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SHORT COMMUNICATION

Mistakes Made, Lessons Learned: The Eulsukdo Wetland Restoration Program

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Abstract

Restoration is the process of reducing or reversing damage to an ecosystem so that it can function in its original manner. However, many restoration programs do not achieve this. In the Nakdong Estuary, the largest migratory nesting site in the center of the East Asian–Australasian flyway, an estuarine barrage was constructed in the 1980s that required site restoration following its completion in 1987 and the expansion of several large industrial complexes(Noksan and Jangrim) and a residential development(Myeongji). The goal of the restoration was to restore the function of the wetland to its pre-disturbance state. To achieve this, a restoration program was designed consisting of three stages. The first stage(1993–1995), saw the construction of three artificial wetlands(Shinhori, Daemadeung, and Eulsuk), the second(2003–2005) involved the dredging and returning of farmed lands to their natural state, and the third(2008–2012) focused on the rehabilitation and vegetation development of the wetlands. However, the project has not achieved all of the desired goals, and it is an example of the lapses in ecological restoration following anthropogenic disturbance. Issues that resulted in an incomplete restoration included the timing of the stages, noncompliance with the restoration plan, not directly monitoring the restoration or continuing the monitoring following completion of the development project, and the political subversion of the restoration plan. For the success of the restoration plan, it is necessary to avoid mistakes such as inconsistent monitoring, unequal levels of stakeholder involvement, and political interference.

Key words : Estuary, Human Development, Nakdong River Estuary, Restoration

1. Introduction

Restoration is the process where a natural site is returned to a state that is similar to its original state following human intervention(Hyberg and Riley, 2009). Achieving this requires forethought in planning and design and interaction among all involved parties. Without following a prescribed program with subsequent monitoring to ensure that the process is successful, mistakes may be made that prevent the restoration from actually producing a replicate ecosystem. There are many examples of both successful(Ndunda and Mungatana, 2013; Statton et al., 2013; Zhang et al., 2012) and unsuccessful restoration programs(Suding, 2011; van Loon et al., 2011). The restoration of Eulsukdo(Eulsuk Island) in the Nakdong Estuary is a prime example of the second type. What makes the

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restoration of Eulsukdo important is its role in the East Asian - Australasian Flyway.

The Nakdong Estuary, located in the southeast corner of the Korean Peninsula, is the final outlet for the Nakdong River catchment, which drains an area of circa 23,635 km^2(Jang, 2014; Ministry of Environment, 2007). The population of the catchment is approximately 8 million people, of which, approximately 4 million live in the Busan metropolitan area(Busan Metropolitan City, 2006), with an estuary of approximately 125.4 km^2. The estuary is an important staging area for migratory birds, a home to several dwindling populations of endangered and endemic species, and is also hydrologically important. Disturbances, in the form of increased urbanization, increases in port holding areas, estuarine barrage construction(completed in 1987), industrial complex development(throughout the 1990s), and, more recently, the construction of the Myeongji Bridge, have altered the estuary. These alterations (Doornbos et al., 1986) and ecological changes (Choy et al., 2008; Du et al., 2009; Jeong et al., 2007) have negative influences on all estuarine functions and impact its ecological value.

Human disturbance is a common feature in the modern world, particularly in East Asia, where population growth is rapidly reducing natural lands (Lavigne and Gunnell, 2006; Malcolm, 2006; Peh, 2010). Accommodating the corresponding alterations and designing methods whereby these alterations can be limited, reduced, and offset is an important feature of ecological restoration. The Nakdong Estuary was subject to urban expansion and development in the 1980s from the adjacent city of Busan. In Busan, plans for the construction of an estuarine barrage were proposed and developed in the 1980s to offset tidal saltwater fluctuations into the estuary. The development of the barrage was also designed to increase land availability for human use. As part of the construction process, the restoration plans included the creation of two replacement wetlands and the enhancement of Eulsukdo Island, the largest point bar island in the estuary.

While there are many scientific reports on the ecosystem components of the estuary, changes in ecological characteristics such as biodiversity and restoration have not been systematically evaluated (Busan Metropolitan City, 2000; Jang, 2014; Joo, 1994; Lee, 2011). Recently, public awareness on the need for wetland restoration has been increasing.

2. Eulsuk Island and the Nakdong Estuary

Eulsuk Island and the Nakdong Estuary have long been subject to human impacts. Originally, they were used as farmland and fisheries, but with recognition of its position on the flyway this role gradually changed and the focus was more on the protection of the estuary. However, in the 1980s the population of Busan began to increase, and this put greater pressure on the surrounding environments to support the development of the urban center. During this period, Eulsuk Island, along with its continued agricultural use, was used for a variety of purposes, such as a solid waste storage and recycling site(1992 - 2006) and waste landfill site(1993 - 1996). In 1997, following the completion of the Eulsuk Barrage Bridge, restoration of the area began.

