陳文雄博士國際學術合作專題研究獎學金
成果報告

鹽田濕地於不同水文環境下之生態服務系統
(Responses of Ecosystem Services under Different Hydrologic Conditions at Abandoned Salt Pond Wetlands)

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目錄

中文摘要

在過去的數十年間，全世界的濕地面積已損失了將近一半，且濕地消失的速度還在迅速地增加。因此，濕地復育的議題越來越在受到關注，與其相關之法令也在國際間陸續地被訂立；在台灣同樣面臨著濕地快速流失的考驗，為使濕地之規劃、保育利用及經營管理更臻明確，內政部以「明智利用」和「零淨損失」概念為基礎，訂立濕地法，並於 2013 年 6 月 18 日通過此法案。台灣目前共訂有 82 個國家重要濕地，其中有四個案址為鹽田濕地，而鹽田濕地目前多缺少完善之水文循環及水位管理計畫，因此其水文環境受氣候操控，汛期時帶來之洪水將直接衝擊濕地及其生物資源，而非汛期時鹽田環境則缺乏水源補助，其水質及水量將無法提供濕地內水文環境需求。有鑑於濕地水文條件驅使了濕地的發展及功能，完善的濕地水文環境建立與水文環境管理將為濕地復育工作之基礎，本研究以水文環境管理為出發點，進行鹽田濕地之水文環境分析，並以跨領域及宏觀角度的生態服務系統概念進行探討。本研究選定布袋鹽田濕地做為研究區域，透過現地之地形調查、水位監測及棲地利用調查分析做為水文環境分析之基礎；藉由情景設計，並利用地文性淹排水模式及景觀生態決策與評估支援模式的應用，比較各情境下之生態系統服務，以擬定水文環境管理策略，達成濕地明智利用之目標。本研究成果，可提供鹽田濕地一個考量濕地洪災管理及永續性之水文環境管理策略。

中文關鍵詞 (keywords)

鹽田濕地、濕地復育、水文環境、生態系統服務

英文摘要

There were 50 % of the original wetlands have been lost around the world in the past decades and the loss rate is still increasing rapidly. Hence, there is increasing attention on wetland restoration and the strategies for wetland conservation have been proposed around the world. In Taiwan, the issue of wetland restoration is also emphasized and thus Wetland Act was legalized on June in 2013. There are four abandoned salt pond wetlands within the 82 national important wetlands in Taiwan. As the abandoned salt ponds suffered the problems of the water quality and quantity are unstable which lead to the increasing flood risks during the flooding period and frequent droughts in dry season due to the inappropriate water management. Considering the hydrological condition drives the development and functioning of wetland, the appropriate hydrology is the fundamental issues for the wetland conservation. Hence, the study focused on the wetland restoration in the hydrological point of view. Besides, the ecosystem services under different hydrological condition were considered.

Budai Salt Pond Wetland, one of the national important wetlands, was chosen as the study area. The field surveys were designed to understand the hydrologic environment at the abandoned salt pond wetland. The Physiographic Inundation Model Model and the Landscape Ecological Decision and Evaluation Support System Model were applied to evaluate the ecosystem services. The scenario analysis under different management strategies, such as Do nothing, Future Plan, Inactive and Active Management, was considered because a well-designed hydrologic condition can help wise wetland management. The findings obtained in this study can support the wise management of the hydrological system for the wetlands for the safety and sustainable development concern. Besides, the experiences in the study could guide future projects for wetland restoration because the current researches related to the wetland issues lack the discussion in the hydrological environment.

英文關鍵詞(keywords)

Salt Pond Wetland; Wetland Restoration; Hydrological Environment; Ecosystem Service

（一）前言。

There have been 50 % of the original wetlands lost around the world in the past decades and the loss rate is still increasing rapidly (Mitsch and Gosselink, 2007 [1]). Hence, there is increasing attention on wetland conservation and different strategies have been proposed. For example, the international conservation on wetlands, Ramsar Convention, was signed in 1971 to ensure the wise use, or sustainable use, of all of the wetlands in the world. In Taiwan, Wetland Act was legalized on June in the year 2013 and stipulated the goal of " No Net Loss for Wetlands." Nowadays, there are 82 national important wetlands in Taiwan. Among them, four coastal wetlands, Budai Salt Pond Wetland, Cigu Salt Pond Wetland, Jiading Wetland, and Yongan Salt Pond Wetland, were abandoned salt ponds (Ueng, 2007 [2]).

