Restoration Outcomes of the Wugu Wetland in the Erchong Floodway in New Taipei City
Liao YT* and Chern SG
Department of Harbor and River Engineering, National Taiwan Ocean University, Taiwan

Abstract
Taiwan is surrounded by seas and has diverse soils and landscapes, a temperate climate, abundant rainfall, and longitudinal and transverse valleys and mountain ranges. These conditions afford Taiwan a rich variety of wetland environments on coasts and around its lakes and rivers. On July 3, 2013, the legislature of the Taiwanese government passed the third reading of the Wetland Conservation Act, which took effect on February 2, 2015. The act lists a total of 42 wetlands of international and national prominence and 41 others of regional prominence (provisional designation) across Taiwan. In addition, before the implementation of the act, the Ministry of the Interior reduced the total area of designated wetlands nationwide from the 56,860 hectares established in 2011 to 47,627 hectares. This study investigated the Wugu Wetland in the Erchong Floodway in New Taipei City, a wetland located in a metropolitan area of northern Taiwan that had been partially damaged from misuse, and examined the recent restoration policies for the wetland implemented by the New Taipei City government. A SWOT (strengths, weaknesses, opportunities, and threats) analysis was subsequently conducted to propose feasible strategies for positive restoration outcomes of the wetland.

Keywords: Wetland degradation; Restoration

Introduction
Wetlands are functionally vital and valuable to the health of nature and are one of the most productive ecosystems. Their biodiversity of fauna and flora is conducive to the breeding of new and propagation of valuable species. Being surrounded by sea, Taiwan is fully encircled by a wetland network, in the broad sense of the definition, that spans mudflats, rocks, estuaries, and beaches in and around the coast, marshes, rivers, ponds, rice fields, and other bodies of inland waters, as well as swamp forests, reservoirs, and high mountain lakes in the mountains. With the ecological value of wetlands being increasingly promoted by private and public sectors and nongovernmental organizations (NGOs) at home and abroad, the Construction and Planning Agency of Ministry of the Interior (CPAMI) had been undertaking extensive wetland conservation and restoration measures to fulfill the mandate of the Basic Environment Act [1] before the Wetland Conservation Act (Laws & Regulations Database of The Republic of China, 2015) was legislated. The CPAMI has also formulated measures for wetland conservation and restoration to expedite the construction of a comprehensive ecological network that would extend progressively from nationally prominent wetlands to major ecological habitats (i.e., starting from coasts and moving inward to estuaries, riparian watersheds, and ponds, and up to mountain lakes). To assess and track the ecological conditions of nationally designated wetlands and encourage public participation in their conservation and restoration, the agency has funded regional governments to develop and launch projects that mobilize the local communities and NGOs, [2] as well as private and public organizations, to survey, restore, and reengineer these essential ecological resources [3]. Because of the implementation of such policies, the Wugu Wetland in the Erchong Floodway in New Taipei City has been undergoing restoration.

Overview of wetlands
Completed in 2005, which was 5 years after being initiated, the Millennium Ecosystem Assessment [4] provided a comprehensive evaluation of all types of ecosystems across the globe, highlighting the importance of wetlands in terms of their ecological and economic value. The MA results revealed that more than half of wetland ecosystems worldwide had been ruined throughout the last century and the remainder were already degenerating.

The MA offered the following valuable conclusions. First, wetlands perform diverse ecosystem services that can benefit human wellbeing. Second, based on the comparison between the market and nonmarket benefits of wetlands, the total economic value of no transformed wetlands is often higher than that of transformed ones. Third, nutrient oversupply poses substantial threats to rivers, lakes, swamps, coastal areas, and coral reefs.

Fourth, wetland ecosystem services (e.g., denitrification and flood and cloudburst prevention) have become increasingly essential. Fifth, wetlands, and thus the species thereof, deteriorate and disappear more rapidly than other ecosystems do. Sixth, the combined effect of biodiversity loss, land degradation, and climate change is undermining the capability of wetlands to reduce negative impacts on nature. In sum, the most effective strategy to address the implications of climate change and the changes to the global ecosystem is to implement cross-

*Corresponding author: Liao YT, Department of Harbor and River Engineering, National Taiwan Ocean University, Zhongzheng District, Keelung, Taiwan, Tel: +886-930-686, extn. 449; Fax: +886 2 8295-9993; E-mail: happy4999tw@gmail.com, ytliao2014@gmail.com

Received October 03, 2016; Accepted October 14, 2016; Published October 24, 2016

Citation: Liao YT, Chern SG (2016) Restoration Outcomes of the Wugu Wetland in the Erchong Floodway in New Taipei City. J Tourism Hospit 5: 250. doi: 10.4172/2167-0269.1000250

Copyright: © 2016 Liao YT, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
sectoral approaches for wetland management [e.g., integrated water resource management [5] and integrated coastal zone management (Wikipedia)], thereby lessening pressure on wetlands and improving their restorative capability. Such approaches are more effective at promoting wetland sustainability than are sector-specific ones, which are currently widely applied in numerous countries.

International wetland conservation

Approximately 5 decades ago, a group of scientists studying wetland bird species discussed how to effectively manage functional wetlands that support biodiversity and serve as stopover sites for migratory water birds from across the world. In 1962, they had their first meeting in what is currently the Camargue Biosphere Reserve in France, but was then a large wetland at the estuary of the Rhône River. Afterwards, the national governments that advocated this movement, including those of Britain, the Netherlands, Iran, France, and the former Soviet Union, convened their own respective technical meetings. An international treaty was subsequently reached on the basis of legal guidance from the Environmental Law Commission of the International Union for Conservation of Nature (IUCN). The treaty was first ratified by participating nations at a meeting in the city of Ramsar in Iran in 1971, amended in 1975, and came into force that year as the Ramsar Convention [formally the Convention on Wetlands of International Importance, especially as Waterfowl Habitat [6]]. The Ramsar Convention soon became universally acknowledged and, in the first 20 years after its ratification, prioritized wetlands upon which water birds ecologically depend. In other words, the convention did not protect waterfowl directly as its formal name suggests; it actually protected wetland ecology. In addition, it did not address concerns of wetland biodiversity until approximately a decade later.

