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Ecological Conservation and Restoration Strategies on Construction and Management Projects
- Focused on Dam Projects

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건설관리 사업의 생태 보전 및 복원 전략
댐사업을 중심으로

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ABSTRACT

본 연구에서는 건설 사업의 수행과정에서 나타날 수 있는 환경훼손을 최소화하거나 저감하고, 자연과의 조화를 이루기 위한 다양한 기술과 공법, 정책 및 제도를 도출하고자 하였으며, 구체적인 사례로 댐건설 사업에 대한 친환경 기술과 공법을 분석하였다.

이를 위해서 기존 연구사례 및 문헌을 고찰하여 친환경 요소를 도출하였고, 이미 조성되었거나 조성 중인 댐을 대상으로 실제 적용되고 있는 친환경 요소를 분석하였으며, 이를 종합하여 건설사업에 도입될 수 있는 친환경 항목을 설정하고 기술 및 공법을 제안하였다.

그 결과 생태계 보전, 생태계 복원, 새로운 생태계 조성, 친수환경 및 위락, 경관 및 역사문화 등이 친환경요소로 도출되었다. 또한 환경친화형 건설사업의 지속적인 추진과 성과를 위한 정부차원의 정책과 제도적 방안을 제안하였다.

이러한 적극적인 생태환경 보전 및 복원을 위한 노력이 지속적으로 이루어짐으로써 건설사업에 의한 환경파괴를 최소화하고 새로운 생태환경을 창출하는 친환경 건설의 대표적인 사례로 자리매김될 수 있으며, 나아가 건설 분야의 친환경 사고 확산을 위한 근거가 될 수 있을 것으로 판단된다.

Key Words : *Environment Policies, Environment-friendly Construction, Biotope, Landscape Ecology.*

Ⅰ. INTRODUCTION

With the public's growing desire for environment conservation, development projects considering environmental values have emerged as a new paradigm today. Accordingly, environment policies need to be changed to seek harmonious symbiosis of nature and humankind and it is necessary to

develop a well-structured and reasonable plan considering environmental value to fulfill the desires.

Large-scale construction projects bring about great efficiency as well as a side effect called destruction of ecological environment. In particular, development of water resources may have a tremendous impact on the ecological environment of a submerged district and a project area despite a number of benefits including flood control, power generation, water supply, local economy promotion, landscape improvement, and creation of a new recreation space. Unlike the trend till now that justified development of water resources, social and environmental circumstances related to water resource development and management are changing significantly.

Establishment of a policy for harmony of development and conservation and social consensus is imperative and a technical approach to resolve ecological problems caused by construction through ecological principles is required.

This study suggests the direction of an environment-friendly policy that respects environmental value as a new paradigm and can minimize an impact on ecological environment in a dam construction and management stage. A water resource development plan that can improve the quality of life by harmonizing nature and humankind is also suggested.

Its details are as follows :

· Generate applicable technologies through the review of literatures on ecosystem conservation and restoration;

· Identify the limitations and problems of ecosystem conservation and restoration technologies by reviewing verified technologies in eco-conservation and eco-restoration literatures and the case studies of planned or built multi-purpose dams and suggest alternatives; and

· Suggest the prototype of an environment-friendly construction project.

Ⅱ. STUDY METHOD

In this study, in order to generate an ecosystem conservation and restoration plan 1) ecosystem conservation and restoration case studies that were applied or are applicable to environment-friendly construction management projects were analyzed through the review of literatures and case studies, 2) technologies that are feasible for actual application were suggested by categorizing the identified ecological technologies by construction methods.

1. Literature and Case Study Review

1) Literature Review

In literature review, theories on ecosystem conservation and restoration were examined and theories that can be applied to dam construction projects were identified. Then, based on study results published in the literatures, applicable eco-restoration technologies were identified.

Conservation ecology, restoration ecology, landscape ecology, UNESCO MAB, environmental ecology, and eco-restoration technology were defined as relevant theories. Literatures for review included literatures on environment-friendly development and eco-restoration published by Ministry of Construction and Transportation, Korea Water Resource Corporation, Ministry of Environment, and a number of universities and academic societies.