2.1. Restoration Stages

The restoration design stipulated that three artificial wetlands(Shinhori, Daemadeung, and the tip of Eulsuk Island(Fig. 1.) be created or modified to offset the loss of wetlands from construction(Stage 1) based on the "No Net Loss Concept"; development of the wetlands and their ecological functions including the acquisition of farmland so that Eulsuk Island is now agriculturally restricted(with the exception of a small area for cultivating bird feed for migratory and resident waterfowl and avifauna(Stage 2); and the construction of sluice gates for water level control to enhance wetland development and function(Stage 3).

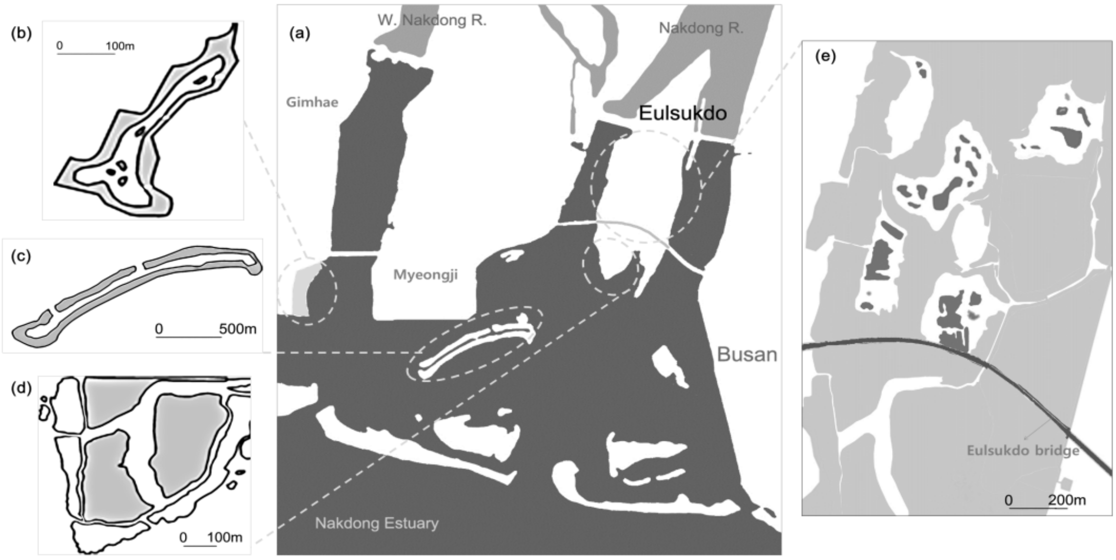

Fig. 1. Eulsukdo Restoration Project.(a) Nakdong River estuary,(b) Shinhori,(c) Daemadeung,(d) Eulsuk Island wetland,(e) tip of Eulsuk Island showing Eulsukdo bridge(Stage 1 = Shinhori, Daemadeung, Eulsuk Island); Stage 2 = Eulsuk Island and Eulsukdo Bridge; Stage 3 = Eulsuk Island).

Of the original nine suggested sites, three were chosen as restoration targets(Fig. 1.). The three sites (Shinhori, Daemadeung, and the tip of Eulsuk Island) were chosen based on a committee decision. Each site was subject to a different set of restoration guidelines.

2.1.1. Stage 1

The restoration of Eulsuk Island involved the assessment of the existing water channels and their restoration, since their alteration had resulted in decreases in water quality and water levels, and constructing a bird observation tower and connecting it to the existing infrastructure. The outcome of the work was a decrease in bird diversity and corresponding avian community complexity.

Daemadeung was an artificial wetland built to the southwest of Eulsuk Island. Originally an offshore point bar island that was under cultivation, the island had a channel with two fresh water(upstream pointing) entrances designed to permit water entrance into the central canal, which had been dug to prevent increased cultivation. This component of Stage 1 has been considered successful when compared to the other two constructed wetlands. It has become the accidental success of the restoration in that the individuals who constructed the site had no knowledge of the required water level depths for waders, and when digging the central canal, they left it shallow, thereby accidentally providing habitat for wading birds and waterfowl. The third wetland, Shinhori, was constructed on a pre-existing mudflat close to the Noksan Industrial Complex. This was a mistake in and of itself. Because of this action, there was an increase in water depth on the mudflat, which led in turn to an invasion of Phragmites. This led to a decrease in waterfowl and a corresponding decrease in the aquatic interface, which further negatively impacted wetland function.

Overall, the three constructed wetlands were essentially failures. The one successful example, Daemadeung, was only successful by accident. There is the issue of the ineffective use of money in the restoration(building a wetland on an existing mudflat). Wetlands are very susceptive to water depth, and by increasing water depth the wetland composition shifts, which in turn impacts the flora and fauna that exist within the wetland. With changes in the water level, the wetlands were subject to invasions by Phragmites, which caused a change in the available food for waterfowl and migratory waterbirds, negatively affecting the diversity of waterbirds found in the estuary. Finally, the action of creating the wetlands actually decreased the active aquatic interface, which had a negative impact on wetland function within the estuary. What is more, these mistakes, while they were observed and identified in the first stage, were not remedied in the second stage, but rather were left as is.