However, the water quality and quantity are unstable due to the inappropriate water management in the abandoned salt ponds. For example, it was observed that there are increasing flood risks due to the extreme rainfall and land subsidence during the flooding period in Budai Salt Pond Wetland. On the contrary, there are frequent droughts due to the lack of the water resource in dry season. Hence, the well management of the hydrological system for the abandoned salt pond wetland is required indeed for the safety and sustainable development concern.

（二）目的。

請詳述本研究計畫之背景、目的、重要性及國內外有關本計畫之研究情況、重要參考文獻之評述等。

The hydrologic conditions define wetlands and the alteration of water volume (increases, decreases, or timing of high and low waters) threatens the area and integrity of wetlands (Zedler and Kercher, 2005 [3]). The hydrologic condition drives the development and functioning of wetland (Mitsch and Gosselink, 2007 [1]). Appropriate hydrology must be established for any wetland restoration to provide habitat support and other functions because hydrology affects soil development, sediment dynamics, plant growth, and dispersal, aquatic animal access, and many other processes (Zedler, 2001 [4]). Hence, the study focuses on the wetland restoration in the hydrological point of view. Besides, the ecosystem services under different hydrological condition is considered. The findings obtained in this study can support the safe and sustainable management of the hydrological system in the abandoned salt pond wetlands.

（三）文獻探討。

請詳述本研究計畫之背景、目的、重要性及國內外有關本計畫之研究情況、重要參考文獻之評述等。

Wetlands, which was defined as the “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metrers” by the Ramsar Convention in 1971, provide the ecosystem functions such as biodiversity support, water quality improvement, flood abatement, carbon sequestration (Zedler and Kercher, 2005 [3]). There are numerous types of wetlands such as the mangrove wetland, estuary wetland, river wetland, lake wetland, and canal wetland. In this study, I focused on the abandoned salt pond. Moreover, the purpose of the study is to understand the responses of ecosystem services under different hydrologic conditions for abandoned salt pond wetlands. I thus did the literature review related to the hydrologic restoration and ecosystem service in wetlands to construct the framework of the study.

3.1 Hydrologic Restoration

The hydrologic condition drives the development and functioning of wetland (Mitsch and Gosselink, 2007 [1]). For example, the changes of hydrological condition of many coastal wetlands due to the activities such as stream channelization, dredging, canal construction may lead to the alterations in the fresh and saline water balance and changes in the way water flows (Day and Templet, 1989 [5]; Day *et al*., 1995 [6]; Ibañez *et al*., 1997 [7]). Hence, the regional water management approach is suggested to restore the wetlands by the hydrological process (Templet and Meyer-Arendt, 1988 [8]). Moreover, the better management of hydrology including both the amount and timing of water flowing into coastal systems as well as the pathways of flow within the systems is indeed to maintain and restore wetlands (Day *et al*., 1995 [6]). In conclusion, the appropriate hydrological restoration should be constructed in the right time and right place with the right amount.

3.2 Ecosystem Service

Ecosystem Services, which were defined as the direct and indirect contributions of ecosystems to human well-being by TEEB (The Economics of Ecosystems and Biodiversity Foundations) in 2010 [9], are the product of ecosystem and human energy (see figure 3.1) (Braat and de Groot, 2012 [10]). Wetlands, one of the ecosystems, provide up to 40% of global annual renewable ecosystem services although wetlands cover less than 3% of the area in the globe (Zedler, 2003 [11]). The salt pond wetland was indicated could provide the ecosystem services such as fiber, timber, and fuel related to the provisioning services, climate regulation, biological regulation, pollution control and detoxification related to the regulating

services, spiritual and personal feelings inspirational and aesthetic related to the cultural services, and nutrient cycling related to the supporting services (Millennium Ecosystem Assessment, 2005 [12]).