A list of literatures reviewed in this study is as follows :

(1) A Guideline on Environment-friendly Design (Korea Water Resource Corporation, 1997),

(2) Theses Presented at the Summer Seminar, 2001(Korea Society for Environmental Restoration and Revegetation Technology, 2001),

(3) The Overview and Prospects of Environment Restoration and Revegetation Technology of Korea and Japan(Korea Society for Environmental Restoration and Revegetation Technology, 1998),

(4) Landscape Architecture Design Criteria (Korea Water Resource Corporation, 1997),

(5) A Collection of Case Studies on Environment-friendly Construction Management(Korea Water Resource Corporation, 2000),

(6) Seminar on Environment Restoration and Afforestation(Ministry of Environment, 2001),

(7) Prospects on the Settlement of Eco-restoration in Korea and its Challenges(Moon and et. al., 2001),

(8) Study on Dam Construction Improvement (Korea Water Resource Corporation, 1999)

2) Korean and Foreign Case Study Review

In case study review, case studies where conservation and restoration strategies identified in the theoretical review had been actually applied in dam construction were examined to check the applicability of the theories and to look for improvement opportunities.

The cases of dam construction analyzed in this study are dams completed since the 1990's or under construction. They are 1) Buan Dam, 2) Boryung Dam, 3) Yongdam Dam, 4) Milyang Dam, 5) Hoengsung Dam, and 6) Tamjin Dam.

Buan Dam, which is located in Byunsan peninsula of Buan county, north Cholla province, is the first case where true environment-friendliness was applied. Since it was completed in 1996, it has been monitored continuously. Boryung Dam is located in Boryung county, south Choongchong province and was completed in 1998. An environment-friendly and eco-restoration concept had not been applied in its initial plan, but an eco-restoration case was introduced when the Korea Water Resource Corporation began supervising the project. Yongdam Dam(Jinan county, north Cholla province), Milyang Dam(Milyang county, south Kyungsang province), and Hoengsung Dam(Hoengsung country, Kangwon province) were applied with an environment-friendly and eco-restoration concept from a planning stage. Tamjin Dam, planned in south Cholla province, is in a planning design stage and environment-friendly and eco-restoration concepts applied previously will be analyzed and applied.

Ⅲ. RESULT AND REVIEW

1. Ecosystem Conservation and Restoration Options

Ecosystem conservation and restoration policies described in the eight literatures on environment-friendly construction and management are analyzed in Table 1.

Eco-conservation and eco-restoration concepts applied or to be applied to the six dams already completed or under construction are shown in Table 2.

Ecosystem conservation and restoration options generated through the theory and literature review and the Korean and foreign case study review are defined in Table 3. In addition to literature review and case study review, conservation and restoration options suggested in other areas were also considered.

2. Ecosystem Conservation Options

As for ecosystem conservation options, natural vegetation and ecosystem conservation, indigenous vegetation and ecosystem relocation, and development of assessment tools for conservation were identified.

Conserving the natural topography, indigenous vegetation, ecosystem, and habitats of a submerged district and a project area is critical in securing a healthy ecosystem. It is especially important in dam construction as it destroys and submerges a large unit area. Because reviewed in the case studies, it is important to come up with plans to conserve natural topography, old trees, vegetation community, animal and plant habitats, wetlands, and other valuable ecosystems in a submerged district. Also, tools to assess function and value are necessary to determine their importance.

Table 1. Ecosystem conservation and restoration policies described in the literatures.

Item		1)	2)	3)	4)	5)	6)	7)	8)
Ecosystem conservation	Ecosystem conservation including forest vegetation				○	○		○	○
	Re-plantation of indigenous trees		○	○	○				○
	Vegetation community protection and relocation		○		○		○	○	
	Habitat conservation				○	○			
Ecosystem restoration	Reservoir slope vegetation restoration	○	○		○	○	○		○
	Dam downstream slope vegetation restoration	○			○				
	Dam top surface linear green area creation	○	○						
	Rock cut-area slope vegetation restoration	○	○	○	○		○	○	
	Ecological restoration of damaged area including quarries	○			○		○	○	○
	Spillway recovery and vegetation restoration	○			○				
	fish way creation	○	○			○			○
	Eco-corridor creation	○	○		○	○	○	○	○
	Nature-type river creation	○	○	○	○	○	○	○	
	Rainwater infiltration system		○				○	○	
	Vegetation islet creation						○		
Ecosystem creation	Man-made wetland creation	○	○				○	○	○
	Eco-park and nature learning center creation		○		○				○
	Eco-pond and bio-tope creation		○		○		○	○	○
	Ecological succession observation center creation		○				○	○	
	Habitat creation		○		○		○		○
	Environment agriculture						○		
	Eco-forest creation			○	○		○	○	
Water-friendly environment	Water-friendly revetment creation	○	○	○	○	○			○
	Water-friendly activity program				○				○
	Eco-tourism				○				○
	Water-friendly facility using water discharged from dam	○							
Landscape and history and culture	Dam landscape assessment and landscape design	○	○		○	○			○
	Application of local image and environmental image	○			○	○			
	Historical and cultural space creation		○		○	○			
Others	Use of local natural materials	○	○		○	○			
	Use of multi-porous permeable materials	○	○		○		○	○	
	Use of recycled materials				○			○	
	Surface soil conservation and recycling				○	○			○
	Eco-monitoring		○	○	○			○	
	Eco-house					○			○