2.1.2. Stage 2

Stage 2 was developed to increase the land available for wetland restoration; this meant that more land was purchased from the landholders to provide room for the wetland. It was during this stage that the accidental success of the second wetland creation was actually identified. There were three phases to this stage. The first of these phases focused on the excavation of material that had been deposited during the construction of the barrage. The second phase focused on the restoration of the purchased farmland(onion patches) along the western edge of Eulsuk Island. The final phase involved the reclamation and remediation of the waste landfill site located on the southeastern tip of Eulsuk Island next to the newly constructed wetland. It was during this phase that the construction of the Myeongji Bridge commenced. This bridge, located at the south end of Eulsuk Island, was the source of another problem. This second bridge, which crossed the southern tip of Eulsuk Island, was in clear violation of national laws, and through political action was allowed to transit both the wetland and natural conservation areas that formed a habitat for endangered cranes. This decision led to the reduction in size and alteration of shape of the crane habitat. With the exception of the reclamation of the landfill site, these changes were cosmetic and had little or no effect on the mistakes made during the first stage of the restoration program.

2.1.3. Stage 3

In 2008, the third stage of the restoration began. This stage was designed to resolve some of the mistakes made in the first and second stages of the restoration program. During this phase, a floodgate was built for the wetland at the southern tip of Eulsuk Island to manage the water level in the wetland. Management of the water in the wetland also had the advantage of creating a fluctuating aquatic interface, which had beneficial results. Furthermore, habitat was created for the Little Tern(Sterna albifrons), and vegetation was planted to both establish habitat and improve the existing wetland aesthetics. As with the preceding phases and stages, however, there were evident problems that affected the functioning of the restored wetland. Changes in the water level promoted an increase in vegetative cover by Phragmites, which further led to decreases in avian diversity. This phase of the restoration had a total cost of $61,000, primarily for floodgate construction.

Restoration ecology cannot define the outcomes of a restoration project; however, if the restoration plans are designed in accordance with ecological restoration principles, then the success of the project, while not being guaranteed, will be more likely(SERI, 2004). SERI lists these principles as: (1) a clear rationale regarding the necessity of the restoration, (2) an ecological description of the site being restored, (3) a statement of the goals and objectives of the restoration project, (4) a designation and description of the reference site, (5) an explanation of how the restoration will integrate with local ecosystems and their ecological flows, and (6) explicit plans, schedules, and budgets for preparation, installation, and monitoring activities, including a strategy for midcourse corrections. Fig. 2. identifies the sequence and the interrelationships

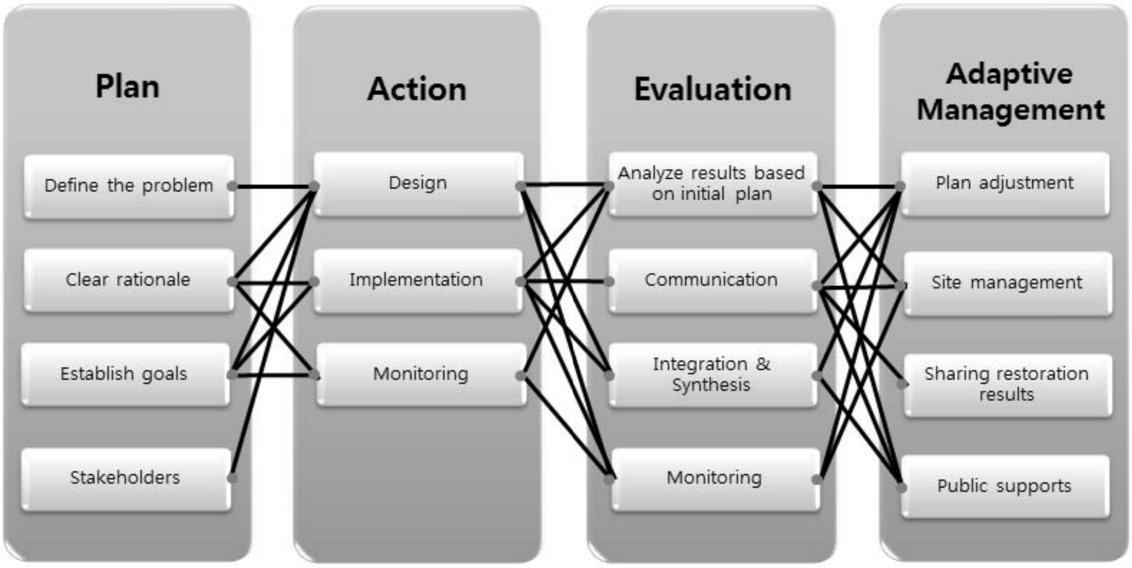

Fig. 2. Stages in wetland restoration, adapted from SERI guidelines(SERI, 2004).

between the different stages and phases suggested by SERI that are fundamental to the successful restoration of a wetland.

