Restoration Needs for Coastal Vegetated Ecosystem in Korea: An Introduction

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In Korea, the importance of coastal wetland was first seriously considered in the middle of 1990s. Since then, Korea became a party to the Convention on Wetlands (Ramsar Convention) in 1997 and established a national legal base, <the Wetland Conservation Act> in 1999 to enact on earnest conservation of wetlands. Coastal wetlands in Korea, however, have been devastated and rapidly destroyed mainly due to reclamation and landfills. Approximately 25 % of Korean tidal flats, which are ironically the largest coastal wetland in the world, have disappeared during last 15 years (Je 2001). During this period, many huge reclamation projects including Yongsangang, Shiwha, Ongjin, Saemankeum, etc. were newly launched or completed.

With these environmentally sensitive and productive areas gone, the ripple effect also started to appear in the fisheries. The catch per unit effort (CPUE) has been gradually decreasing in the Yellow Sea during last several decades even though the fishery production has been increased (Republic of Korea 1999). This decline in fisheries resources is presumed to be result of habitat losses along

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the coastal areas of spawning and nursery grounds. Most of coastal spawning grounds are located in the bays and estuaries where developers have been focusing on as good reclamation sites since early 1970s. Bays and estuaries have vegetated wetlands consisting in at least one kind of reeds, sea grasses and/or halophytes. Moreover, the reed communities in estuaries are usually very productive, and other specific vegetations are found on sand dunes in the open coasts.

In case of Ganghwa Island, there is a wide tidal flat of approximately 90 km^2, but more than 80 % of islands coastline is now become artificial (KORDI 1999). It means that only a few of natural salt marshes are left to survive, and the productivity of the tidal flats in terms of shell production has become very low compare to other tidal flats in the west coast of Korea. Coastal development and local constructions to build shrimp aquaculture farms and bridges have also removed marshes, i.e., including coastal vegetation areas thus affecting sedimentation in the tidal flats.

Coastal wetlands of Korea are also very important as resting and feeding places along the flyways for migratory birds. Particularly, tidal flats along the west coast of Korea are staging areas for one of three main migratory flyways between Siberia and Australia (KORDI 1999). Most of staging areas may be specifically fixed as Ramsar sites thus considered as internationally important wetlands (Moores 2001). In addition to places for the fisheries and resting places for migratory birds, the coastal wetlands also have either ecological and/or social functions such as water purification, protection from coastal erosion, prevention of natural disaster, education places, places of aesthetic and recreation, etc.

In order to recover degraded coastal wetlands, it was necessary nationally to develop wetland restoration technology during later part of 1990s. The first study on the restoration of coastal ecosystem focusing on ecological restoration was started in 1998, though many restoration projects have been carried out for streams and terrestrial areas since 1955 (Kim 1994; Environment Protection Agency 1994). In Korea, the concept of restoration meant to include from restoration of ecological functions to creation of artificial wetlands or just rehabilitate their aesthetic landscape architecture.

Vegetated coastal ecosystems

Reed dominant ecosystems

A perennial plant *Phragmites communis*, commonly known as reeds, prefers estuarine areas where freshwater meets salt water as its habitat and is widely distributed especially along the river mouths and coastal salt marshes (Fig. 1). It is possible to find several km^2 of reed communities in natural estuarine areas. In standing crops, parts of this plant hidden below the ground are more than twice the parts shown above the ground. The underground parts not only prevent soil erosion but also purify polluted water coming down from land before flowing into the sea (Min 1998). Also, the reed communities provide nesting and hiding places for wildlife including snakes, frogs, birds, mammals, crabs, insects and other numerous invertebrates.

The economic value of estuary is considered to be the highest among natural ecosystems on the Earth (Costanza *et al.* 1997). All big riverine estuaries but one, the Han River, in Korea have been seriously modified or essentially shut down by dykes to become freshwater reservoirs or to be reclaimed. Because the Han River flows along the border between the South and North Koreas, by chance, the river estuary has been well protected from human developments.

Even though the tidal flats of about 2,400 km^2 are still left undeveloped along the south and west coasts of Korea, most of natural salt marshes connected to tidal flats and estuarine reed communities have been rapidly disappearing by landfill and reclamation projects during the last several decades. Salt marshes also are consisting of reeds and many different halophytes including *Triglochin martimum*, *Carex scabrifolia, Limonium tetragoum, Suaeda* spp. etc., while reeds dominate estuarine wetlands as mono-species communities. And, the coastal wetland ecosystem may be functionally unstable without buffering areas such as salt marshes and estuarine reed or other vegetated areas.