International conventions on wetland biodiversity that were ratified in the 1970s and 1980s include the World Heritage Convention [7], the Convention on Migratory Species [8], the Convention on International Trade in Endangered Species [9], as well as the Dublin Statement on Water and Sustainable Development, which was applied at the International Conference on Water and Environment in 1992 [10]. Although the final version of the Dublin Statement made no mention of wetlands, its emphasis on effective water management indicated the importance of the wise use of wetlands, which are also considered a water resource. The Dublin Statement also played a part in the World Conference on Environment and Development [11], which was convened in the city of Rio de Janeiro in Brazil 20 years after the 1972 Stockholm conference. At the globally known WCED, three United Nations treaties were approved: The Convention on Biological Diversity [12], the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification [13].

The concept of ecosystems, developed in the 1990s, was first incorporated into the MA as a precursor to the formulation of environmental protection policies. Moreover, “the ecosystem approach,” [14] an essential element for the implementation of the Convention on Biological Diversity, was integrated into the development of the MA as a mechanism for managing biodiversity and played a role in international conferences on biodiversity protection and management. Thus, the conceptual framework of the MA was developed with the provisioning, regulating, and supporting, as well as cultural services of the environmental protection system. All these services are intended to benefit human wellbeing [15].

Wetland conservation in Taiwan

To maintain the health and stability of ecosystems, promote the sustainability of the natural environment, and improve the conservation and restoration of wetlands, it is crucial that government organizations at all levels and the public at large properly manage and wisely utilize the natural resources and ecological functions of wetlands to ensure no net loss to these areas.

Types of wetlands in Taiwan: Defined by the formation condition, wetlands can be divided into “natural wetlands (NWs)” and “constructed wetlands (CWs).” NWs can then be dichotomized into coastal and inland wetlands [16]. Coastal wetlands: distributed in and around coastal regions and formed as a result of tidal movements. Coastal wetlands come in different forms:

- Swamps
- Mudflats (located in areas such as the Lanyang Estuary, Zengwen Estuary, and Kaoping Estuary),
- Forest swamps (located in areas such as the Zhuwei Shoreline of the Tamsui River, the Hongmiao Port in Hsinchu, and the coastal area in Budai Township in Chiai),
- Intertidal zones/offshore shoals,
- Lagoons and saline lakes (e.g., the Qigu Lagoon in Tainan),
- Islets (e.g., the Mianhua Islet off the coast of Keelung).

Inward wetlands: wetland systems distributed in and around rivers, lakes, high mountains, and plains. Inward wetlands come in different forms:

- Freshwater swamps/ponds,
- Shrub swamps,
- Peat swamps (e.g., the Menghuan Lake at the foot of the Qixing Mountain in Taipei),
- Lowland broadleaf forests,
- Forest swamps,
- Seasonally flooded grasslands/forests,
- Constructed wetlands (e.g., rice fields, fish ponds, salt pans, reservoirs, and artificial lakes),

Based on the wetland classification proposed in 1975 by the IUCN, wetlands are further divided into the following (available from the Database of Natural Resources and Ecology of Forestry Bureau of Council of Agriculture, [17]):

- Shallow sea bays and straits (less than 6 meters deep at low tide),
- Estuarine waters/estuarine systems of deltas,
- Islets,
- Rocky marine shores and sea cliffs,
- Sandy beaches,
- Tidal flats and mudflats,
- Coastal mangrove swamps,
- Coastal brackish and saline lagoons and swamps,
- Salt pans,
Wetland conservation outcomes in Taiwan: It was not until the early 1980s, when public demand for protecting the mangrove forest at the mouth of the Tamsui River spread nationwide, that the Taiwanese society began to appreciate the relevance of wetland protection. Since 1986, the Council of Agriculture has designated the mangrove forest and other NWs as nature reserves in accordance with the Cultural Heritage Preservation Act. It has also designated ecologically rich wetlands (e.g., seas, estuaries, swamps, lakes, streams and brooks, and farmland, which are listed in the implementation guidelines of the Wildlife Conservation Act) as major wildlife habitats and wildlife reserves [18].

There are currently 83 nationally designated nature reserves, major wildlife habitats, wildlife reserves, and protected natural areas, spanning 11.38% of the entire area of Taiwan. Numerous natural resources in the Taiwanese domestic wetlands have accordingly been safeguarded (Tables 1 and 2).

- Wetlands of international and national prominence. Designated on account of their global relevance in the fields of ecology, botany, zoology limnology, and hydrology. This type of nomination is proposed by the competent authority and reported to the executive branch of the Taiwanese government for approval.
- Wetlands of regional prominence. Areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or both, including areas of marine water with a depth at low tide that does not exceed 6 meters, and without any inclusion in the list of wetlands of international or national prominence. The nomination shall be proposed by local governments and reported to the competent authority for approval.

Undesignated. Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or both, including areas of marine water with a depth at low tide that does not exceed 6 meters.