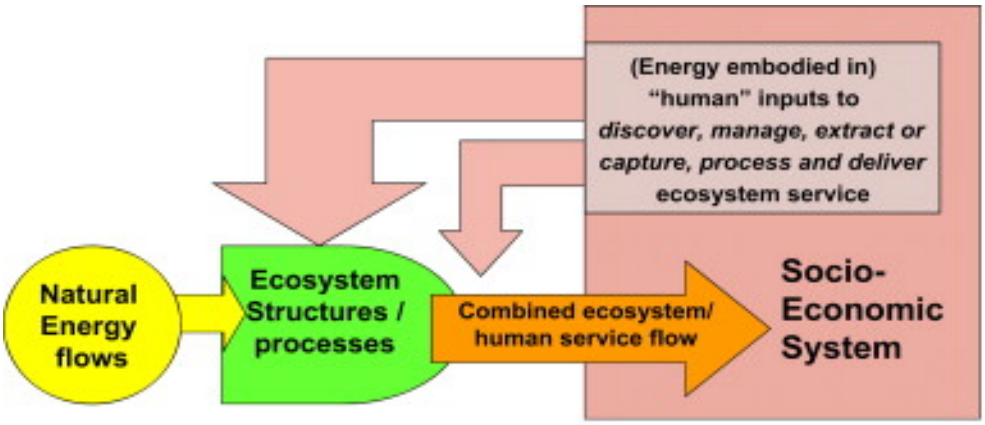

Figure 3.1 The concept of the ecosystem services (Braat and de Groot, 2012 [10])

For the ecosystem services assessment, nine major tasks, i.e. identifying and categorizing ecosystems and their attendant services, identifying links between services and human societies, identifying indirect and direct drivers, selecting indicators of ecosystem conditions, services, human well-being, and drivers, assessing historical trends and the current state of ecosystems and their services and drivers, evaluating impact on human well-being, developing scenarios, evaluating possible responses, and analyzing and communicating uncertainty, have been proposed in Millennium Ecosystem Assessment (2005 [13]) as shown in figure 3.2. However, there are many difficult issues such as the handling, data analysis, uses of modeling, scenario analysis should be solved. Hence, models, which can be used to analyze interactions among processes, fill data gaps, identify regions for priority data collection, and synthesize existing observations into appropriate indicators, play an integrative role and complement data collection and analysis (Millennium Ecosystem Assessment, 2005 [13]).

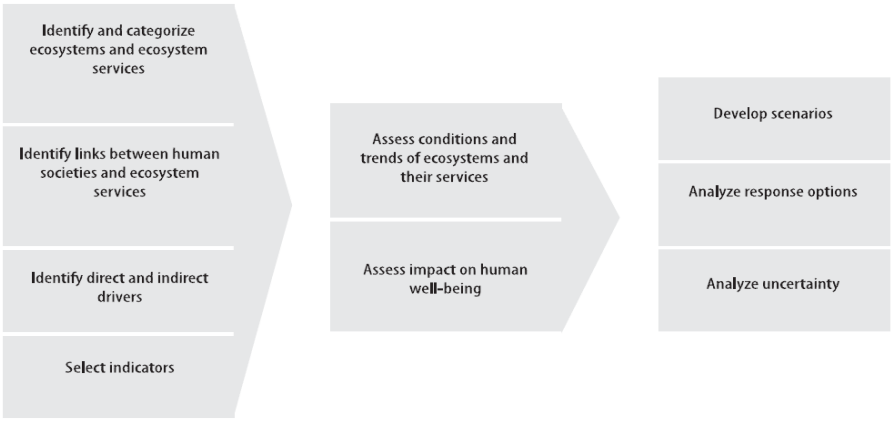

Figure 3.2 The analytical approach of the Millennium Ecosystem Assessment (excerpted from Millennium Ecosystem Assessment, 2005 [13])

The values of ecosystem services are associated with the significant service. There were wide techniques for the wetland ecosystem services valuation such as contingent valuation, damage cost approach, hedonic pricing, market-based, optimization models, replacement cost method and travel cost based on the overview of empirical studies. For the valuation of ecosystem services in wetlands, de Groot e*t al*. (2006 [14]) defined three main valuation components, ecological, socio-cultural, and economic, together to determine the total value of wetlands as shown in figure 3.3 and illustrated as following. Ecological valuation measures the role or importance of attributes or functions of a system to maintain ecosystem resilience and health (Bingham *et al.* 1995 [15]). Socio-cultural valuation tries to measure the moral assessments (Barry and Oelschlaeger, 1996 [16]). Economics valuation mainly measures the exchange value or price to maintain a system or its attributes (Bingham *et al*. 1995 [15]). The value of the ecosystem services provided by the wetlands is sought to fully be understand based on the valuation of the three main components.