There are many instances where restoration programs have failed due to the inadequate implementation of designs and goals(Gulati et al., 2008; Hackney, 2000; Hopfensperger et al., 2006; Suding, 2011). The failure of restoration programs can be due to interference in the designed restoration plans or to a lack of understanding of how the targeted ecosystem actually works(Suding, 2011). Understanding the success of a restoration program requires understanding how the goals are defined and targeted(SERI, 2004; Zedler and Callaway, 1999).

2.2. Urbanization of the Busan Area

Busan had steady population growth from the 1950s, when the population increased substantially from an influx of refugees during the Korean War, to the 1990s. This population placed pressures on the periurban space as it developed into urban space. This has been the situation around Eulsuk Island, with the loss of ecological space for the inhabitants. This loss of space has been shown to negatively influence the natural environment surrounding the city through the loss of environmental space and habitat. It is the requirement for space that led to the need for urban expansion, which in turn produced the impetus for the development of the area.

Urban development produced the need for expansion, which led to the creation of three large urban development projects in the area. Along with the construction of the barrage, these resulted in large-scale alterations to the natural environment, and in turn created the need for the restoration of the area due to the loss of wetlands in the region(Fig. 3.). This need for remedial restoration, along with a natural tendency to want things done quickly, produced the mistakes that would follow. Fig. 3. shows that the loss of wetland area corresponded to an increase in reclaimed area and development projects aimed at enhancing the development of the region.

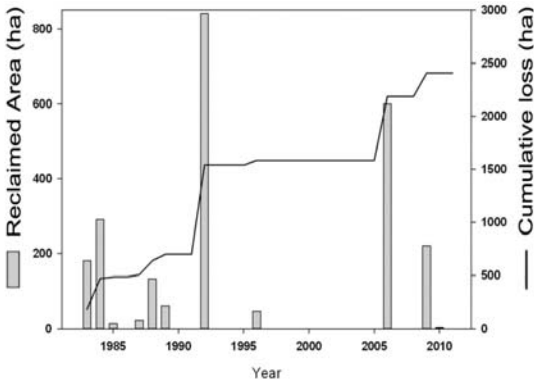

Fig. 3. Cumulative loss of wetland area in the Nakdong River Estuary.

3. Restoration of the Nakdong Estuary

The Restoration of Eulsukdo was performed in three stages beginning in the early 1990s and ending in 2012.

3.1. Stage 1: Construction of Three Artificial Wetlands in the Mid-1990s

Following barrage construction, three wetlands were designed and created. Two of these were located on pre-existing wetlands(Daemadeung and Shinhori). The third, South Eulsuk Island, was constructed on a waste landfill. The site was designed around a wetland ecocenter and involved construction of a bird-watching tower, for a total cost of approximately $20,000,000 (Table 1.). The created wetland lacked an extensive interface between the water and the terrestrial surface. This was remedied in Stage 3, during which several internal interfaces were added to the wetland. The sites for the artificial wetlands were chosen without forethought as to the applicability of the restoration process. These three wetlands attempted to provide compensation for land that was lost to urban development, but actually produced more problems than benefits. As noted earlier, the first wetland (Eulsuk) was problematic in that it created more problems than benefits. Correspondingly, Shinhori, instead of increasing wetland area, actually destroyed wetland area, in reality doubling the loss once for the original land area, and once again for the mudflat that was destroyed when the new wetland was created. Daemadeung, while being created as a substitute wetland, was successful only accidentally because the people constructing it did not know how to establish it in the first place. While this does not reduce its beneficial attributes, its success was still accidental and not designed.

3.2. Stage 2: Eulsukdo Restoration Plans

In 2001, Eulsukdo Island underwent a second restoration component comprised of three phases. This required the development of a conversion plan, prepared by Busan Metropolitan City in 2001(Busan Metropolitan City, 2001). This plan involved the reclamation of cultivated fields and their conversion into a functioning wetland. The land was purchased from the farmers and then, via soil removal and the addition of a water component, conversion to a wetland was begun. While project completion was expected in 2005, it was not completed until 2010. The plans for

Table 1. Previous land-use and present problems of three artificial wetlands

Name of Wetland	Area(m^2)	Previous land-use	Present problems	Cost for Construction(won)
Eulsuk Island	$4.62x10^5$	Agricultural practice	Unutilized bird watching tower Lack of interface between land and water	~5000000 $
Daemadeung	$3.29x10^5$	Agricultural practice	Uniform channel morphology Lack of interface between land and water	~5000000 $
Shinho-Ri	$4.16x10^5$	Mudflats	Uniform channel morphology Lack of interface between land and water	~5000000 $
Bird Observation Tower	-	Mudflats	Inaccessible	~5000000 $