The most ecologically ideal option for wetlands, habitats, and indigenous vegetation in a submerged district is conservation of ecosystem. However, if destruction or extinction is inevitable, relocation of ecological environment or creation of an alternative ecosystem can be considered. In such a case, it is important to relocate an unit ecosystem environment including entire habitat environment instead of relocating individually.

It is to seek ways to preserve the surface soil of a submerged district and to preserve the useful vegetation through a natural environment survey

Table 2. Ecosystem conservation and restoration examples applied to the six dams in Korea.

Item		1)	2)	3)	4)	5)	6)
Ecosystem conservation	Ecosystem conservation including forest vegetation	○	○		○		○
	Re-plantation of indigenous trees	○	○	○	○	○	○
	Vegetation community and ecosystem relocation	○	○				○
Ecosystem restoration	Dam downstream slope vegetation restoration		○	○	○	○	○
	Rock cut-area slope vegetation restoration			○	○	○	○
	Restoration of destroyed area including quarries				○		○
	Fish way creation						
	Eco-corridor creation			○		○	○
	Nature-type river and mountain streams creation			○	○		○
Ecosystem creation	Man-made wetland creation			○			○
	Eco-pond and nature learning center creation	○		○			○
	Eco-pond creation			○			
	Eco-forest creation						○
	Habitat creation						○
Water-friendly environment	Water-friendly revetment creation			○	○		○
	Water-friendly facility using water discharged from a dam	○			○		
Landscape and history and culture	Dam landscape design						
	Application of local image			○			○
	Historical and cultural space creation			○	○	○	○
Others	Use of local natural materials	○	○		○	○	○
	Use of permeable pavement matierals		○	○			
	Recycling surface soil		○		○		
	Woodchip using lumbered trees				○		
	Ecosystem change monitoring	○					

(soil, flora, and fauna) of a submerged district in a project area and to introduce a concept of a nature learning center leveraging indigenous trees around a dam. Also, a nature restoration system will be introduced for an area destroyed by construction.

In addition, development of standardized assessment tools that can perform wetland and habitat function assessment is requested.

3. Ecosystem Restoration Options

As for ecosystem restoration options, restoration of destroyed ecosystem, connection of disconnected or fragmented ecosystem, and restoration of river ecosystem were generated.

1) Restoration of Destroyed Ecosystem

Restoration of destroyed ecosystem was divided into habitat restoration, reservoir slope vegetation restoration, dam downstream slope vegetation restoration, and slope vegetation restoration, and recovery of destroyed areas such as quarries.

Despite a number of conservation strategies, there are some ecosystems and habitats inevitably destroyed or eliminated in a submerged district and a project area. Therefore, in order to restore species diversity and to improve the function as habitats, it is necessary to create diverse habitat conditions. In particular, alternative habitats should be created for birds, amphibians and reptiles, fishery, and other animal species that live in streams, shallow water, gravel, sawdust, and shrubs, which are affected relatively greatly.

Although living environment is created as an unique space for each species, each space is inter-related ecologically. Habitats should be created based on habitat types found to be suitable from an ecological

survey on a dam basin. In principle, vegetation and spaces should be created utilizing prototypes observed in a local ecosystem. In a natural ecosystem, habitation of small organisms including

Table 3. Ecosystem conservation and restoration options in dam construction.