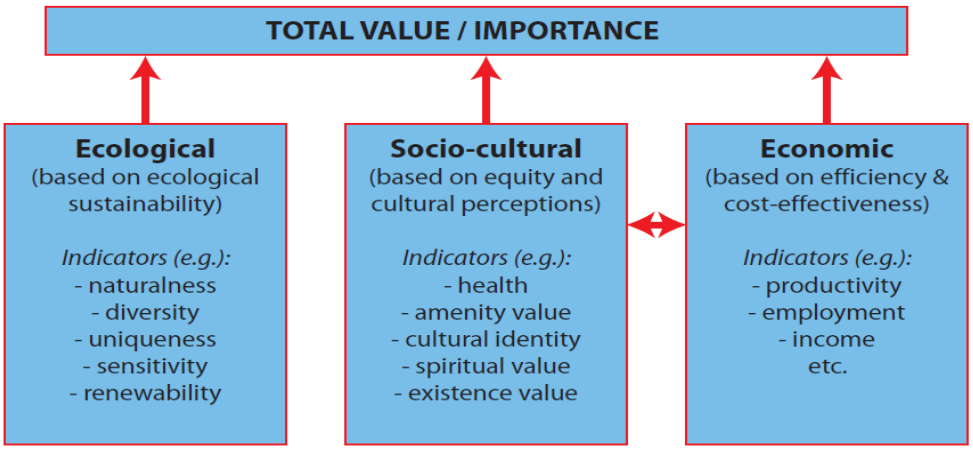

Figure 3.3 The components of the total value of a wetland
(excerpted from Groot *et al*., 2006 [14])

The literatures above provided the methodological framework for the ecosystem service evaluation. The ecosystem services under different hydrologic conditions for abandoned salt pond wetlands in the study thus will be assessed and evaluated based on the above frameworks.

（四）研究方法。

1.本計畫採用之研究方法與原因。

The study aimed at the evaluation of the ecosystem services for the abandoned salt pond wetlands under different hydrologic condition. Budai Salt Pond Wetland, one of the national important wetlands, was chosen as the study area. The field surveys for the hydrologic environment, hydraulic simulation, and water budget analysis were designed to understand

the hydrologic environment at the abandoned salt pond wetland. The scenario analysis under different management strategies, such as Do nothing, Future Plan, Inactive and Active Management, was considered because a well-designed hydrologic condition can help wise wetland management. The PHD (Physiographic Inundation Model) Model, and the LEDESS (Landscape Ecological Decision and Evaluation Support System) Model were applied to evaluate the ecosystem services.

4.1 Study Area

Budai Salt Pond Wetland, one of the national important wetlands was chosen as the study area (Figure 4.1). It is located in Chiayi County in southwestern Taiwan with the area of about 7.21 km^2 and is a typical low-lying coastal area within the elevations of -1.5 to -0.5 m meter (Wang, 2013 [17]). Moreover, the area is the severe land subsidence, with an estimated subsiding rate of 16 cm and 3 cm per year in 1989 to 1996 and the 2011 to 2012, respectively (Land Subsidence Database in Taiwan, 2013 [18]).

Figure 4.1 Location map of the study area, Budai Salt Pond Wetland. It is surrounded by Tsan-Liao Drainage to the north, Long-Kung River to the south and Taiwan Strait to the west There are five water gates set around the study area and provide the intermittent flows to the area. (Source of the map: Google earth, 2008).

The study area was transformed to salt pond in 1987 to support salt making industry. In 2001, Taiwan Salt Company ended the operation due to the cost consideration. Nowadays, it is a historical sight and the critical habitat for the migratory birds such as black-face spoonbill (Ueng, 2007 [2]) However, the inflow water relies only on precipitation and intermittent flows from the water gates around the area and the area has been suffering inappropriate water management resulting in frequent droughts in dry season, and degrading habitat. In flood periods, the flooding problem is serious due to land subsidence and thus leads the increasing flood risks on both human being and ecological environment.

4.2 Hydrologic Environment Analysis

4.2.1 Field Survey

The field surveys including the topography survey, water depth monitoring, and the survey of the habitat utilization for birds habitat was designed in the study to provide the background of the hydrologic environment in the study area. The illustrations of the surveys are shown in Table 4.1.