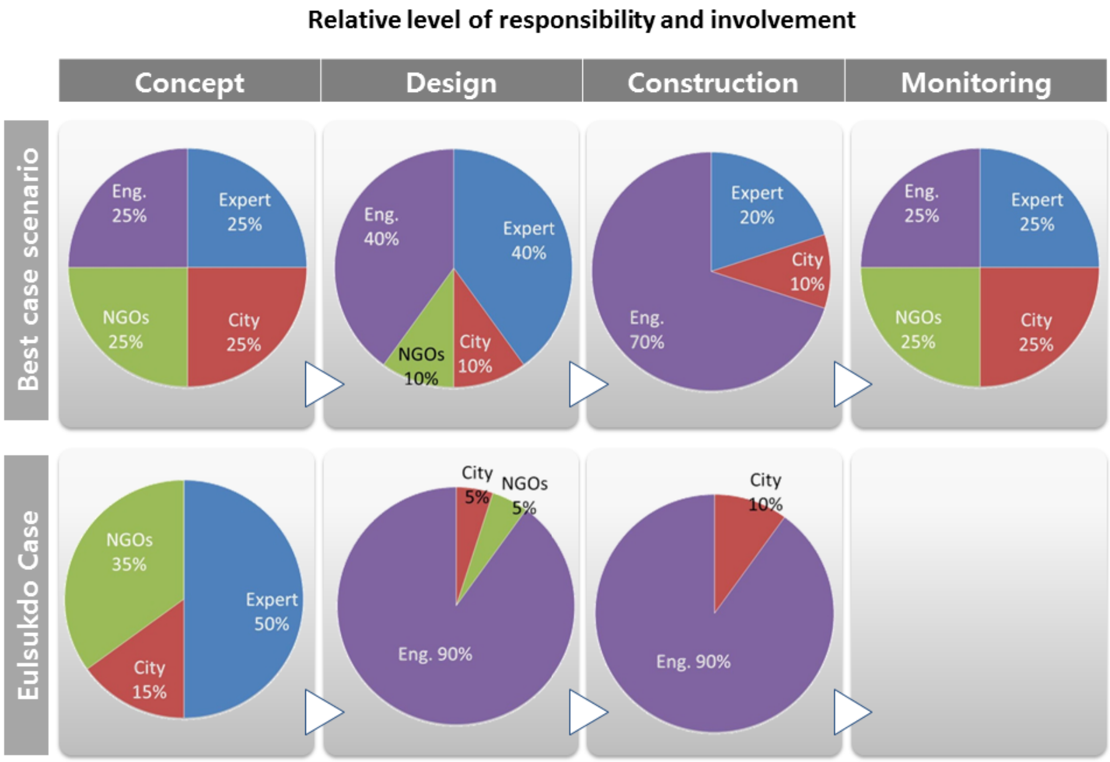

Fig. 4. Representation of the levels of responsibility in the Eulsukdo restoration(NGOs – Non Government Organizations, Eng – Engineering).

the Ecopark were established during this phase. While a large part of the wetland was purchased from farmers, a part of the wetland was constructed on a pre-existing waste landfill. Thus, land illegally utilized as farmland was converted to a wetland, and some abandoned grassland and part of an old waste fill site were turned into a composite wetland, park, and grassland. Within the recreated wetland area, dredging was performed to facilitate water management. Finally, wetland plants were planted to initiate wetland development.

3.3. Stage 3: Construction Period(2007-2012)

During the third stage of the restoration project, dredging was continued to maintain water levels and prevent sedimentation of the wetland. The wetland, built during Stage 2, is currently in a water and vegetation management stage, whereby dredging continues and vegetation is controlled with flooding. This stage of the project, initiated in 2007, was finally completed in 2012, and involved the design and construction of several Eco Park structures, dredging, and a modified restoration plan that covered the south and north ends of Eulsuk Island and the four upstream riparian areas. This third phase was completed in summer 2012.

4. Mistakes in Eulsukdo

The development of the estuary barrage required that a restoration plan be established to offset the impacts of the barrage on the river and its associated wetlands. The original plan called for the construction of three artificial wetlands to offset wetland losses to the estuary created by the construction. The three created wetlands were designed as offshore bar island wetlands, and were established to support the migratory birds that used the estuary as a stopover site on their semiannual migration flights.

A proper restoration program, as designed within the existing system, would follow the process, shown in Fig. 4, that, ideally, would involve the interaction and involvement of the four primary agencies involved, non-government organizations(NGOs), restoration experts(Experts), the city government (City), and engineers(Eng). These four groups each have a role to play in the different phases of the restoration process(concept, design, construction, and monitoring). The best-case scenario for the breakdown for each phase is presented in Fig. 4. as are the actual results of the Eulsukdo restoration.

