Research on Restoration Technology and Protection of Island with Ecological Damages

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Abstract. Island is a natural platform for people to develop marine resources. With the increasing marine economic development, the island ecology and environment are inevitable to be disturbed by human activities. Degeneration of island ecological functions will restrict sustainable development of economic society in island regions. It is necessary to coordinate consistence of economic development with resource protection and ecological environment in order to solve problems and contradictions in development of island, improve investment environment of island regions and realize sustainable development economic society in island. By analyzing environmental influences of island development, some ecological restoration technologies and protection countermeasures to destroyed islands were proposed based on a case study of the ecological restoration project in Qiaoliangshan Island, aiming to realize the goal of constructing a harmonious and ecological island as well as achieve the sustainable use of marine resources.

Keywords: Marine economy; Island development; Ecological environment; Ecological restoration; Sustainable development.

1. Introduction
As an important component of marine, island plays an extremely important role in marine ecosystem. Island possesses rich natural resources which are vital to sustainable development strategy of marine. Degeneration of ecological functions of island will restrict sustainable development of economic society in island regions.

For some islands with serious ecological damages (e.g. beach erosion, landslide and degeneration of sand beach), some engineering measures have to be adopted for ecological restoration. For instance, the Hambleton Island in America is divided into two islands due to long-term beach erosion. Garbisch et al. [12] connected two islands into one by creating a wetland in the intertidal zone and stabilized the wetland by planting herbaceous plants on the wetland. Moreover, Ecological environment in islands were restored by using corresponding engineering technological measures, which achieved good effects. Pilkey O H and Clayton T D et al. [13] summarized date, quantity, length and cost of ecological restoration and maintenance of several barrier islands in the east coast of the United States, which provided basic data for subsequent studies for beach restoration. Liao Lianzhao et al. [14] analyzed main causes of ecological degradation in the Monkey Island which is an uninhabited island in Xiamen City and assessed restraints against ecological restoration. By combining biological technologies and engineering technologies, they proposed several island protection and ecological restoration measures for islands, such as construction of protective beaches and slopes, improvement of local soils,
reasonable distribution of arbor-shrub-grass vegetation, selection and cultivation of plant species, and so on.

With respect to ecological restoration in islands, scholars have explored various measures in addition to engineering construction, such as ecosystem adjustment in accordance to relations among different populations and among different communities, habitat protection, species protection, etc. For instance, buffalo population in the Amsterdam Island (in the South Indian Ocean) increased from 5 in 1871 to about 2000 in 1998, which caused great threats to other animals and plants. To protect and restore ecology on the island, people divided the island into two parts by fences and expelled buffalo from the larger island. Therefore, the vegetation in the larger island was restored to some extent \cite{15}. With references to the adjacent primary island, David R. Towns \cite{16} expelled rabbits and mice on the Korapuki Island in New Zealand and introduced in original species by using the biogeography and other techniques, which restored the ecosystem on the island. Bruce D. Clarkson and Joanna C. McQueen investigated the current status of ecosystem in Hamilton City on the north island of New Zealand. Local species accounted for an area of less than 20 hm² in the Hamilton City and there were only 1.6% local plants. The government gradually realized the importance of ecological restoration and protection. Therefore, it updated and restored the urban ecological appearance by reconstructing an ecosystem of local species \cite{17}.

In this study, ecological restoration technologies and protection countermeasures for the damaged islands were investigated by a case study of ecological restoration project in the Qiaoliangshan Island, aiming to realize the goal of constructing a harmonious and ecological island and achieve sustainable development of marine resources.

2. Example of Ecological Restoration Project

2.1. Project Profile

Qiaoliangshan Island is 0.7km away on the northwest of Qushan Island in Daishan County, Zhejiang Province and it covers an area of about 0.1 km². The local ecosystem has been destroyed significantly by the long-term artificial quarrying activities. After stopping exploitation of the island, some simple greening project was implemented in early stage, which, however, achieved little progresses. In 2010, the State Oceanic Administration used the Qiaoliangshan Island as a demonstration test base of island ecological restoration. Key attentions were paid to ecological restoration caused by quarrying-induced environmental problems like serious island damages, shoreline erosion, landslide, water-soil loss.

