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CONSTRUCTION AND APPLICATION OF WATER RESOURCE ACCOUNTING INFORMATION SYSTEM IN TAIWAN

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ABSTRACT

Since the last decade, rapid industry growth and booming world population increase the demand of water resource which brings out severe problems on water supply. In the Global Risk Report 2015 published by the World Economic Forum, water resource was ranked the greatest risk to the world. Taiwan is in 18th place in the UN global ranking among water-scarce countries. However, Taiwan has not established an integrated water resource information system to provide useful information to policy-makers and resource users. Therefore, this study adopts the international conceptual framework for water accounting to construct a water resource accounting information system tallied with Taiwan's economic and policy conditions. The system is expected to provide useful information on water resource assets, liabilities, revenues and cost for economic sustainability. This study uses the case of Liyutan reservoir in Taiwan to illustrate the usefulness of the accounting information system which indicates new accounting research directions on water resource.

Contribution/Originality: The paper's primary contribution is constructing the first water resource accounting information system in Taiwan by using the theories and techniques of financial accounting, and verifies the feasibility of this study with actual cases. This system contributes a lot to sustainable use of regional water resources.

1. INTRODUCTION

According to the Global Risks Report released by World Economic Forum earlier this year, the risks associated with climate change are the top five risks for potential and material catastrophes for the five consecutive (GRR17 Report web, 2017). Therefore, extreme climate events and the ensuing natural disasters and agricultural losses should be presented as the external environment risk factors in relation to the financial situations of companies. At the end of 2015, the Financial Services Board (FSB) established the "Task Force on Climate-related Financial Disclosures" to devise the suggestions for climate-related financial risks disclosure in order to provide investors, financers, insurers and other stakeholders with reliable and relevant financial metrics and other relevant information (Final-TCFD-Technical-Supplemenf, 2017).

Water is the source of life. The risks in relation to the hydro environment are the major issue in the 21st century. Our world is now confronted with the complexity of water crises and challenges regarding water resources, environments, ecosystems, disasters and resources management (Yang, 2012). The production attributes

of water resources are the combined outcome of climate, rainfall, topology and surface structures, and hence are not consistent with the social and production activities recorded by traditional accounting. Currently, the key issue of water resource management lies in the difficulty of accurately calculating and disclosing water costs and other information. The main source of information in water management for governments around the world are the statistics on the website of United Nations Statistics Division (UNSD) and Eurostat (the statistical office of the European Union), as well as reports from research institutions in different countries. However, there are very few academic accounting studies on water. Most of the literature on environmental accounting focuses on the disclosure of corporate social responsibility. Very few papers examine the reporting and disclosing of water assets and environmental liability, or the definition, measurement, recording and reporting of environmental cost and income.

Currently, the tracking of water resources data in Taiwan is limited to the compilation of hydrologic statistics. The calculation of water costs comprises nothing more than the costs for operations and management. None of the input costs, maintenance costs and environmental costs for the development of water resources is included. Such information is not useful to water management and strategic planning. Meanwhile, this practice is not consistent with the international standards and trends in water resources management. Therefore, it is important to explore how to utilize the accounting information system to manage the finite water resources through a quantitative and holistic approach. The presentation of useful information regarding water resources, by applying accounting theories to the environmental factor, will be a new paradigm for policymakers.

This paper refers to the up-to-date international practices in water resources management, and uses the case of the Liyutan reservoir in Taiwan to illustrate how to establish a useful water accounting information system in Taiwan.

This paper is made for the following purposes:

1. The establishment of the accounting methodology for the hydro environment in Taiwan, in order to fill the gap between the current government statistics and real water resource data. The purpose is to construct a database for the water environment and systems so as to provide consistent, reliable and relevant water resources information.
2. The analysis and recording of water utilization and changes to effectively enhance water allocations and utilization efficiency. The goal is to catch up with international practices and provide a template for water resource policymakers.
3. The leverage of financial accounting and management techniques to offer useful and transparent information on the hydro environment. This allows for the accurate calculation of the economic value and real cost of water, as a key metric for decision makers and management authorities regarding the protection and sustainability of water resources.

2. LITERATURE REVIEW AND RESEARCH MODEL ESTABLISHMENT

Environmental accounting encompasses a massive scope. It covers all the natural resources (e.g. water, forests, land and minerals). Water environmental accounting is an important element of environment accounting. In fact, it is a branch of environmental accounting. Considering the effects of climate change and industrial pollution, it is necessary to construct a theory on water environmental accounting capable of estimating information relevant to the capital and materials of companies, in order to truthfully reflect, and effectively control, the hydro environment associated with corporates (Miao, 2007). It is hoped that these efforts can ensure the economic, social and environmental relevance of the information thus derived. Only the theoretic framework that serves companies and society can contribute to the market economy and encourage the development of accounting theories.

The structure of the United Nations' water environmental accounting stems from the System of National Accounts (SNA) passed in 1993. In 2003, the United Nations worked together with European Commission (EC), International Monetary Fund (IMF), Organization for Economic Co-operation and Development (OECD), and

World Bank by calling for all the scholars and experts in statistics, accounting, economics and environment studies to develop the accounting concept and structure of SNA. The purpose of this collectively developed framework of accounting is to present the information relevant to environments and the economy (United Nations, 2003) as the basis of the green national accounts for Taiwan. In 2005, the UNSD again invited all the water experts to develop the draft for the System of Environmental-Economic Accounting for Water (SEEA-Water). The SEEA-Water manual published by the UNSD in 2012 provides the conceptual structure for the organization and layout of hydro and economic information in a consistent and continuous manner. The system and structure for water environmental and economic accounting serves as the template for the interaction between the economic system and the environmental system (UNSD, 2012).