Table 4.1 The Illustrations of the Field Surveys

Item	**Purpose**	**Frequency**
Topography	To analysis and simulate the flow direction.	once
Water Depth (seasonally)	To understand the current hydrologic environment.	once per month
Water Depth (Flood)	To track the progress of the changes on water depth after the flood.	once per week after the flood events
Water Depth (Gate Operation)	To understand the opportunity for managing Budai Salt Pond Wetland. To collect the data for verification the results in the hydrological simulation.	twice
Survey of the Habitat Utilization	To understand the utilization of the habitat such as the habitat type and water depth demands for the birds.	once per season

4.2.2 Hydraulic Simulation

PHD model, a physical-process based quasi two-dimensional flow model developed by Chen *et al*. (2007 [19]), was employed to simulate the water depth under different hydrologic condition and spatial design. The physiographical factors, hydraulic facilities, land use, digital elevation model, transportation system and water system, are required to discretize computational cells. In addition, a recorded or deign rainfall hyetograph is needed to estimate the effective rainfall at each cell, which initiating the surface runoff processes. The sea level along the coastal areas, which comprises integrated effects of astronomical tide and storm surge, is the downstream boundary. The water stage of each cell in the lowland area under various hydrologic conditions is then determined by the proposed PHD model. The framework of PHD model is shown as Figure 4.2.

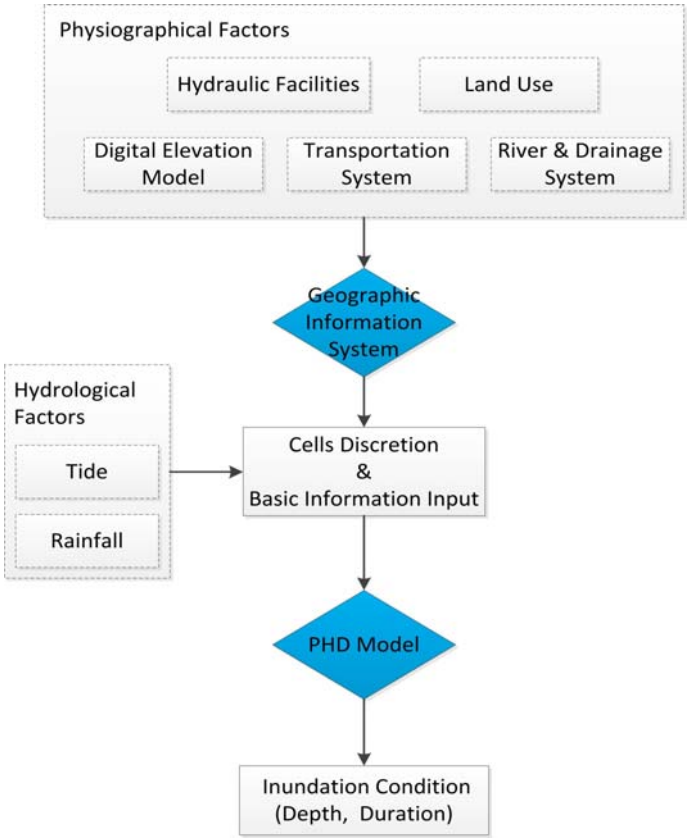

Fig. 4.2. The framework of PHD model

4.2.3 Water Budget Analysis

The analysis of the water budget in different timing under different initial condition could support to understand the hydrological process in different timing. Water budget is based on the water balance as shown in Equation 4.1. Because the soil in the abandoned salt pond wetlands is clay within high salinity, the vegetation is lack. Besides, the clay plays the role of waterproof. Hence, the influence of groundwater was ignored in the study. The equation of the water balance at the abandoned salt pond wetlands thus was modified as the Equation 4.2

Sum of input = Sum of output+ Change in storage

$$(P_{net} + Q_{in} + G_{in}) = (E + Q_{out} + G_{out} + \Delta S) \quad \text{(Equation 4.1)}$$

$$(P_{net} + Q_{in}) = (E + Q_{out} + I + \Delta S_w) \quad \text{(Equation 4.2)}$$

where,

P_{net}	:	net precipitation
Q_{in} & Q_{out}	:	the surface flows into and out of the elementary area
E	:	the evaporation
I	:	the infiltration
ΔS_w	:	the change in storage of water in the water surface

4.3 Ecological Response Analysis

In the study, the LEDESS Model was applied to evaluate the ecological responses under different scenarios. LEDESS Model, developed by Alterra Institute of Wageningen University, is a GIS based expert software and its mechanism is based on input the GIS maps of existing landscapes, proposed measures and relative expert knowledge rules on ecosystems and species involved (Eupen *et al*, 2002 [20]). There are three modules, Site Module, Vegetation Module, and Habitat Module, included in the LEDESS. Site Module is based on the physiotopes, which is relevant to the abiotic environmental characteristics. The Site Module can check the ecological consistency under different scenarios. Vegetation Module can simulate the expected vegetation structure under different scenario based on the abiotic site conditions and management according to relevant knowledge tables. Habitat Module can determine the suitable habitats for fauna populations based on the abiotical conditions, vegetation structure which is generated from Vegetation Module and habitat requirements. The framework of LEDESS model is shown as Figure 4.3.