Item	Creation method	Detailed implementation strategy	Literature review	Case study	Other factors
Ecosystem conservation	Indigenous vegetation and ecosystem conservation	Conservation of forest vegetation and ecosystem	○	○	
		Conservation of habitats	○		
	Indigenous vegetation and ecosystem relocation	Replantation of indigenous trees	○	○	
		Relocation of vegetation community and ecosystem	○	○	
Ecosystem restoration	Restoration of destroyed ecosystem	Reservoir slope vegetation restoration	○		
		Dam downstream slope vegetation restoration	○	○	
		Rock cut-area slope vegetation restoration	○	○	
		Recovery of damaged area including quarries	○	○	
	Connection of disconnected and fragmented ecosystem	Creation of linear green area at the top of a dam	○		
		Spillway cover-up and vegetation restoration	○		
		Fish way creation	○	○	
		Eco-corridor creation	○	○	
	River ecosystem restoration	River environment restoration			○
		River habitat restoration			○
		Nature-type river and mountatin stream creation	○	○	
	Other restoration options	Rainwater infiltration system	○		
		Vegetation island (floating islet) creation	○		
Ecosystem creation	Man-made wetland and eco-pond creation	Man-made wetland creation	○	○	
		Eco-pond and bio-tope creation	○	○	
		Water purification wetland	○	○	
		Habitat creation	○	○	
	Eco-park and nature observation center creation	Eco-park and nature learning center creation	○	○	
		Ecological succession observation center creation	○		
	Other creation options	Environment-friendly agriculture	○		
		Vegetation Filtering System (VFS)			○
		Eco-forest creation	○	○	
Water-friendly environment and recreation	Water-friendly environment creation	Water-friendly revetment creation	○	○	
		Creation of water-friendly space to boost local economy			○
		Setting up water-friendly facilities using water discharged from a dam	○	○	
	Eco-tourism and recreation	Eco-tourism	○		
		Water-friendly activity program	○		
Landscape and history and culture		Dam landspcae assessment and landspcae design	○	○	
		Application of local image and environmental image	○	○	
		Creation of history and cultural space	○	○	
Others	Environment-friendly materials	Use of native natural materials	○	○	
		Use of multi-porous permeable materials	○	○	
		Use of recycled materials	○	○	
	Soil environment restoration	Surface soil conservation and recycling	○	○	
		Removal of soil pollutants in a submerged area			○
	Policy and program	Eco-monitoring	○	○	
	Environment-friendly living environment	Eco-road	○		
		Eco-house, eco-village	○		

micro-organisms play an important role for a balanced natural ecosystem.

Accordingly, plant communities of various species need to be created in a living environment inhabited by small organisms. Each community should have different species, age, and succession stage and promote habitation of various species through the complexity of structure and layer of vegetation communities.

In a large reservoir where extensive water surface is created due to dam construction, waterside boundary is deforested upto a flood level as a countermeasure against serious water level fluctuation, which results in deterioration of landscape and ecosystem. Restoring ecosystem by introducing vegetation in such a reservoir water level fluctuation section has landscape improvement effect as well as an ecological significance.

In building a new dam, adjusting deforestation upper limit to a normal time water level or an average water level may be applicable. In case of existing dams, vegetation has been already eliminated to a flood level and bare ground is exposed causing erosion. Therefore, it is necessary to restore by introducing tree species resistant to submergence as well as creating a foundation.

In order to manage water quality of a dam reservoir, vegetation in reservoir slopes lower than flood level has been removed exposing bare ground. This deteriorates landscape and destroys ecosystem as well as having a negative influence on water quality.

Since ecosystems between the two sides of a river is disconnected by a dam structure, the ecosystems can be connected by improving the dam structure. Landscape is improved and ecosystems are restored by creating a banking area at the downstream of a dam and introducing vegetation, and this will also lead to connecting ecosystems in the both sides of a river. The banking area is created in an original hill shape and the surface soil of a submerged district is used. Also, the surface soil of nearby forests with similar vegetation structure is used. Vegetation restoration is done in the same way natural ecological restoration is done. Visual heterogeneity is eased by introducing vegetation similar to nearby forest vegetation. Forest trees in an area to be submerged can be re-planted, but port saplings can be introduced to save budget and to facilitate creation of natural ecological community.

If these trees are not enough, trees cultivated in farms can be planted to achieve an afforestation target effectively. At the lower part of a dam itself, a banking area is created to plant trees from a submerged district or the same species, but it should be in the same structure with surrounding vegetation belts.

It is very important to restore ecosystem by introducing vegetation in rock cut-area slopes, but it is technologically challenging. In creating slopes, their surface evenness is varied according to a vegetation restoration plan and either an entire area or a part of the area is afforested depending on the stability of a base rock and a natural joint. As for vegetation selection, the goal is to restore an indigenous vegetation-led structure based on a dam basin vegetation structure survey.