It is important to note that the best case and the actual case differ greatly, and that this is the reason for the status of the Eulsukdo restoration. In a hypothetical best-case scenario, each group has an equal level of involvement in the conceptual development; in reality, the engineers were left out of this phase of the restoration program. In the second phase, the design phase, the four groups' ideal involvement levels change substantively, to the point where the experts and the engineers have the greatest level of involvement. Once again, this was violated in the Eulsukdo restoration program, and the experts were removed from the process and the engineers came to control the program. The third aspect of the restoration program best-case scenario has three of the groups involved at different levels, but the engineers comprise the largest group involvement. With Eulsukdo, only two of these groups were involved, with the removal of the experts once again occurring. The best-case scenario sees the monitoring phase as again equally divided between the four groups. With Eulsukdo, this has not happened.

Each of these changes altered the success of the restoration program. By not involving different groups during different phases of the restoration program, the restoration itself was not given the best shot at developing the way it was designed. The first mistake was not to involve engineers in the design component. This led to issues in engineering later on, including issues with the placement of the mitigation wetlands. The second mistake, and probably the most important one, was the non-inclusion of the experts in the design phase, accompanied by a total reliance on the engineers. This mistake was repeated in the construction phase of the restoration. In the final monitoring phase, the mistake was a lack of planning. Each mistake on its own will produce problems for a restoration program; however, all together, they seriously limit the viability of the restoration program.

Not having the engineers in the design phase of a restoration program can restrict the effectiveness of the program by allowing engineering problems to enter the process, problems that engineers can readily solve and correct if they are involved. Engineers have a unique knowledge of physical structures that scientists, NGOs, and government officials lack. This allows them to recognize and plan for engineering-based problems that may harm the restoration from the outset.

Likewise, leaving the experts out of the loop in the design phase is a very large mistake, since they too have specialized knowledge that the other groups lack. It is important to remember that, with restoration, the process is to restore the habitat as closely as possible to the original. Only those individuals who know the processes and functions that were in place prior to the development can achieve this. This was by far the gravest mistake made in the restoration, since it resulted in the largest problems with the restoration. By removing the experts from the design phase, the design became an engineered solution. In essence, it was just another project where engineers design solutions to a natural system, thereby removing nature from the ecosystem. This in itself is a negation of the concept of restoration. The removal of the restoration experts from the design led to inevitable problems, and, in the end, it was a vital mistake.

The third mistake occurred in the construction phase of the restoration. Again, the experts were not involved in the process; thus, when mistakes were made in the implementation of the original design, there were no experts involved to correct them. This is just the reverse of the first mistake, which involved the omission of the engineers. When the inevitable problems arose from the second mistake, there were no ecological experts there to notice them, compounding the other mistakes. The fourth and final mistake is ongoing and will be an issue in the future; this is the restricted monitoring of the restoration sites. While some monitoring is underway, it is, due to funding issues, inconsistent and lacks a strategy aimed at defining when and if restoration is occurring, let alone whether the site will eventually reach its restoration target.

The restoration program began with the establishment of the design plans for the estuarine barrage, which was completed in 1987. When the plans for the barrage were developed they included creating mitigation wetlands to offset the damage done to the estuary. Sites for the mitigation wetlands were not chosen based on ecological importance, but rather accessibility and proximity to the damaged site. In itself, this is a mistake; if the new sites do now match the damaged site, then the restoration becomes tenuous. Furthermore, the mitigation wetlands included a naturally stable mudflat that required no restoration.

Restoration requires a sound reason for its use. The damage to a national protected site is a fundamentally sound reason for the restoration of the damaged wetland, and the implementation of mitigation sites as well. Secondly, when performing restoration of a disturbed site, it is necessary to have information about the site as it existed before the disturbance. This information was scarce, if not nonexistent. The next phase arising out of this was the construction of the barrage. While the engineers focused on barrage construction, the construction process was affecting the estuary.

Compared to SERI(2004) restoration guidelines, the Eulsukdo restoration lacked many characteristics that are currently incorporated in most restoration programs. SERI(2004) framed restoration guidelines structured on the principles of restoration ecology that can be used for any restoration project. While the Eulsuk restoration was not a total success, there are successful wetland restoration examples. In these examples, the restoration plan was designed before the disturbance occurred, making it easier to have supporting evidence for the restoration program. Successful wetland restoration programs, such as the Bellona Wetlands(California), Carpinteria Salt Marsh (California), Tijuana Estuary(California), Straight River Marsh(Minnesota), Grass Lake Project(Minnesota), Atocas Bay Project(Ontario), Kississimee(Florida), Akanyaru complex of the Nyabarongo(Rwanda), and Rugezi(Rwanda), have all been successful because of what was done and how it was done. In each case, knowledge of the site prior to disturbance was used to provide target information that was then used to aid in the design of the restoration plan. Once the restoration plan was designed and its implementation put in place, modifications to the plan were based on ecological functions and not on other factors, such as bargaining for political exchange.