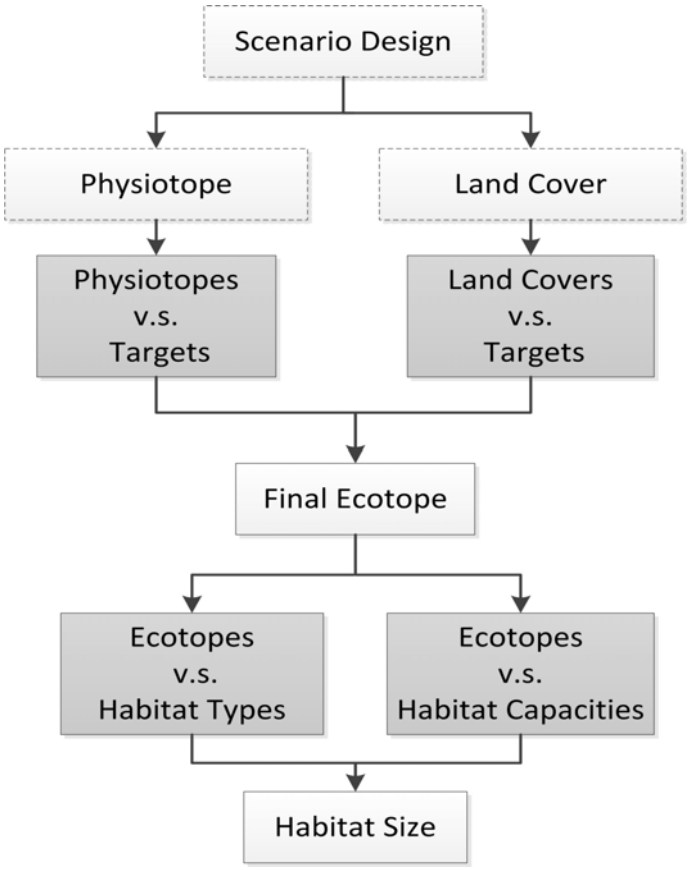

Fig. 4.3. The framework of LEDESS model

4.4 Scenario Design

Scenario analysis could support to seek the wise management of the hydrologic system for the abandoned salt pond wetlands in this study. The scenario design in the study included Do Nothing, Future Plan, Inactive and Active Management. Both situations in dry season, winter, and wet season, summer, were discussed under different scenarios for the safety and sustainable development concern.

Table 4.2 The Scenario Design. The scenario design considers different hydrologic conditions to seek the wise management for the hydrologic system of the abandoned salt pond wetland.

Strategies	**Purpose**
Do Nothing	To reflect the possible outcome on the ecosystem service based on the current landscape and hydrologic condition in dry season and wet season.
Future Plan	To consider the impacts on the hydrologic condition and ecosystem service under the policy of Taiwan's government such as the Country Comprehensive Development Plan and Regulation Project of Flood-Prone Areas.
Management	To consider the impacts on the hydrologic condition and ecosystem service under the inactive and active management such as the gate operation and the related experiences for the hydrologic management in wetlands such as the South Bay Salt Pond Restoration Project in USA and the experiences of the adaptive water management applied by Alterra, Wageningen University and Research Centre, the Netherland.

4.5 Ecosystem Service Evaluation

The ecosystem services assessment was follow the analytical approach of the Millennium Ecosystem Assessment (Figure 3.2) based on field survey, the interviews with the experts, managers, stakeholders, and decision makers in the study, hydrologic environment analysis, ecological response analysis and scenario design in the study (Table 4.3). Three main valuation components, ecological, socio-cultural, and economic were considered for the ecosystem services evaluation. The concept of the Land Use Functions (LUF's) framework (P'erez-Soba *et al*., 2008 [21]) and Paracchini *et al*., 2011 [22]) was applied in the study to quantify the value of the ecosystem services. According to the concept, the ecological, socio-cultural, and economic indicators that are used to evaluate the individual impacts on ecosystem services are the base. The multiple individual impacts are finally integrated into an overall value of ecosystem service on scenario to understand the ecosystem services under different hydrological conditions.