Wetland conservation measures in Taiwan: To balance commercial environmental and spatial planning with ecological sustainability [19], the CPAMI promulgated the Wetland Conservation Act on February 2, 2015, requiring wetland developers and users to submit wetland-impact statements detailing the damages to major wetlands from their land development and use. The CPAMI formulated guidelines within the act on the verification, dissemination, and public review of the submitted statements, as well as the calculation of off-site compensation and ecological compensation, to minimize the impact of land development and use on wetlands. The measures regarding this objective are detailed as follows:

- Standards and criteria for wetland-impact statements of land development and use within or around major wetlands and implementation guidelines on public participation.
- Implementation guidelines on impact minimization and ecological compensation associated with land development or use within or around major wetlands.
- To facilitate wetland conservation, wetland developers and users are required to contribute specific amounts of their monetary reward toward funds for wetland conservation and restoration and environmental education.
- Guidelines on the application for “wetland badges,” calculation of monetary reward, and wetland land management and use certificates. This market mechanism is intended to promote wetland conservation.
- The delineation of the functions of wetland ecosystems, limitation and prohibition of certain actions on wetlands, and management and wise use of them.

Comprehensive comparison of wetlands in Taiwan and other countries: The position of a wetland park is specified by an overall assessment of the features, faunal and floral species, environmental

| Northern | Central | Southern | Eastern | Outlying Islands |
|----------|---------|----------|--------|-----------------|
| Region   | Number of wetlands | Region | Number of wetlands | Region | Number of wetlands | Region | Number of wetlands |
| Taipei City | 2 | Miaoli County | 4 | Chiayi County | 8 | Hualien County | 3 | Lienchiang County | 1 |
| New Taipei City | 1 | Taichung City | 3 | Chiayi City | 2 | Taitung County | 7 | Kinmen County | 1 |
| Keelung City | 0 | Nantou County | 5 | Tainan City | 8 | Penghu County | 2 |
| Taoyuan City | 2 | Changhua County | 1 | Kaohsiung City | 12 |
| Hsinchu City | 1 | Yunlin County | 2 | Pingtung County | 10 |
| Hsinchu County | 4 | | | | |
| Ilan County | 6 | | | | |
| Total: 16 | Total: 15 | Total: 38 | Total: 10 | Total: 4 |

Table 1: Distribution of wetlands in Taiwan.
| Name and Level of Designation | Total Number of Bird Species | Area (Hectare) | Type |
|------------------------------|-----------------------------|----------------|------|
| **International**            |                             |                |      |
| Zengwen Estuary Wetland      | 121                         | 3128           | Coastal NW with partial CW |
| Sicao Wetland                | 160                         | 547            | Coastal NW with partial CW |
| **National**                 |                             |                |      |
| Menghuan Lake Wetland Limited| 1                           | 1              | Inland NW |
| Danshuei River Drainage Wetlands |             |                |      |
| North-Jetty of Port of Taipei Wetland Limited | 477 | . |
| Wazhweii Wetland Limited     | 60                          | Coastal NW     |      |
| Danshuei River Mangrove Wetland Limited | 190 | Coastal NW |
| Guandu Wetland               | 139                         | 394            | Combination of coastal NW and CW |
| Wugu Wetland Limited         | 358                         | 58             | CW with partial inland NW |
| Dahan-Sindian Wetland Limited| 101                         | 650            | Inland NW |
| Sinhai Manmade Wetland Limited| 101            | 129            | Inland NW |
| Fujhou Manmade Wetland Limited| 165                        | 129            | Coastal NW |
| Daniaopi Manmade Wetland Limited | 76             | CW              |      |
| Chenglin Manmade Wetland Limited | 36            | CW              |      |
| Lujiao River Manmade Wetland Limited | 25 | CW |
| Taoyuan's Reservoir and Canal Wetlands | 49 | 2974 | Inland NW with partial CW |
| Xucuo Harbor Wetland         | 180                         | 1836           | CW |
| Sinfong Wetland              | Limited                     | 165            | Coastal NW |
| Yuanyang Lake Wetland Limited| 374                         | 165            | Coastal NW |
| Siangshan Wetland Limited    | 277                         | 1600           | Officially included in the East-Asian Waterfowl Protection Network at the 1996 Conference of the Contracting Parties of the Ramsar Convention |
| Xiuhu Wetland. Limited       | 183                         |                |      |
| Cijiaowan River Wetland Limited| 7221                       | Inland NW      |      |
| Gaomei Wetland               | 135                         | 701            | Coastal NW |
| Dadu Estuary Wetland         | 235                         | 4136           | Coastal NW |
| Aogu Wetland Limited         | 259                         | 512            | Coastal wetland behind a seawall, with a partial mudflat outside the seawall |
| Puzhi Estuary Wetland Limited| 179                         | 8522           | . |
| Haoneiliao Wetland           | 93                          | 1171           | Coastal NW with partial CW |
| Budai Salt Pan Wetland Limited| 93                          | 721            | CW with partial coastal NW |
| Bajhang Estuary Wetland Limited | 93 | 635 | Coastal NW |
| Jianan's Reservoir and Canal Wetland Limited | 1383 | Inland CW with partial coastal NW |
| Beimeim Wetland              | 119                         | 2447           | Coastal NW with partial CW |
| Guantian Wetland             | Limited                     | 15             | CW |
| Cigu Salt Pan Wetland Limited| 121                         | 2997           | Coastal NW with partial CW |
| Yanshuei Estuary Wetland     | 200                         | 635            | Coastal NW |
| Nanzhisiian River Wetland. Limited | 130 | Inland CW |
| Daguei Lake Wetland          | Limited                     | 39             | Inland CW |
| Jhouzai Wetland              | Limited                     | 10             | CW |
| Nannen Lake Wetland          | Limited                     | 118            | Inland CW |
| Longluan Lake Wetland Limited| 289                         | Inland CW      |      |
| Sinwulyu River Wetland Limited| 193                         | Inland CW      |      |
| Dapochih Wetland             | Limited                     | 41             | Inland CW |
| Beinan Estuary Wetland Limited| 98                          | 947            | Coastal NW |
| Silaqguai Lake Wetland Limited| 18                          | Inland CW      |      |
| Hualien Estuary Wetland Limited| 259                        | Coastal NW     |      |
| Falaan Wetland Limited       | 177                         | Inland CW      |      |
| Shuangliian Reservoir Wetland Limited | 17 | Inland CW |
| Lanyang Estuary Wetland      | 236                         | 2799           | Coastal NW |
| S2-jia Wetland               | 150                         | 299            | CW with partial coastal NW |
| Wuwei Harbor Wetland         | 140                         | 684            | Coastal NW |
| Nanao Wetland                | Limited                     | 200            | Inland NW |
| Chingluo Wetland             | Limited                     | 221            | Coastal NW with partial CW |
| Chi Lake Wetland             | Limited                     | 188            | Inland NW |
| Cingshui Wetland. Limited    | 12                          | Coastal NW     |      |
| **Regional**                 |                             |                |      |
| Jhubei Lianhua Temple Wetland| 1                           | CW             |      |
### Table 2: Classification and distribution of wetlands in Taiwan.