It is important to ecologically restore areas that were used to mine stone, aggregate, and soil or that were destroyed by other external causes. Usually, altitude is adjusted to be suitable for a restoration plan and surface soil is restored to be suitable for creating vegetation or for other purposes. As same as in vegetation restoration of rock cut-area slopes, vegetation is selected with a goal to restore an indigenous vegetation-led structure based on a dam basin vegetation structure survey result.

In a dam project, a quarry is developed within a submerged district. In a limited number of cases, it is inevitably supplied from outside. Also, areas destroyed by other artificial or natural causes should be restored.

2) Connection of Disconnected and Fragmented Ecosystems

External ecological spaces should be created to function as a corridor to prevent disconnection of created green areas. In preserved vegetation and observation routes, decks should be set up to avoid destruction of the ecological space. The ways to connect the disconnected ecosystems include dam top surface vegetation restoration, spillway recovery and vegetation restoration, fish way creation, eco-corridor creation, and stepping stone ecosystem creation.

A vegetation tunnel that is formed by creating vegetation in certain sections of the top surface of a dam and connecting green area systems at the top surfaces of both sides serves as a corridor connecting disconnected ecosystems. At the upper part of a dam itself, herbaceous plants and lumbered stumps are planted for long-term succession and vegetation introduction.

Unless there is a structural problem, a spillway is buried in a tunnel or box type to conceal the concrete structure from outside. Vegetation belts are created around a spillway or other man-made structures to hide the structures from outside and ecological linkage is assured by planting in the same structure as nearby forests. Also, if possible, a spillway is covered up to create a vegetation belt or to improve landscape by introducing the images of extinguished landscape factors.

If a reservoir or a dam is built at an estuary, the passageways of anadromous fishery such as silver fish, eel, and king crab that travel to and fro ocean are blocked and they become extinct in dam upper stream. If a fish way is not built in an inland dam, the passageways of aquatic animals including fishery, benthos, and amphibians that circulated locally will be blocked and they will become extinct. Therefore, their passageway, i.e., a fish way needs to be created. The purpose of creating a fish way is to eliminate or ease obstacles in movements of fishery in a river. In addition, it is important to design in a way to protect and promote a river ecosystem and to maintain environment-friendliness. In Korea, it is mostly set up in an estuary embankment where water level difference is small.

In order to introduce a natural restoration system, creating corridors to allow migration of wild animals is important. Therefore, an adequate size of a green area to perform such a function needs to be secured and man-made facilities need to be set up to create corridors in disconnected green areas. Wild animal corridors allow migration of animals by connecting the habitats of wild life, secure a food source to maintain species, maintain ecosystem balance, and increase bio-diversity.

As a strategy to create habitats by introducing ecosystems in an independent space such as a rooftop micro-ecosystem, there is a stepping stone ecosystem in an ecosystem network. In order to secure a green area insufficient in an urban area, water was introduced and vegetation was planted in a limited space of a building rooftop to create a space inhabited by living creatures. This is a very effective means as a stepping stone ecosystem promoting connection of ecosystems.

3) Restoration of River Ecosystem

The strategies include river environment restoration, river habitat restoration, and natural-type river and stream creation.

Like a city river, rivers around a dam are improved on a basis of a standard section under hydrological principles. This is far distant from a river in its natural state. It is important to restore water-friendliness and an environmental aspect as well as the natural features of a river.

Natural-type river is an effort to return a river improved on a basis of a standard section with a man-made technique like a city river to its natural state. In other words, water flow is meandered, shoals and pools are formed, and steep and gentle slopes, sawdust and gravels, and various revetments,

and the habitats of aquatic life are created.

4. Creation of Ecosystem

As techniques to create new ecosystems that can replace ecosystems destroyed or removed by construction works, creation of man-made wetland and eco-pond, creation of eco-park and nature observation center and other eco-villages were identified.

1) Creation of Man-made Wetland and Ecopond

In a man-made wetland and eco-pond creation strategy that functions to purify water and offer habitats, man-made wetland creation, bio-tope and eco-pond creation, water purification wetland(eco-pool) creation, and habitat creation techniques were analyzed.

If a wetland with preservation value is reclaimed in a project area, an alternative wetland should be created. Also, if wetland destruction is inevitable in a development project, an overall project benefit should be a net gain to wetland conservation (no net loss of wetlands). In here, the definition of wetland replacement are not simply the same wetland area but the same wetland functions and the same wetland value. Such man-made wetlands function as habitats and have water purification effect as well as aesthetic factors and other various wetland functions.