5. Conclusion

The Nakdong Estuary, including Eulsukdo, has long been subject to increasing urbanization. Even as a protected area, the site is continually being carved up by development to support increasing urban growth. The resultant loss of natural space is producing a loss of native species and a corresponding decrease in biodiversity. Conversion to urban uses has resulted in the loss of wetland interface and estuarine size. The decrease in interface affects the ability of the wetlands to survive, and therefore is a negative influence on the physical and ecological composition of the estuary. Mistakes made during the period of construction and as part of the restoration following construction have compounded to reduce the efficacy of the restoration. These mistakes are not a singular event, they have been found elsewhere with other restoration programs, and they still have impacts on the restoration to the prior state.

Restoration in other countries has suffered similar problems(Zedler and Callaway, 2000). The process of restoration requires that all agencies involved participate in the development, initiation, implementation, and monitoring phases of the project. As the project progresses, variables may change during the project that affect the implementation, and this in turn will require modifications to the original plan(SERI, 2004; Zedler and Callaway, 1999). This fluidity in the management strategy is the one aspect that can ensure the success of the restoration process(Aber et al., 2012). While it may appear that this is the case for Eulsukdo, it is actually not. Eulsukdo in reality was subject to political decisions affecting the organization of the restoration program and the utilization of project staff. The result of these changes led to alterations in the project that affected its integrity and its success.

5.1. Nakdong Estuary and Eulsukdo Restoration

In building the estuarine barrage, the city agreed to a restoration program(Busan Metropolitan City, 2000) modeled on the "No Net Loss Concept". While the idea has its merits, it is ineffective if not properly applied or implemented(Bendor, 2009). The restoration plan(Busan Metropolitan City, 2000) initially involved the construction of three artificial wetlands within the estuary. These wetlands had problems with both construction and

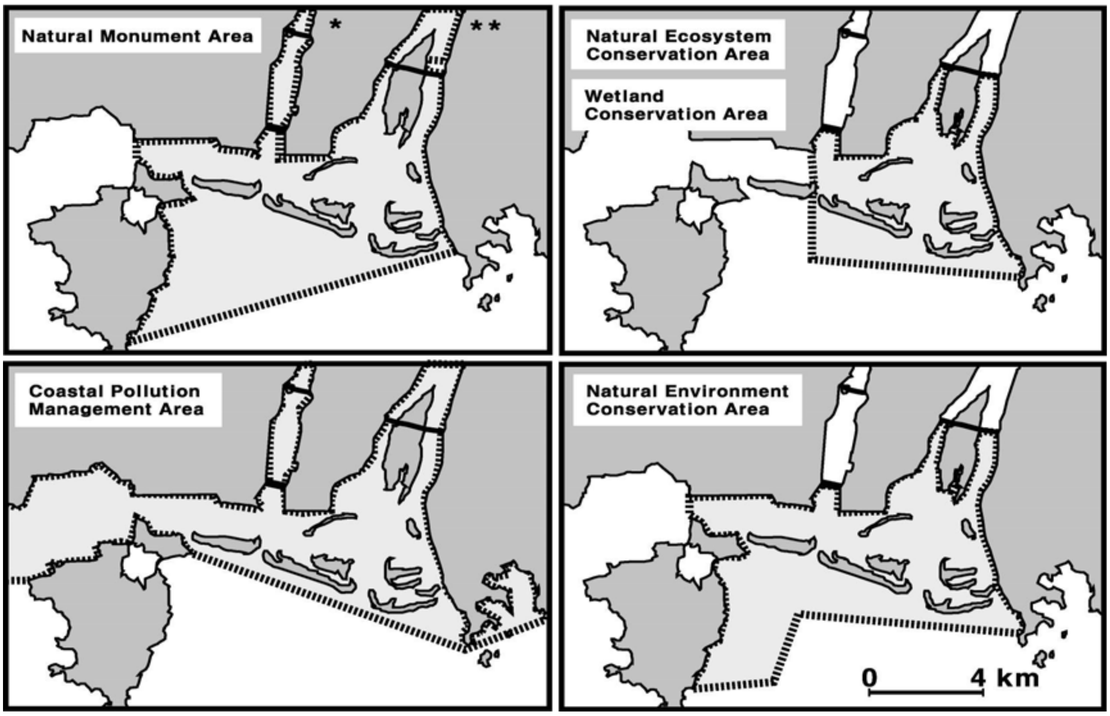

Fig. 5. Protected area designations of a part of the Nakdong River Estuary(*, up to Bulamgyo(Bridge); **, up to 2nd Nakdonggyo(Bridge)).

design that lowered their effectiveness(Lee, 2009). This was followed by the second phase of the restoration to reduce the area of illegally farmed land and to return it to its original state(Busan Metropolitan City 2001). This required the construction of a wetland in the southern half of Eulsuk Island; however, the program was not monitored and, once again, there was a further loss of the aquatic-terrestrial interface that decreased the effectiveness of the constructed wetland. Other mistakes that have occurred have resulted in money being spent on developing facilities that cannot be used because they were constructed in areas without access. Decisions based on political arguments rather than ecological arguments have reduced the effectiveness of the restoration program(Rebelo et al., 2012).