| Ecological Park of Toucian River | 492 | - |
|---------------------------------|-----|---|
| Jhunan Mannmade Wetland         | 9   | Coastal CW |
| Siangtian Lake Wetland          | 3   | Coastal NW with partial CW |
| Danan Lake Wetland              | 9   | Inland NW |
| Dongshih Mannmade Wetland       | 4   | Inland NW (planned to be rebuilt as CW) |
| Caonan Wetland                 | 2   | Inland NW |
| Shinjie Cold Spring Wetland     | 50  | - |
| Twin Lakes Wetland              | 12  | - |
| TouSher Basin Wetland           | 13  | - |
| Caodi Wetland                  | 2   | Inland NW |
| Chingsong Wetland               | 171 | Coastal CW with partial NW |
| Yiwu Wetland                   | 1857| Coastal NW with partial CW |
| Miluo Wetland                  | 30  | Inland NW |
| Bajhang River Mid-Stream Wetland| 363 | Inland NW |
| Baihe Elementary School Mannmade Wetland | 0.4 | CW |
| Chianan University of Pharmacy and Science Mannmade Wetland | 1 | CW |
| Wetland of the National Kaohsiung University | 5 | - |
| Jiading Wetland                | 171 | CW with partial coastal NW |
| Yongan Salt Pan Wetland         | 133 | Coastal CW |
| Dashu Mannmade Wetland          | 177 | CW |
| Niaosong Wetland               | 4   | CW |
| Linyuan Mannmade Wetland        | 50  | CW |
| Yuanhong Harbor Wetland         | 39  | Coastal CW |
| Banping Lake Wetland            | 12  | CW |
| Fongsian Reservoir Wetland      | 118 | Inland CW |
| Linluo Mannmade Wetland         | 3   | - |
| Wuluo River Mannmade Wetland    | 15  | CW |
| Kanding Wetland                 | 153 | - |
| Pingtung University of Science and Technology Mannmade Wetland | 56 | CW |
| Sihochong Estuary Wetland       | 25  | - |
| National Museum of Marine Biology and Aquarium Mannmade Wetland | 5 | CW |
| Shihinger Mountain Wetland      | 2   | - |
| Dongyuan Wetland               | 112 | - |
| Guanshan Mannmade Wetland       | 2   | CW |
| Luanshan Lake Wetland           | 4   | CW |
| Jilong Lake Wetland             | 5   | CW |
| Lioushihhan Mountain Wetland    | 6   | Inland NW |
| Jhuan Wetland                   | 1417| Coastal NW with partial CW |
| Caiyuan Wetland                 | 82  | Coastal NW with partial CW |
| Undesignated                   |     | - |
| Changhua Coast Wetland          | 21152| Coastal NW |
| National Taiwan University Wetland|     | - |
| Fubow Wetland                  | 30,000 (approx.) | - |
| Hanbao Wetland                 | 3800| - |
| Puzhi Estuary Wetland           | -   | - |
| Daja Wetland                   | -   | - |
| Newei Wetland (a.k.a. Kaohsiung Museum of Fine Arts Wetland) | - | - |
| Yanshuei Estuary Wetland        | -   | - |
| Jhongsiou Wetlands Park         | -   | - |
| Love River Wetland              | -   | - |
| Shezihlini Wetland Park         | -   | - |
| Linyuan Mannmade Wetland        | -   | - |
| Baoan Wetland Park              | -   | - |
| Benhe Village Flood Retention Pond | -   | - |
| Baoye Village Flood Retention Pond | -   | - |

*"-" denotes data unavailability from the CPAMI. (Source: Compiled by this study).*
conditions, geographical location, development goals, and specified functions of the wetland in the park. This assessment determines whether the wetland is characteristic of the park and makes it capable as a model for other wetland parks in the local region or nationwide [20].

Case comparison

Wetlands of national prominence from three countries were compared (namely, the Wugo Wetland and Wuwei Harbor Wetland in Taiwan, the Sungei Buloh Wetland Reserve in Singapore, and the Kushiro Shitsugen National Park in Japan). Table 3 presents the comparison results [21].