Biotopes including eco-ponds and natural mountain streams can be created by utilizing water spouting from idle land in a dam. Also, spaces are created completely according to a natural restoration system to stir interests by space type and season ranging from ecosystem observation to active water-friendly activities.

Improving water quality by purifying domestic sewage and agricultural and livestock waste water discharged from relocated complexes and the non-point sources of dam upper stream villages using hydrophytes and oxidation pond and facilitating them to function as habitats are important. It can be introduced in individual buildings and the influx part of reservoirs shared by an entire village.

Restoration of animal ecosystem becomes possible through creation of wild animal habitats. In order to create wild animal habitats, food types and activity characteristics need to be considered. If the functions of a fish way described earlier are limited, creation of new habitats for fishery at dam downstream may be considered.

2) Creation of Eco park and Nature Observation Center

Various ecological spaces created through ecosystem creation are very useful as ecosystem learning places as well as water purification and biotope functions. For these purposes, creation of eco-park and nature learning center and creation of ecosystem succession observation center can be considered.

An eco-park is a park green area restored and conserved ecologically to observe and learn nature and a place provided to users to observe how plants, animals, and insects grow and behave in natural environment. In short, it is a park created to easily approach and observe how small organisms live. While wild life habitats are introduced, the park is designed to be maintained on its own by ecosystem orders(species diversity, ecological soundness, and sustainability). It refers to a park created by setting a higher priority on ecological environment than other parks.

3) Others

In addition, there are eco-village and environment-friendly agriculture, creation of vegetation filtering strip(VFS), and eco-forest creation.

In eco-village and environment-friendly agriculture, project managers such as the government and the Korea Water Resource Corporation recommend environment-friendly farming through economic and technical support to fundamentally control non-point sources that can accelerate water pollution of a dam reservoir. It refers to farming that do not use

artificial fertilizers or agricultural chemicals and includes organic farming, duck farming, mud snail rice production, organic farming using food wastes, food waste compost, and earthworm breeding. Also, high altitude farming using cold water discharged from a dam reservoir is supported.

The VFS is a strategy to control non-point sources flowing from a dam basin to a river and a dam reservoir and to provide habitats. By creating the VFS of a certain width along with wetlands created artificially in a dam basin, the inflow of pollutants and the erosion along surface outflow can be controlled and rapid currents in a flood season and influx to a reservoir can be eased.

Meanwhile, an eco-forest, which is applied with a multi-layer vegetation structure that can be found in natural vegetation, is vegetation introducing local native tree species and creates the most stable forest in a dam basin.

5. Water-friendly Environment and Recreation

The strategies include creation of water-friendly environment, eco-tourism and green tourism, and development of water-friendly activity programs.

As a non-powered water landscape facility using a gap of water head level caused by the water level of a reservoir, it may be a good example of use of hydraulic power. By leveraging river maintaining water discharged from Buan Dam, water-friendly spaces including a fountain and man-made mountain streams were created.

As a typical resource conservation tourism, eco-tourism consists of seasonal excursion routes, environment description program, designation of conservation zones, creation of habitats to protect and observe wild animals, and bird observation facilities. In other words, this is a proactive tourism format that pursues intellectual satisfaction by observing and experiencing firsthand and seeks to understand the dispensation of nature. On a large scale, Baikdu range, DMZ, and wetland belts can be used as eco-tourism resources. On a small scale, a national park, individual wetland, and other natural resources with conservation value can be introduced as eco-tourism resources. Various eco-tourism programs are being developed and introduced in Korea and abroad.

Meanwhile, a relocation complex can be created into an eco-village and serve as a base for green tourism by introducing eco-architecture and environment-friendly farming. By linking natural eco-tour destinations around a dam and establishing eco-tourism programs centering on dam basin ecological resources, a dam can emerge as a center of tourism and be defined as an important facility for environment education and boosting local economy.

Water-friendly activity programs for a dam reservoir and dam rivers can be developed. Non-powered water-friendly activities are recommended in consideration of sensitivity to water pollution and a purification system for pollutants should be developed.

6. Landscape and History and Culture

In relation to landscape and history and culture, options applicable to a nature-friendly dam include landscape assessment and landscape design, application of local image and environmental image, and introduction of traditional cultural elements. They serve as a base for preserving environment-friendliness, historical features, and native features by individually or networking together.

When a large area is submerged due to dam construction, landscape elements are lost or destroyed and structures including a dam itself act as factors harmful to landscape. Therefore, it is critical to improve the quality of landscape by creating new landscape elements in a process of dam construction and applying landscape design techniques on dam structures and attached facilities. In order to determine the preference for landscapes before and after submergence and the landscape improvement effect of landscape design, a landscape

impact assessment must be introduced.