It is important to note that, while the Eulsukdo restoration has not been 100% effective, it has provided some very valuable lessons in how to formulate restoration programs. The learning has not been in how to make things fail, but rather in how to make them succeed. As noted earlier in the paper, the success of a restoration program can be achieved if design guidelines and monitoring plans are established and followed(Zedler and Callaway, 1999).

The failure at Eulsukdo is due to interference with the process, a lack of communication between involved agencies, and not following a continuous monitoring procedure that ensures the success of the plan. While wetland restoration is a commendable goal for any government, it is necessary to remember that what is being restored is ecological and not political(Everaert et al., 2013; Garcia-Barrios et al., 2008; Hopfensperger et al., 2007; Kukkala and Moilanen, 2013; Zanou et al. 2003). The original decision to alter the landscape was a political one, focusing on jobs and the development of the region. However, this was where the original mistake was made. By not communicating between stakeholder groups, different groups were left out of specific design and implementation stages. This lack of communication led to plans not being implemented correctly and things being implemented haphazardly (e.g., a bird observation tower being built where no one could use it, a wetland being built on a mudflat, and a wetland being built without thought as to how it would function and thus facilitating invasion by the giant reed grass). These decisions were further compounded by more miscommunication and the use of an ecological target for political purposes, meaning that some part of the restoration would not be successful.

These mistakes were extended with the construction of the second bridge, Eulsukdo Bridge. Here again, the decision to alter the existing restoration and its components had a negative impact on the restoration. It was a political decision that routed a freeway bridge through a wetland and natural ecosystem conservation area, and it had nothing to do with the ecological functions or processes that enable the wetland to work properly. One of the factors influencing the political direction was changes in land use patterns for the estuary and its surrounding area. Changes in the goals and objectives of the political parties will often result in changes to existing restoration programs such that the restoration can fail in part or in all of its goals. In Eulsukdo, political decisions have resulted in the construction of the second Eulsuk Bridge through the existing natural monument area, wetland conservation area, natural ecosystem conservation area, and natural environment conservation area(Fig. 1. & 5.). The outcomes of this are not known yet since, as with the other stages, monitoring is being conducted in an inconsistent manner, which will have more detrimental results in the future.

Change is a natural part of successional processes in ecosystems(Dinerstein, 1979; Risser, 1995). However, when the rate of change exceeds the ecosystem's ability to recover, the ecosystem is drastically altered and loses all connection to its prior state(Tousignant et al., 2010). The Nakdong Estuary, including Eulsuk Island, in pre-development conditions supported a large variety of organisms and complex biodiversity(Joo, 1994), which were impacted by both the construction and its consequent restoration.

To compensate for impacts from development and construction, a restoration program designed along the guidelines of the US ‘No Net Loss Policy” was implemented for Eulsuk Island. Political interference and alterations of the designed restoration plan have further increased the loss of wetland and ecological function of the existing wetland. The construction of wetland areas as compensation for infrastructure construction has failed in its prescribed goals(Huang and You 2013, Soomai et al. 2013). Of the plan components, the lack of monitoring has led to the loss of information that could be used to assess the restoration plan.

Before an original wetland is lost, the design of an appropriate restoration plan is necessary if it is desirable to retain the functions of the compromised ecosystem(Awimbo et al., 1996; Boumans et al., 2002). However, this did not happen in the Nakdong Estuary. The result is that the restoration program did not achieve its design goals. This is primarily due to the failure of Busan Metropolitan City to adhere to the original restoration plan. While components of the design have been constructed, their placement within the landscape and their resulting limited use have resulted in noncompliance.

Restoration programs, if applied as they are designed, have shown themselves to be productive for achieving their objectives(Jenkinson et al., 2006; Rydgren et al., 2013; Wortley et al., 2013). Projects in Europe and North America have all shown successful results at the preliminary stages, in the first 5 to 10 years of the restoration program(Furukawa, 2013; Gumiero et al., 2013), if the restoration management plan has been followed. One major issue with restoration programs is the long-term projections of the restoration programs, which are usually not reached or assessed. Most projects fail with respect to long term monitoring(Pander and Geist 2013). The program proposed for the Nakdong Estuary has not been followed because of political interference and sector involvement, and thus the outcomes are nowhere near the original restoration program.

The Eulsukdo case has taught some valuable lessons regarding restoration practices. Primarily, it is necessary to plan the project in an involved manner. That is, all stakeholders should be involved, to a greater or lesser extent, throughout the restoration design and its implementation. This ensures that situations that arise that may require modification of the restoration can be dealt with quickly, thereby satisfying steps 1 and 6 of the SERI guidelines(see above). As well, knowing exactly what was there pre-disturbance is vital, since it identifies the parameters that need restoring or ought to be focused on, which satisfies steps 2 and 4 of the SERI guidelines. Finally, it is important to understand why the restoration is being performed and how it will increase ecological stability within the disturbed area, which is stated in steps 3 and 5 of the SERI guidelines. Performing these tasks, while they may not guarantee the success of the restoration program, will increase its probability.

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