Recommendations for wetland construction and management

The comparison of these four cases yielded the following suggestions for organizations involved in the construction and management of wetland habitats:

- Identify the characteristics of wetland habitats. A wetland should be developed on the basis of the characteristics and distribution of ecological resources in the wetland park, as well as the integrity of natural and cultural landscapes, managerial convenience of the park, and reasonable planning of wetland use.
- Formulate specific conservation objectives. The functions of a wetland should be specified in accordance with the ecological characteristics and dependence on ecological processes of the species listed for protection. Thus, the ecological characteristics of the wetland can be maintained and the protection of endangered faunal and floral species can be prioritized.
- Build partnership and integrate ideas. Public and private sectors should cooperate to develop relevant policies, as well as exchange and synergize ideas on regional development topics.
- Focus on the local environment. To facilitate its management, a wetland should have its functions specified in accordance with the attributes, characteristics, and immediate environs of fauna and flora inhabiting the ecological area. This is to ensure correspondence between the indigenous animals and plants and their immediate environs.
- Seek resources from the society. Through integration and dissemination, societal resources can be exploited to the greatest extent possible.

| Item | Wugo Wetland (Waterfowl Reserve) | Wuwei Harbor Wetland (Waterfowl Reserve) | Sungei Buloh Wetland Reserve | Kushiro Shitsugen National Park |
|------|----------------------------------|------------------------------------------|-----------------------------|-------------------------------|
| Protection Range | Within the Erchong Floodway in New Taipei City, Taiwan | Between the villages of Aozajiao and Dakengu in the southeast of the Lanyang Plain in Ilan, Taiwan | The northwest shore of Singapore | The east of the island of Hokkaido, Japan |
| Area (hectare) | 177 | 102 | 130 | 26,861 |
| Designation Year | 1900 | March 1993 | January 2002 | 1890 |
| Formation | The mountain pass of Shizitou in the narrowest part of the estuary of the Tamsui River was blasted to expedite the flow of the river into the sea. However, this subsequently caused seawater intrusion into many areas of agricultural land, turning them into swamps. | Because a channel through which the Xincheng River used to empty into the Pacific Ocean was deposited, the River shifted to the north, leaving the channel to become a swamp. | Naturally formed | Naturally formed |
| Relevance | The floodway in which the Wugo Wetland is located stems flood damage and property loss. | A crucial waterfowl wintering site in the northeast Taiwan. | The only mangrove forest left in Singapore, a major stopover for migratory birds flying to East Asia, and a critical wintering site for black-faced spoonbills. | Maintains the health of and promotes the restoration of natural environments, facilitates the use of agricultural land and the development of agriculture, and contributes to the local region. |
| Feature | CW with partial inland NW. | Hosts waterfowl flocks during winter. | A regenerated wetland | Restores the ecosystem and natural landscape in the park. |
| Water Level Control Mechanism | Natural tidal | Artificial control and natural tidal | Artificial control and natural tidal | Natural tidal |
| Objectives of Management | Restoration, protection, education, preservation, and public participation. | Restoration, protection, education, preservation, and community participation. | Restoration, protection, education, recreation, and research | Restoration, protection, education, preservation, and citizen participation |
| Management Characteristics | The local residents, conservation groups, and government cooperate on conservation and water quality improvement. | The local residents, conservation groups, and government cooperate on conservation and conflict resolution of economic interests of land use. | The government leads the management of the reserve and works with the local schools, conservation groups, and the private sector on environmental restoration. | The local residents, conservation groups, and government cooperate on environmental conservation. |
| Challenges | The impact of human activity and human-made facilities. | The requirement for more land, water pollution from metro areas and industrial activity, and coastal road development. | Pollution from the north of Malaysia. | Regulating the flood control capacity of the wetland to prevent the inflow of sand sediments caused by soil self-regulation. |

(Source: Compiled by this study).

Table 3: National wetlands in Taiwan versus those in Singapore and Japan.
Case Study of the Erchong Floodway and the Wugu Wetland

Erchong floodway

Located in a metropolis area of Taipei in northern Taiwan, the Erchong Floodway travels north–south, with its western and eastern embankments bordering the districts of Luzhou, Sanchong, Wugu, Taishan, and Xinzhuang in New Taipei City. Emptying into the Tamsui River and measuring 7.7 kilometers in length and 450 to 750 meters in width, the floodway was previously used to prevent floods as part of a flood control project implemented in Taipei and later extended to afford recreation and ecological protection. It is a 424-hectare high riverbank lying in the boundary of the Taipei Basin and includes an extensive green space approximately 16 times the size of Daan Forest Park (one of the largest parks in Taipei) and times the size of Central Park in New York City.

The Erchong Floodway is an ecological corridor that links with major waterways in several cities of a conurbation. Located in a wetland site where fresh and saltwater bodies intersect, it appeals to diverse bird species, creating an environment conducive to the existence of Mortonagron hirosei, an endangered insect. Its expansive hinterland provides optimal conditions to improve the ecosystems of urban areas.

A part of the estuarine system of the Tamsui River and located near the low-lying Taipei Basin, the Erchong Floodway serves as the confluence of three major tributaries (Dahan Creek, Xindian Creek, and Keelung River) of the river, which typically surges during typhoons. The floodway provided the source of farmland irrigation during the Japanese colonial period in the nineteenth century. Following the retrocession of Taiwan from Japan in 1945, the Nationalist government erected levees in Taipei to prevent residential areas from floods, although this measure intensified flooding in the neighborhood of the Erchong Floodway. In 1961, the government ordered that the mountain pass of Shizitou at the estuary of the Tamsui River be blasted to quicken the flow of the river into the sea. However, this subsequently caused seawater intrusion into numerous areas of agricultural land in the Wugu district, turning them into swamps. Afterwards, levees were erected in four phases as floodways for this region to stem floods and minimize property loss.