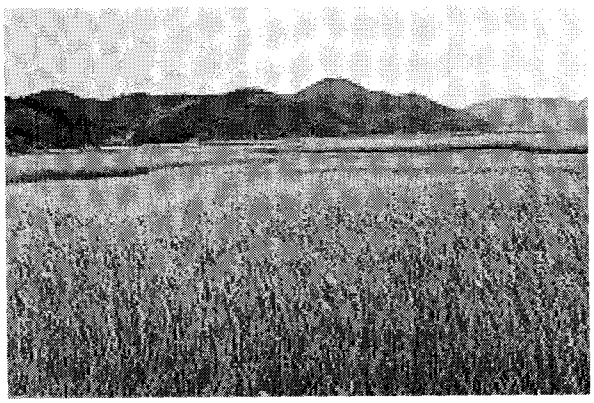

Fig. 1. A reed, *Phragmites communis* dominant community found in brackish water area where Dong Stream meets sea water in Suncheon Bay.

Fig. 2. Degrading sand dune ecosystem in Shinduri, Chungcheongnamdo which is one of representative coastal dunes in Korea.

Sand dune ecosystems

In Korea, 133 sand dunes were found by an inventory survey conducted by the government (The Ministry of Environment 2001). Among them, 114 sand dunes (86 %) were either seriously destroyed or modified as results of development of swimming beaches, construction of parking lots, resorts and restaurants. Sand dunes, transitional areas between land and ocean, similar to salt marshes, are formed at wave and wind dominant coastal environment than tide-dominant areas (Fig. 2).

Natural sand dunes have important functions including providing habitats for animals and plants, storage sites for coastal freshwater resources, and protection from land erosion. In the dune environment, dune vegetation plays a very important function. For example, the dune plants act as key factors in the rise and decline of sand dunes and beach topography change (Torri 1999). Willetts (1989) suggested that the vegetation is one of three important factors to effect dune formation. If the density of plants on a sand dune is high, the distance of sand movement is much reduced. The vegetation may especially contribute in the formation of foredune and dune growth (Hesp 1983).

As dry coastal environment, sand dunes are barren and unstable by continuous deposition and erosion processes as well as changing temperature. A few plant species that tolerate this unique environment can survive on sand dune. The ecosystem of sand dunes basically depends upon the vegetation of these plants. Therefore, it is very difficult to rehabilitate sand dune ecosystem after the vegetation has been disturbed.

There are several plant communities that represent sand dune ecosystem along the Korean coastline. The representative plants are *Carex* spp., *Lathyrus japonica, Calystegia soldanella, Rosa rugosa and Vitex rotundifolia* (Min 1998). Two shrub species, *R. rugosa* and *V. rotundifolia* have been collected to use materials for traditional medicine. It is hard to find these plant communities, however, in the coast of the Korean peninsula at the moment. The vegetated areas on sand dunes are noticeably in a decreasing trend in recent years.

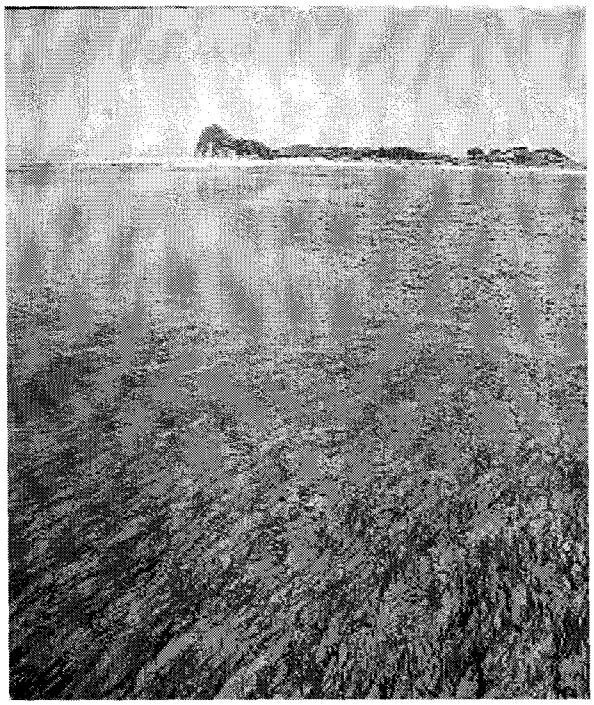

Fig. 3. Comparatively natural seagrass bed left in an island, Sabsido in Chungcheongnamdo.