Table 4.3 The ecosystem services assessment in the study

Tasks	Methods
Identify and categorize ecosystems and ecosystem services	field survey and interviews
Identify links between human societies and ecosystem services	field survey and interviews
Identifying direct and indirect drivers	field survey and interviews
Selecting Indicators	field survey and interviews
Assess conditions and trends of ecosystems and their services	field survey and interviews
Assess impact on human well-being	field survey and interviews
Developing scenarios	scenario design
Analyze response options	hydrologic environment and ecological response analysis
Analyze uncertainty	hydrologic environment and ecological response analysis

2.遭遇之困難及解決途徑。

The main challenge in the study was how to evaluate the ecosystem services. During the visiting at Alterra, Wageningen UR, I had the discussion with Dr. Leon Braat, Senior Researcher International Biodiversity Policy at Alterra and the editor-in-chief of the journal, Ecosystem Services, to clarify the framework of the ecosystem service evaluation in the study. Besides, IR. Michiel van Eupean, the DLO researcher at Alterra, provided me the concept and the case study of the LUF's framework to quantify the value of the ecosystem services. Hence, the framework of the ecosystem service evaluation in the study was completed. However, the evaluation still relies on the widely ecological, socio-cultural, and economic database to complete it. I will do the literature reviews and the interviews to accomplish the research.

（五）結果與討論。

1. 已完成之工作項目。

The main works in the study include field surveys, hydraulic simulation, ecological response analysis and the ecosystem service evaluation. Among the works, the field surveys, PHD Model and LEDESS Model construction for the hydraulic simulation and ecological response analysis, respectively, were done already. However, the study is still ongoing because the ecosystem service evaluation still relies on the widely ecological, socio-cultural, and economic database to complete it. The progression of this study is illustrated in Table 5.1.

Table 5.1 The progression of this study

Item	What have been done	Ongoing work
Field Survey	All of the field surveys in the study were finished in the end of October in 2013. The completed surveys are as following. ● topography survey ● the survey of the habitat utilization ● the water depth monitoring	none
Hydraulic Simulation	The PHD model was constructed.	The model is verified and modified based on the data of the field surveys.
Ecological Response Analysis	The LEDESS model was constructed.	The model should be modified based on the ecological, socio-cultural, and economic indicators for the ecosystem services evaluation.
Ecosystem Service Evaluation	The framework of the ecosystem service evaluation was built during the visiting in Alterra, Wageningen University and Research Center.	● The interviews with the experts, managers, stakeholders, and decision makers in the study should be done to assess the ecosystem services. ● The database of ecological, socio-cultural, and economic indicators should be collected to evaluate the ecosystem services under different scenarios.

2. 對於台灣學術研究、國家發展及其他應用方面預期之貢獻。

Wetland restoration is a popular and valued issue around the world because the wetland loss is serious and the losing rate is still increasing rapidly. In Taiwan, the issue is also emphasized and thus the Wetland Act was legalized on June in 2013. However, the researches related to the wetland issues in Taiwan lack the discussion in the hydrological environment. The study focused on the wetland restoration in the hydrological point of view, hence the experiences in the study could guide future projects for wetland restoration. Besides, the findings obtained in this study can support the wise management of the hydrological system for the wetlands for the safety and sustainable development concern. Furthermore, the suggestions of the hydrological system management in the study could be applied in the other abandoned salt pond wetland in the south-western coastal area of Taiwan to build the ecological corridor.

3. 執行本計畫的訓練及心得。

I stayed in Alterra, Wageningen University and Research Center, the Netherlands on September in 2013 to do the project of international collaboration research. Alterra is part of the Wageningen University and Research Centre for the green living environment and the sustainable use of our living environment. The expertise areas at Alterra include Water resources & climate change, Spatial planning & ecology, and Green economy & biodiversity Soil, water & food security. During the stay at Alterra, I worked with Professor Henk Ritzema who worked on the adaptive water management and has the abounded experiences of the international cooperation. He shared me the experiences of agricultural water management in peri-urban areas including the topic of adaptation to climate change, flood risk management in the Netherlands, agribusiness parks & water management, restoring the river Rhine. The experiences could be the references and fundamentals for my further research related to the field of disaster prevention and sustainable development. I also participated the practical course of irrigation and water management. The methods of the infiltration measurement in the practical could be applied in my field works to conduct the volume of the infiltration to build the water budget in my study. Besides, I had the discussion with Dr. Leon Braat, Senior Researcher International Biodiversity Policy at Alterra and the editor-in-chief of the journal, Ecosystem Services, and IR. Michiel van Eupean, the DLO researcher at Alterra, to complete the framework of the ecosystem service evaluation in my study.