Wugu wetland

Situated at the Erchong Floodway in Wugu District (a low-lying, southwestern region of the Taipei Basin) in New Taipei City in Taiwan (25° 5′ 19.7016° N, 121° 26′ 3.084° E) and penetrated by the Un-A Channel, the Wugu Wetland spans the north end of the Erchong Floodway, borders the Guandu Wetland on the north, the National Highway No. 1 (a.k.a. the Sun Yat-sen Freeway) on the south, the Shuhong 1st Road (County Highway 59 on the north), the eastern levee of the floodway on the west, and is approximately 177 hectares in area. The wetland was built as a CW with partial NW because some of its area is subject to the tidal influence of the Tamsui River. It has been listed by the CPAMI as a wetland of national prominence, managed by the High Riverbank Construction Management Office of New Taipei City Government, and adopted by the Society of Wilderness (SOW), although the adopter has no legal power.

The formation of the Wugu Wetland dates back to the mid-seventeenth century. As policies were increasingly implemented to accommodate a growing population in the local region, it evolved from a fertile, arable soil to a tidal, ecologically rich swamp and ended up as a turf-blanketed sporting park, with its ecological functions undermined throughout all these major changes. The transformation of the wetland can be divided into five periods:

Before 1960: Farmland: During this period, the predecessor of the Wugu Wetland was a major farming site in Greater Taipei that yielded bountiful rice, citrus fruits, and taros. With populations growing and buildings being developed on the Taipei Basin and the surge of the Tamsui River increasing in frequency, the once fertile field degenerated into an infertile, highly saline swamp, encroaching on the lives and properties of the public at large.

1960-1980: Seawater intrusion and wetland formation: Excessive land development, groundwater overexploitation, and flood control implementation caused land subsidence along the Un-A Channel, making the Wugu Wetland one of the most severely subsiding sites in the Taipei Basin. In addition, the riparian location of this field was within tidal reach of the Tamsui River that, because of discharged bottlenecks at the mountain passes of Guandu and Shizitou, used to flood into low-lying areas, causing seawater intrusion into the districts of Wugu and Luzhou, and eventually turning fertile fields in the regions of the modern Wugu Wetland. Formed by chronic flooding, the Wugu Wetland now nourishes animals and plants, making it one of the major bird-watching sites in northern Taiwan and one of the top 12 wetlands nationwide.

1980-2000: Booming economy, declining environment: To meet the flood planning prevention requirements of the greater Taipei area, the construction of the Erchong Floodway took most of a 20-year period to complete. During this construction, the residents of the Wugu Wetland were forced to relocate and the local culture and history were completely eradicated. Additionally, the wetland area shrunk by almost half as its environmental wellbeing continued to be deteriorated by the construction of soil disposal and waste dumping sites in the Wugu Industrial Park. It was further damaged by industrial effluents from a cluster of factories upstream, as well as by private plantations and use, resulting in ecological degradation.

2000-2004: Green space establishment and the Wugu wetland conservation movement: Between 1997 and 2001, the Taipei County Government (predecessor of the New Taipei City Government) undertook a revitalization project to build green areas, sports fields, and many other facilities along the entire Erchong Floodway. However, this project caused the disappearance of riparian vegetation downstream the Un-A Channel, threatening the ecological environment of the Wugu Wetland. In 2002, the SOW led other NGOs to establish a Floodway Ecological Conservation Alliance, which launched a movement for the conservation of the wetland, giving rise to the establishment of the Wugu Wetland Ecological Park.

2004-present: Adoption and management of the Wugu wetland by the society of wilderness: To increase the area of green land in the densely populated, highly urbanized Taipei region by utilizing idle spaces, the government initiated a 5-year construction project, establishing a 420 hectare multiple-function recreational park. Because the development of the recreational park along the floodway focused on providing sporting fields, the SOW applied to the government to adopt the Wugu Wetland in November 2004 and build an ecological park for it. The SOW has since conducted projects in ecological education and wetland maintenance on a 3-year basis.

Conservation of the Wugu wetland

Geographical and climate characteristics of the Wugu wetland: Geography: Located in the lowest-lying region of the Taipei Basin...
and penetrated by the Un-A Channel, the Wugu Wetland serves as the confluence between the Keelung River and the major tributaries of the Tamsui River. These characteristics impede water discharge for the Wugu Wetland, which is further aggravated by the influence of the Guandu mountain pass. The wetland was the main agricultural area in the Greater Taipei, but tidal influence, flood surges of the Tamsui River, and human activity gradually made it barren and turned it into the largest reed cluster in northern Taiwan. It was subsequently reserved as a habitat for Mortonagrion hirosei, an endangered insect.

- Climate: The Wugu Wetland is in a warm and humid climate with annual and monthly average temperatures of 22.6°C and 15-28°C respectively, annual and monthly average precipitation amounts of 2325.2 mm and 136-337 mm respectively (the rainfall on the wetland is typically the highest in June, August, and September and lowest from November to January), and a relative humidity of 75-80%.

Conservation strategies

- Establish a long-term water quality monitoring mechanism to reduce the impact of water pollution from industrial zones.
- Undertake a comprehensive development plan for the ecological conservation space by persuading the owners of illegally established vegetable gardens to relocate their gardens to the upstream area of wastewater and irrigate them through soil treatment, thereby improving the water quality and wetland conservation of the space.
- Evaluate the wastewater purification effectiveness of the CW as a reference for determining the requirement to retain and expand eco-purification sites of other CWs for future waterfront projects, or to change their functionality (Figure 1).

