development area was 1,450,000 m², which exceeded the side of one of most popular districts, Yongin & Suji District (1,350,000 m²).

3) Sociocultural effects

The Nanjido Ecological Park has become a representative eco-friendly project of Seoul and been annually visited by about 9.8 million citizens and foreign visitors. The representative camping ground of Seoul, Noeul Camping Ground was visited by 52,000 people in 2013 compared to only 21,000 people in May, 2010 (the first year) and the continued annual growth is promising. Popularity has increased to the extent that first-come-first-served reservations are often finished in 5 minutes through the Internet. It is also full of visible and enjoyable delights – including park golf, the silkworm ecology experience center, natural playgrounds, the firefly eco center and habitat, and the urban farmers' garden.

Additionally, Seobu Park & Green Field Office, Green City Division, Seoul is operating monthly firefly eco center description programs, silkworm ecology tours, and different programs using natural objects for the citizens to experience the Nanjido Ecological Park. The environment programs are free for children and families, and more families are applying for the

environment experience as eco-friendly education becomes more and more popular.

Program name	Day	Time	Workforce	Subject	Description
Kindergarten Let's play in the forest!	Tue- Thu	10:00-12:00	20	6 to7- year-old groups	 To know seasonal changes To walk in the park the things that disappear in winter To share the dreams of children
Korean paper experience	Sat- Sun	10:30-11:20 14:00-14:50	20	Families	 Explanation of process from paper mulberry to paper To recognize the importance of Korean paper by making Korean- paper post cards by themselves
Wood handcrafts	Sat- Sun	13:30-14:50 10:30-11:50	20	Families	 To make creative pieces using waste wood
Firefly description program	Tue- Fri	10:00-12:00 14:00-16:00	20	Anyone	 Description about fireflies at the eco center Description of the ecology of firefly, and observation of larva and imago

Table 2. Ecology	program	of World-cup	Park
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Source: http://worldcuppark.seoul.go.kr

The Nanjido Ecological Park draws high attention from other countries. It is an excellent and exemplary landfill recovery and development project. It has been benchmarked by developing countries such as Indonesia and Cambodia, and serves as a stepping stone for Korea to enter environment markets of other countries. Pleasingly, it receives high attention from municipalities of developing countries for the sustainable urban development.

9. Challenges & Solutions

One of the difficulties for the Nanjido Ecological Park project was to find new housing for the urban poor who were living in Nanjido. The waste collecting workplace of Nanjido residents was closed as the Nanjido landfill was closed in May, 1993. However, they wanted the land where they were living to be granted so that they could stay. If they had stayed at the location, the entire ecological park development – including the landfill stabilization and park development – would have been hindered and their safety continually threatened by the mountains of waste as high as 100m. Seoul, therefore, gave purchase rights for permanently rented apartments and private ones to many of about 1,000 households so that they could

populate the region. However, about 400 households refused to move until Nanjido was confirmed as the World Cup site and construction began. The roofs and walls of structures were seriously corroded and catastrophic disaster was more and more likely if the banks of the landfill were to collapse due to heavy rain. Seoul gave them jobs through job placement and job-producing projects and provided rights of residence for rented and sold apartments as well as relocation expenses support to demolish the temporary housing. Meanwhile, 400 employees of 61 waste collecting centers who were living in prefabricated housing complexes were given a chance to move to the Sihwa Industrial Complex while 3 aggregate providers in the northern part of Landfill No.2 were also relocated.

Another challenge of the Nanjido Ecological Park development was the purpose issue of Noeul Park. Noeul Park was originally planned as the Nanji Golf Course. The Korea Sports Promotion Foundation was eventually selected as an investor in March, 2000 so it invested 14.6 billion KRW to develop a 9-hole golf course in Noeul Park and open it in October, 2005. However, the land owner, Seoul City Government and Korea Sports Promotion Foundation had conflicting ideas concerning the operation method and management rights so they undertook legal proceedings. Furthermore, Seoul amended the ordinance to transform the golf course into a park and the Korea Sports Promotion Foundation opened the golf course for free. Finally, Noeul Park was turned into a real park and Seoul compensated the Korea Sports Promotion Foundation with 18.5 billion KRW, including the Nanji Golf Course development expenses. The Korea Sports Promotion Foundation transferred the ownership of the golf course to Seoul. Seoul then spent an additional 4 billion KRW installing new trails, water supplies, drinking fountains, toilets, shade canopies, and benches while trying to retain as much of the lawn field of 9-hole golf course as possible so as to renovate it as a family park and thus invite more visitors.

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