2.2. Idea and Key Technologies of Ecological Governance

According to the original topography and by following the principle of “keeping feet on the ground with considerations to local situations”, the governance idea of “reasonable distribution of trees, grass and bare areas” was adopted. Some technological measures, such as artificial risk clearance, solid barrier with ecological bags to eliminate potential geological hazards, and reconstruction of vegetation, were implemented to prevent secondary geological hazards caused by ecological failures. Several years later, the artificial vegetation was domesticated and formed a stable symbiont with local wild plants after adapting to surrounding environment on the island. In this way, the final governance goal of ecological restoration and environmental beautification was realized.

Ecological bag is an important component in the ecological slope engineering system. It can prevent soil penetration but allows smooth water flow, thus enabling to prevent loss of fillers (mixture of soils and nutrients) and assures normal flow of water in soils to supply water for growth of plants. In this project, ecological bags were piled up as a barrier for the stability of slopes.
Ecological bags were piled up according to the designed order and local situations. Firstly, gravels were used as the foundation bed (Fig. 2). Subsequently, ecological bags were piled up in parallel (Fig. 3) and corners were inflected. The sealing sides of ecological bags were kept on the side close to the slope. Next, ecological bags were beat for compaction, flattening and stability. The piling process of ecological bags has to be adjusted in accordance to practical slope ratio in the region. Considering settlement after piling of ecological bags, the dip angle was slightly smaller than the local slope angle and the slope feet was kept stable to prevent slippage of bags.

Ecological bags were piled up along the slope surface and the gradient. Backfilling of solid bags was suggested in regions with deep pits, but the backfilling shall be compact. The big protuberant rocks shall be surrounded by ecological bags according to the principle of “bare in appropriate regions”.

Figure 1. Ecological bags.

Figure 2. Using gravels as the foundation bed.

Figure 3. Putting ecological bags based on the foundation bed.
Figure 4. Solidification effect by ecological bags.

Spray-planting-turf technology was applied for the slope re-greening project. Spray-planting-turf technology is a new technology that creates a soil environment artificially on steep rock slopes where is inappropriate for plant growth, stabilizes and protects slopes by combining plant growth and geotechnique materials, and restore vegetation ecological environment on slope gradually.

Local high-quality yellow clay was applied as the planting soil. Sawdust produced by a local wood processing plant was used as organic matters. Finished organic compound fertilizer which is appropriate for growth of grass seeds was chosen. In this project, the procedure of spray-planting-turf technology was introduced as follows: retest of slope - slope finishing – artificial cleaning of the slope- pavement of a galvanized iron mesh for reinforcement – crushing and mixing of base raw materials –mixing of raw materials by mechanical stirring – mechanical spraying of local soil subbase course (0.05-0.25 m) – mixing plant seeds into base materials according to the mixing ratio – mixing by mechanical stirring – spraying the secondary soil-based grass layer (0.05m) – covering a sunshade net – irrigation in early stage (30d-45d) – forming a green lawn on slope – remove the sunshade net on the slope – maintenance and management in the late stage.

2.3. Governance Effect

Construction of spray seeding turf 2 months late, the ratio between green vegetation coverage and the area that can be greened on the slope could reach over 70%. According to previous experiences, it is speculated that an evergreen effect of at least 8 months in a year can be achieved basically.

Figure 5. Ecological restoration effect on the slope.

According to examination on the greened slope after 2 months, erosion resistance of the slope is further enhanced as a response to the collaborative effect of slope vegetation and base. Root systems of plants on the slope cross each other. A porous stable structure has been formed, which not only could assure normal growth of plants, but also increased soil cohesion and soil strength to solidify the slope.
2.4. Problems for Discussing in Future

(1) Late maintenance
In the engineering practices of Qiaoliangshan Island, there are two major challenges against the late maintenance: ① term of late maintenance. How long the slope shall be maintained to assure sustainable development of plant slope. ② Which maintenance technology can shorten the maintenance period to accelerate the greening process and reduce greening cost.

(2) Selection of plants and mixing ratio
This ecological restoration project mainly applied the external grass seeds. However, stress resistance, adaptability and hazard of external grass seeds in the slope shall be further discussed. If local wild plant species could be used fully and matched with foreign species reasonably, it can not only overcome shortages of external grass seeds, but also is conducive to improve landscape and stability of the slope.

3. Conclusions
At present, the impact of human development on the environment and ecological restoration of islands has attracted extensive attention. Based on a case study of ecological restoration project in Qiaoliangshan Island, this study proposes some ecological restoration technology and protection countermeasures for damaged islands by discussing influences of island development on environment. Qiaoliangshan Island is the first demonstration test base for island ecological restoration in China. Currently, preliminary ecological restoration has been finished. However, there are still many technological researches that have to be carried out thoroughly.

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