Conservation sites of the Wugu Wetland: The SOW, the adopter of the Wugu Wetland, has divided the wetland into five conservation sites (Table 1):

- Shuhong Ecological Park: comprises a ditch, a swamp, a tidal pond, high grass, and recreational turf in an area of 30.4 hectares and is designated for ecological education and as a waterfowl habitat.
- Ecological Pond: comprises a tidal pond, a mudflat, and barren land in an area of 15 hectares and is designated as a waterfowl habitat.
- Reed Cluster: comprises a tidal reed cluster and land in an area of 22.6 hectares and is designated as a reserve and habitat for Mortonagrion hirosei.
- Shuhongzhenbian Park: comprises a freshwater pond, a partial tidal pond, and high grass in an area of 33.3 hectares and is designated as a freshwater ecological site, insect ecological site, and partial habitat for Mortonagrion hirosei.
- Shuhong Swamp Park: comprises a swamp, a freshwater pond, and high grass, in an area of 75.7 hectares and is designated as a reserve that can be used as a water purification park.

Development orientation and management objectives

To fulfill the aforementioned conservation strategies and development goals for the Wugu Wetland that focus on water quality improvement and wetland conservation, the development orientation for the wetland, as well as the approaches thereof, was proposed in consideration of the proximity of the Tamsui River watershed to the Taipei metropolitan area and the development potentials associated with the advantageous geographical location of the river.

Maintaining wetland biodiversity

Potential habitats for focal species should be protected and developed to create an ecologically rich habitat environment.
for different species should be regenerated and expanded to build diverse biotopes that facilitate the growth of marine life, provide food supplies and habitat for seabirds, serve as stopover sites for migratory birds, and ensure the coexistence of these substantive habitats.

Implementing ecological monitoring

Ecological surveys and education should be conducted periodically. A database that records ecological changes to the wetland on a long-term basis should be developed. Short- and long-term plans should be established to manage ecological reserves effectively and an ecological monitoring system that enables a long-term observation and a regular review of management strategies should be installed.

Controlling the source of water pollution to improve water quality

The source of water pollutants into the Erchong Floodway, which hinder the growth of vegetation in the Wugu Wetland, should be limited to improve the structure of the wetland and increase its purification efficiency. An educational system should be implemented to develop effective maintenance and monitoring mechanisms.

Undertaking wetland conservation and control

Human activity has hindered the growth of the Wugu Wetland ecosystem and reduced the population of the indigenous mammal species. To safeguard its ecosystem against such impacts, functional requirements, spatial configurations, and personnel control should be planned for dividing the Wugu Wetland Ecological Park into core, protected, and transition ecological zones.

Restricting visiting time and visitor numbers to the ecological park

Multiple noise sources, as well as habitat deterioration associated with human activity, have hindered the population growth of species living in the ecological park. Thus, the visiting time and visitor numbers to the core ecological zone of the park should be restricted to maintain the ecological wellbeing of the wetland.

Regulating visitor activity through zone designation

A buffer area should be established between the protected area and visitor routes. In addition, the ecologically sensitive zone should be divided into non protected and ecologically recreational areas to regulate visitor activity.

Protecting rare species in the wetland ecological environment

To sustain the habitats of rare species in the Wugu Wetland, habitat conservation and the development of potential habitats should be undertaken and diverse habitats be established. This would improve ecological abundance and the capability of peripheral habitats to interlock with each other to maintain the integrity of the ecological environment of the wetland.

Providing wetland education

Guided tours and interpretative facilities should be provided at the Wugu Wetland to disseminate information on how the planning and design of the wetland enables the Tamsui River to cleanse water and neutralize miasma. Moreover, because this wetland boasts species diversity, it allows urban residents to come into close contact with animals and waterfowl without having to travel far.

Imposing land use regulations

Human activity should be strictly prohibited within 50 meters of the Wugu Wetland and areas within 100 meters outside of the embankment of the wetland watershed should be designated as parks or green spaces. Such regulations would establish ecological buffer zones to protect the core and ecologically sensitive zones and minimize the impact of recreational activity on the wetland.

Training the locals as guides and promoting ecological education

Training programs that involve long-term observation of environmental problems and increase environmental awareness should be offered to cultivate local interpretive guides and volunteers. In addition, environmental education on the wetland and water resources should be provided through printed and electronic media to the general public, thereby achieving the management of the wetland watershed and sustainable management of ecological resources.

Expected outcomes

A conflict between economic development and environmental protection has always existed because the latter is achieved by invoking environmental responsibility and ethical concerns in many cases and diminishing economic activity in some. However, environmental conservation, which promotes the “wise use” of natural resources and the environment, is encouraging the shift in the “rivalry” between environmental and economic concerns toward a “partnership.” To facilitate this change in the environment–economy relationship, the government should seek to cooperate with environmental activists and resolve this long-term conflict.

Thus, wetland conservation in Taiwan should be undertaken by the society as a whole to create value for ecological systems. The government can establish a market mechanism to promote wetland conservation, rather than create a clash between conservation practices and the market. Such a mechanism is referred to as "mitigation banking" (Table 4).

Strengths–weaknesses–opportunities–threats analysis of the restoration of the Wugu wetland

Current observations indicate that most ecological characteristics of the Wugu Wetland have been constantly changing since 2004, when reservations were first established. Purified water, increased species populations, and an improved ecological landscape have given the wetland a combination of natural, cultural, and scenic values, suggesting its potential to develop ecologially. Thus, the restoration outcomes of this degraded urban wetland indicate that its ecological characteristics have improved.

| Damages | Restoration outcomes |
|---------|---------------------|
| Area wassubstantially reduced, accelerating the rate of loss | Decreased in wetland area, increasing the restoration area restoration |
| Ecosystem structure and habitats were degraded | Habitats were expanded through ecosystem structure integration |
| Biodiversity declined | Biodiversity was increased |
| Soil and water pollution | Quality of soil and water was improved |

Table 4: Restoration outcomes for the Wugu Wetland.
The restoration outcomes of the Wugu Wetland, as listed in Table 4, are results of required improvements. To develop viable approaches to improving the restoration of the wetland, all the internal and external conditions of the wetland’s ecological characteristics were identified through a SWOT analysis (Table 5).