Each structure or facility can be differentiated by reproducing native elements that can represent the images of a dam basin or a submerged village and by replicating local environmental identity in space composition and design. Also, resources that can maintain ecological resources, unique landscape, and cultural elements, and other village tradition in a dam basin and enhance local features should be introduced and reflected in a space design and structure design.

While maintaining the existing natural topography of a village as much as possible, a variety of plants are actively used including creation of a persimmon tree complex and re-production of a village forest to replicate native landscape and allow the residents of a submerged area to feel nostalgia. Also, existing farmhouses, stone walls, village name tablet, bridge name pillar, gate pillar, cornerstones, waterways, statues symbolic to a village, filial piety statues, dolmens, and ponds are relocated and restored.

7. Others

Other strategies for ecosystem conservation and restoration include application of environment-friendly material and engineering methods, soil environment restoration, and environment-friendly living environment.

1) Environment-friendly Materials and Engineering Methods

Use of native natural materials, use of multi-porous permeable materials, use of recycled materials, rainwater permeable system, and vegetation island techniques can be considered.

With diversified interests in landscape architecture, a lot of physical materials including wood, stone, and concrete as well as plant materials were used. Furthermore, interests on environment-friendly materials have increased as environmental impact on materials and methods is stressed. In particular, interests on ISO14000 series in Korea and abroad served as an opportunity to place an absolute value on environment-friendliness in every process including materials. Materials in the 21st century are expected to stress the frontier, environmental, and amenity aspects, which are the characteristics of environment-friendly materials.

Vegetation concrete refers to materials that secure continuous apertures to allow the growth of roots based on multi-porous concrete and create a growth environment by putting a soil dressing layer, organic fertilizer, and water possessing materials to allow afforestation. Currently, a pilot test to check the feasibility of introducing in a landscape architecture space is underway(Bon-hak Koo and Yong-kyu Kim, 1999).

Afforestation block (grass block) is material that can be introduced in pavement or slope finishing. It has spaces to plant grasses or wild flowers and is useful when creating an environment base space such as an eco-park.

Also, structures can be created by using natural stones collected at the site or blast rocks generated in a course of construction. Materials can be developed using sewage treatment sludge (permeable pavement materials and organic fertilizers).

Rainwater infiltration system is a system to store rainwater temporarily and recycle it. Rainwater at rooftop, parking lot, or green area is stored at a certain place instead of running it down to a river immediately through a rainwater pipe. Then, the stored water is used for irrigation, rest rooms, car wash, and maintenance water. There are infiltration collector well, infiltration drainage pipe, and reservoir infiltration pond types.

A vegetation islet is a man-made structure to improve water quality and provide habitats by putting a floater in a reservoir to create a vegetation base and introducing hydrophytes. Studies on its structure and vegetation state are underway to introduce at ponds, reservoirs, and dam lakes.

A base for vegetation introduction is created by

putting a floater of a certain size in a water space such as a reservoir or a pond and hydrophytes and water-friendly trees are planted to offer habitats as well as water purification function and, furthermore, to promote landscape improvement effect.

2) Restoration of Soil Environment

Surface soil conservation and recycling and elimination of soil pollution and pollutants in a submerged area were identified.

Through a soil survey on the soil of fields and forests in a submerged district, a collectable surface soil layer should be checked and recycled it is collected and stored. In particular, it should be carefully handled to prevent the loss or disturbance of surface soil when ecosystems or vegetation communities are relocated.

As soil is likely to be polluted by various contaminants including domestic sewage, there should be measures to eliminate contaminants and to purify and replace already polluted soil. Once soil is judged to be contaminated, entire soil needs to be replaced.

3) Environment-friendly Living Environment

In here, eco-roads, eco-villages, and eco-houses are included.

For eco-roads, a route that minimizes ecosystem destruction and topography change is selected. If a slope is inevitable, a breast wall at a lower part should be afforested to create a base for vegetation. It should be an afforested sound absorbing wall including an afforested breast wall. At the base part of a sound absorbing wall, an afforested breast wall is introduced and a panel part is afforested using vines such as ivy. If ecosystem is disconnected by a road, a variety of wild animal corridors should be set up. In particular, corridors for amphibians and reptiles and small mammals should be provided. Also, rainwater drainage, infiltration collector well, permeable drainage, and grass waterway can be introduced.