Because the researches and the practices related to the hydraulic engineering, disaster prevention and sustainable development in the Netherlands are worthy to learn, I also participate the related symposiums such as Environmental Sciences for a Sustainable World Symposium in Wageningen University and the PHD Symposium in UNESCO-IHE Institute for Water Education and visited waterstudio office during the stay in the Netherlands. The Sustainable World Symposium concerned the sustainable issues related to the spatial and social developments within the balance between people, profit and planet. The PHD symposium were focused on the issues of safe drinking water & sanitation, water-related hazards & climate change, water & ecosystem quality, water management & governance, water, food & energy security, and the information & knowledge systems. The symposiums really broadened my knowledge and provided me some ideas related to my research. Moreover, I got the valuable discussions with the experts and students during the symposium and built the connections for the further collaboration. For the visiting at waterstudio office, the architect, Koen, shared the concepts of the design and construction of the floating house. The memorable and valuable concept for me is that the floating houses are not only constructed in the coastal areas or the downstream areas within the open water but also can be applied in the flood-prone area to prevent the extreme events. The floating house thus could be a choice for the flood mitigation.

Finally and the most important, I appreciated Dr. Winston Chen support me the scholarship for the international collaboration at Alterra, Wageningen University and Research Center, the Netherlands. During the visiting, I solved the problems related to the ecosystem valuation in my study and learned the new concept and knowledge especially in the topic of the disaster prevention and sustainability. Without Dr. Chen's support, I cannot have the opportunity to gain the precious experiences of the research training and the international collaborative experience during the visiting in the Netherlands.

Table 5.1 The schedule and the records in the period of the international collaboration

Date	**Place**	**Purpose**
Sep. 2nd to 28th	Alterra, Wageningen University and Research Center	International Collaboration
Sep. 2nd	Alterra, Wageningen University and Research Center	Sustainable World Symposium
Sep. 20th	Waterstudio Office (http://waterstudio.nl/)	Visiting and Experiences Sharing
Sep. 23th	UNESCO-IHE Institute	PHD Symposium
Sep 28th to Oct 5th	Mardin, Turkey	1st World Irrigation Forum and the 64th IEC meeting of ICID




The practical of infiltration measurement in Alterra.

	
The visiting and experiences sharing with Koen in waterstudio office.	The participation of PHD Symposium in UNESCO-IHE Institute

4. 已完成之研究成果及績效（如期刊論文、研討會論文、專書、技術報告、專利或技術移轉等質與量之預期績效）。

Because the study is ongoing, the papers related to the research are in preparing.

5. 結論與建議

The study focused on the responses of ecosystem services under different hydrologic conditions at abandoned salt Pond wetlands. Except the ecosystem service evaluation which still relies on the widely ecological, socio-cultural, and economic database collection, most of the works including the field surveys, PHD Model and LEDESS Model construction for the hydraulic simulation and ecological response analysis, respectively, were done. The findings obtained in this study are expected to support the wise management of the hydrological system for the wetlands for the safety and sustainable development concern.

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成果報告自評表

學生：郭品含

系所：水利及海洋工程所

計畫名稱：鹽田濕地於不同水文環境下之生態服務系統

指導教授：王筱雯

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■ 達成目標

□ 未達成目標（請說明，以 100 字為限）

□ 實驗失敗

□ 因故實驗中斷

□ 其他原因

說明：本研究已於國際交流的期間，與相關學者進行討論，完成生態系統服務評估架構建立之目標，並達成合作協議，未來將持續進行學術上之合作與交流。

2. 研究成果在學術期刊發表或申請專利等情形：

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技轉：□已技轉 □洽談中 ■無

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說明：本研究還在進行中，因此相關之學術成果發表工作，尚在準備中。

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

說明：本研究為以環境永續發展為考量，以濕地水文環境管理為出發點，透過跨領域之整合研究，探討鹽田濕地於不同水文環境下之生態服務系統，以提供鹽田濕地一個考量濕地洪災管理及永續性之水文環境管理策略，達成濕地明智利用之目標。由於濕地復育為目前台灣及國際間受到重視之環境議題，然而卻少有以濕地水文環境為考量之研究，因此本研究在創新性及應用層面，都有其價值及重要性。