### Conclusion

An ecological characteristic description summarizes the current status of a wetland, providing technical support for wetland management. An analysis of ecological characteristics reveals the threats to these characteristics. This analysis method applies to the protection of not only wetlands of international and national prominence but undesignated ones and can be conducted at any temporal points depending on the objectives or requirements of wetland management.

Although the Wugu Wetland is isolated in an urban environment,

| SW | Internal Strengths | Internal Weaknesses |
|----|-------------------|-------------------|
| OT | • Promotes ecological education | |
|    | Prioritizes ecological education over scenic education | Promotes wetland waterfow conservation |
|    | Promotes the prohibition of hunting protected insects | Promotes ecological protection and environmental education |
|    | To improve visitors’ ecological awareness | |
| External Opportunities | | |
|    | • Policy-promoted reengineering of ecological landscape | To reengineer the ecological landscape on the basis of the reduction principle and ecological engineering method |
|    | To maintain the ecological functions of the wetland | To reduce bird-watching facilities |
|    | To establish a management mechanism for water quality | To determine whether to reduce human-made facilities |
|    | To reduce recreational activities in the ecosystem | |
|    | To create ecosystem management plans | |
|    | To reduce the impact of recreational activities on the ecosystem | |
|    | To reduce human activity near protected areas | |
|    | To secure the characteristics of the wetland | To control ecological zones close to public roads and conduct this control plan in accordance with the recreational functions of these zones |
|    | To use resources beneficial to ecological characteristics | To strictly limit the discharge of water pollutants |
|    | To fulfill the ecological functions of the wetland | To reduce recreational parks and expand ecological habitats |
|    | To create ecosystem management plans | |
|    | To maintain biodiversity | |
| External Threats | | |
|    | • Bursting activity on weekends and holidays near the wetland caused by its proximity to the transportation hub of Taipei | To reduce the traffic outside of street blocks and designate traffic areas to lessen the traffic volume within the blocks |
|    | To implement effective control plans for the protected zones | To build parking spaces outside of the wetland |
|    | To control ecological zones close to public roads and conduct this control plan in accordance with the recreational functions of these zones | To reduce water pollutants |
|    | To narrow biking and walking paths and limit access to them | |
|    | To rearrange recreational facilities in activity zones | To limit human activity near protected areas |
|    | To maintain biodiversity | |
|    | To encourage recreational activities that have less impact on the ecosystem | To designate protected and buffer zones |
|    | To provide ecological education for visitors of all ages | |
|    | To establish a stable monitoring and education mechanism | |
|    | To form a cooperation mechanism between the general public and local educational institutions | To narrow biking and walking paths and limit access to them |
|    | • Habitats disturbed by visiting routes | |
|    | To maintain biodiversity | |
|    | To encourage recreational activities that have less impact on the ecosystem | |
|    | To designate protected and buffer zones | |
|    | To provide ecological education for visitors of all ages | |
|    | To establish a stable monitoring and education mechanism | |

(Source: Compiled by this study)

Table 5: SWOT matrix of the Wugu Wetland restoration outcomes.
its degraded ecosystem has undergone comprehensive restoration to accommodate social, economic, and natural requirements. Improvements in water purification, species population size, and the ecological landscape have contributed toward restoring the wetland environment and water bodies, increasing species diversity, and improving soil quality (that facilitated the restoration of native helophytes). The aforementioned restoration outcomes confirmed the feasibility of the ecological restoration practice in restoring the function of damaged urban wetland ecosystems according to the structural characteristics of the ecology. Such practice is an effective measure for restoring damaged urban wetlands, improving the water quality, and managing wetland conservation.

References

1. Construction and Planning Agency Ministry of the Interior (2013).
2. Google Translate (1995).
3. Urban and Rural Development Branch of the Construction and Planning Agency of Ministry of the Interior (2010).
4. Millennium Ecosystem Assessment (MA) 2005 (2005) Ecosystems and Human Well-being: Wetlands and Water Synthesis. Washington, DC: World Resources Institute.
5. International Decade for Action ‘Water for Life’ 2005-2015 (2009).
6. The Encyclopedia of Earth (2007).
7. United Nations Organization for Education, Science and Culture (UNESCO) (1946).
8. Convention on the Conservation of Migratory Species of Wild Animals (CMS) (2015).
9. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2016).
10. International Conference on Water and Environment 1992 (ICWE) (1992) The Dublin Statement on Water and Sustainable Development. Dublin, Ireland.
11. World Commission on Environment and Development (WCED) (1987) Our Common Future: Report of the World Commission on Environment and Development. Oxford, UK: Oxford University Press.
12. Convention on Biological Diversity (CBD) (2010) Inland waters programme of work.
13. United Nations Convention to Combat Desertification (UNCCD) (1994).
14. Convention on Biological Diversity (CBD) (2016) Ecosystem Approach Programme.
15. The United Nations Framework Convention on Climate Change (UNFCCC).
16. Zhuang YZ, Wang HF (2001) Wetlands in Taiwan. Taipei, Taiwan: Walkers Cultural Enterprise Ltd.
17. NGIS ecological resources database website (2013).
18. Integrated coastal zone management, Wikipedia (2016).
19. Laws & Regulations Database of The Republic of China (2015).
20. Rogers K, Wilton KM, Saintilan N (2006) Vegetation change and surface elevation dynamics in estuarine wetlands of southeast Australia. Estuarine, Coastal and Shelf Science 66: 559-569.
21. Sutula M, Day JW, Cable J, Rudnick D (2001) Hydrological and nutrient budgets of freshwater and estuarine wetlands of Taylor Slough in Southern Everglades, Florida (U.S.A.). Biogeochemistry 56: 87-310.