Seagrass bed ecosystems

The seagrass (or eelgrass), genus *Zostera*, a marine flowering plant group, is widely distributed in many coastal areas of Korea. Numerous seagrass beds are found on sand and muddy sand bottom from intertidal zones to 20 m in depth (Lee 2001). The most common species in Korean coasts, *Zostera marina*, prefers sandy bottom in sheltered or moderately sheltered areas slightly effected by freshwater as its habitat (Fig. 3). This plant forms seagrass beds in brackish water lagoons and bays.

In the southern coast with many bays, these seagrass beds were common just few years ago, however, now they are found in only few areas. Seagrass beds were also commonly found in intertidal flats along the west coast, but now it is hardly found except for some islands such as Damuldo, Sabsido and Seungbongdo.

Seagrass beds support very dynamic coastal food-chains through high-level primary and secondary productions and also serves as important nurseries for numerous animal species, including many of commercially important fisheries species. This type of submerged vegetation also reduces impacts from waves and currents helping to stabilize sediments as well as be an integral component of the shallow water nutrient cycling process (Johanssen and Greening 2000). The importance of these areas are recognized by the USA, and the seagrass ecosystems are protected under the USA federal "no-net-loss" policy for wetlands and form one of the most productive plant communities on the planet, performing important ecological functions (Fonseca *et al.* 1998).

Recently seagrass beds have been declining in coverage due to reclamation, dredging and water pollution (Terawaki *et al.* 1999). Tremendous losses of these habitats have occurred as a result of development within the coastal zone. Disturbance usually kills seagrasses rapidly, and recovery is often comparatively slow (Fonseca *et al.* 1998). In many cases of seagrass decline are related to overgrowth by epiphytic diatoms and filamentous macroalgae.

One of the most ubiquitous factors contributing to demise of seagrass populations throughout the world is excessive nutrient enrichment from adjacent watersheds especially in temperate regions suggesting that seagrass is very sensitive to environmental changes resulting from coastal development (Murray *et al.* 2000). Therefore, coastal development has not only been simplifying Korean coastlines, but it has been removing seagrass habitats and producing and discharging turbid materials into the sea worsening its ecosystem.

Restoration of coastal vegetated ecosystems

Restoration generally means to include any actions or combination of actions to restore, rehabilitate, replace, mitigate or acquire the damaged natural ecosystems. It is necessary to understand the structure and functions of natural ecosystems and to grasp the condition of degraded ecosystem in the processes of ecological restoration. Ecosystems are extremely difficult to restore because they have too many components to be considered and support very complex interactions (Zedler 2001).

In Korea, there have been some different approaches with restoration technologies to counteract tidal wetland reclamations and coastal developments since later part of 1990s. For example, an artificial wetland can be built for water purification after removing a natural wetland, a combination of rice paddies and environmental parks designed on reclamation land instead of replacing coastal vegetated wetlands (UNDP · SNU 2000). At the present, a research project is carried out which is going to create big tidal flats using coastal engineering technique.

Korea has more than 3,000 km^2 of coastal wetlands, mostly tidal flats (Je 1999). It is, however, safe to assume that the coastal vegetated wetlands in Korea are much less than 20 % of total coastal wetlands in size from previous tidal flat studies (KORDI 1999, 2000a). Zedler (1996) indicated that the salt marshes are about 61 % of tidal flats in the Pacific coast and 330 % in the Atlantic coast of USA. Therefore, the restoration of coastal ecosystems in Korea must focus on replacing original ecosystem, or restore ecologically vegetated ecosystems instead of just expanding the acreage of tidal flats. Moreover, it is a recent trend that the restoration of coastal vegetated ecosystem to use as ecological techniques or tools to conserve coastal environment.

This introduction is to raise the special issues on restoration of degraded coastal ecosystems. Most of papers in this issue are results from early stages of a research project on the restoration of degraded coastal ecosystems that is fully supported a grant of the Ministry of Environment as a G7 project. I also appreciate Ms. M.J. Lee and Dr. H.J. Woo for their careful reading at the manuscript and providing valuable comments.

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