Eco-village is a new residential culture model for the 21st century where humankind's residence, production, and lifestyle are ecologically environment-friendly and economically and culturally sustainable. In particular, eco-village aims at minimizing material and energy input from outside, production and consumption of organic agricultural products, resource reproduction and recycling, and minimization of environment burden. Eco-village is used as a place for environment education for the public as well as a marketplace for direct trade of organic farming products. It also contributes in increasing the income of people engaged in organic farming who seek environment conservation farming.

Eco-construction is a solution to reduce the evil practices of construction culture. In principle, it uses ecologically friendly construction materials and re-newable energy resources and disposes various wastes discharged from buildings in an eco-friendly manner. In other words, it is a construction method using natural resources and energy efficiently while minimizing environment pollution.

Ⅳ. CONCLUSION

This study aimed to generate various technologies, construction methods, policies, and programs to reborn dam construction projects, which have both a positive aspect of efficient management of water resource and a negative side of destruction of ecological environment, as the harmony with environment or an environment-friendly action instead of simply being an environment destruction action.

To this end, technical aspects related to dam construction were categorized into ecosystem conservation, ecosystem restoration, ecosystem creation, water-friendly environment and recreation, landscape and history and culture, and others for a review. In a regulatory aspect, alternatives for the government-level policies were suggested.

When efforts for such proactive ecological envi-

ronment conservation and restoration continue, environment destruction by dam construction will be minimized and dam construction will be positioned as a good example of environment-friendly construction creating a new ecological environment. Furthermore, it will serve as a stepping stone in disseminating an environment-friendly mindset in a field of construction. In doing so, following should be considered with special importance.

First, conservation of natural landscape and ecosystem and conservation of human settlement environment should have the highest priority in developing an environment-friendly dam construction plan.

Second, a plan to develop water-friendly spaces and to promote local economy should be developed by building a consensus among local governments and local residents to create a foundation for setting local resident-involved dam construction in place as well as to seek a plan to create an eco-theme park where visitors may enjoy.

Third, regulatory programs should be improved to introduce environment-friendly means in a master plan stage. Also, local residents should participate and their opinion should be reflected in a development project stage.

LITERATURE CITED

Bradshaw, A. D. and M. J. Chadwick. 1980. The Restoration of Land. Blackwell Scientific Publications.

Harada, J. 1999. Comprehensive development and environmental conservation in reservoir watersheds-Japanese experience.

Koo, B. H. 1996. The Technical Method of Ecological Rehabilitation for the Waterlevel Fluctuation Areas of Manmade Dam Lake Slopes. Taejon College. vol.22 : 355-378.(in Korean)

Koo, B. H. and Y. K. Kim. 1999. The Properties of Concretes for Planting Vegetations Based on Porous Concretes. Journal of the Korea Society for Environmental Restoration and Revegetation Technology. 2(2) : 62-69.(in Korean)

Koo, B. H. and G. K. Kim. 2001. The Ecological Changes and Ecological Restoration Strategies of Dam Construction : Cases on Yongdam Multipurpose Dam. Theses Presented at the Summer Seminar. The Korea Society for Environmental Restoration and Revegetation Technology. pp. 19-46.(in Korean)

Korea Society for Environmental Restoration and Revegetation Technology. 2001. Theses Presented at the Summer Seminar(in Korean).

Korea Society for Environmental Restoration and Revegetation Technology. 1998. The Overview and Prospects of Environment Restoration and Revegetation Technology of Korea and Japan.(in Korean)

Korea Water Resource Corporation. 1997. Landscape Architecture Design Criteria.(in Korean)

Korea Water Resource Corporation. 1997. A Guideline on Environment-friendly Design.(in Korean)

Korea Water Resource Corporation. 1999. Study on Dam Construction Improvement.(in Korean)

Korea Water Resource Corporation. 2000. A Collection of Case Studies on Environment-friendly Construction Management.(in Korean)

Ministry of Environment. 2001. Seminar on Environment Restoration and Afforestation.(in Korean)

Moon, S. K., B. H. Koo. and S. J. Nam. 2001. Prospects on the Settlement of Eco-restoration in Korea and its Challenges. Journal of the Korea Society for Environmental Restoration and Revegetation Technology. 4(1) : 67-79.(in Korean)

National Research Council. 1992. Restoration of Aquatic Ecosystems Science, Technology, and Public Policy. National Academy Press.

WWF(World Wildlife Fund). 1999. WWF's global conservation programme.

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