The European Union has come up with a detailed classification of water-related economic activities, including water-related activities for production accounts and non-production accounts, taxations on water extraction and water emissions, and subsidies for water-related activities. The monetary value in relation to water, pollution and emissions is then measured and exchanged. These economic activities include: (1) economic activities related to water; (2) distribution of water and recycling of waste water in the economic system; (3) recycling of water and water pollution in the economic system and the environment; (4) water extraction and release, water pollution and emissions, or the emission of economic activities related to the hydro environment.

The China Institute of Water Resources and Hydropower Research, National Bureau of Statistics and Renmin University of China modified the SEEA-Water accounting system for the hydro environment and economy published by the UNSD so as to ensure better applicability and practicability in China. The accounting framework specifically designed for the Chinese hydro environment consists of the following elements: (1) the calculation of the physical volume of water resources; (2) the calculation of water resources related to the amount of economic activity; (3) the structure of integrated water resources accounts. The calculated physical volume of water resources and water resources related to the amount of economic activity serves as the basis for the evaluation of the relationship between water resources and national accounting. This is followed by the calculation of water resources value, the costs associated with water resources depletion and hydro environmental degradation, as well as the study on policies and applications (Teng *et al.*, 2009).

While China and the European Union have formulated their accounting systems for hydro environmental information on the basis of the template created by UNSD for water resources reporting, all these efforts are still limited to policy frameworks, locking hydro accounting guidelines or operating procedures as of the present time. Up to now only Australia (where water resources are extremely scarce) in 2012 published the Exposure Draft of Australian Water Accounting Standard (ED AWAS), demanding that companies and the organizations involved in water resources transactions or management comply with these standards (Chen and Yang, 2015).

The Australian Bureau of Statistics (ABS) has been proactively revising the country's water accounting system since 1990. Based on the SEEA-Water framework developed by the United Nations, the Water Accounting Standards Board (WASB) is responsible for the formation of standards (Australian Bureau of Statistics, 2000). In October 2010, the WASB published its first consultation paper for the ED AWAS, constituting an important milestone for the formalization of water accounting standards. After two years of the trial, the Exposure Draft of Australian Water Accounting Standard 1, ED AWAS 1 was released in May 2012 (Auditing and Assurance Standards Board (AUASB) - Home, 2014).

ED AWAS is a set of general purpose standards for water accounting. It draws upon financial accounting experience and shares many similarities with extant finance and accounting systems. For instance, accounting reports contain both qualitative and quantitative information, cash basis and accrual basis, as well as double entries (Michae *et al.*, 2007). However, the characteristics of water result in many differences between water accounting and financial accounting. Water accounting information aims to empower users or stakeholders to evaluate and formulate water resources policies, while financial accounting information enables users to make economic

decisions. The unit in water accounting is capacities; whereas in financial accounting, it is monetary units. The capacities for water are often estimated or measured, given the uniqueness of water resources. On many occasions models are constructed with Big Data analytics.

In 1998, Taiwan began to advocate the preparation of green national accounts. In 2013, Taiwan referred to the System of Environmental and Economic Accounting 2012--Central Framework released by the United Nations in 2012, and reviewed and revised its own accounts accordingly. The structure contains the following elements:

(1) Environment asset account: mainly to reflect the material gains from the natural inputs of environment assets by companies and households via economic activities, excluding indirectly resultant non-material gains such as gains from water purification or ecosystem services;

(2) Directorate General of Budget, Accounting and Statistics, manufacturing, consumption and accumulation. Three categories include air pollution, water pollution and solid waste;

(3) Environmental transactions account: presentation of the transactions aiming to preserve and maintain the environment as part of the economic and environmental activities in monetary units. These accounts include the expenses for environmental protection and for resources management activities, the statistics from products and services departments, the environmental fees payable to the government, environmental subsidies and similar transfers, and permits for the use of environmental assets (Directorate General of Budget Accounting and Statistics, 2016).

While the hydro statistics provided by government agencies contains comprehensive information on hydrology and water consumption volumes, there is insufficient data granularity. For example, water consumption data is categorized by regions, and not by industries or sub-sectors (Chou, 2015). Green national accounts are compiled each year, but only the water assets account and water pollution account are available in the water resources segment. Data are primarily sourced from the frontline offices responsible for water resources management; however, a lack of consistent calibrations or standardized procedures among government organizations significantly undermines the accuracy of their reports. The statistics required for the water pollutions account comes from a wide range of sources, and yet there are no common rules or requirements. As a result, the data shown on green national accounts cannot serve as useful information for either the buyers or sellers of water resources; this is not conducive to the activities of water resources trading. Therefore, it is imperative to establish a framework for the environmental accounting of water resources in order to provide fair, consistent and accurate information for the strategic options determined by managers and decision makers.

By referring to the relevant literature on environmental accounting, this paper attempts to incorporate the existing theories of financial accounting, and modeling methodologies of environment, economy and society to develop a structure of the water environmental accounting system for Taiwan.

2.1. Elements and Assessment Criteria for Water Resources Environmental Accounting

The objective of water environment accounting is to provide useful accounting information regarding water environments to meet the decision-making purposes of users (Shen *et al.*, 2005). The key information on water resources include environmental protection policies, water inventories and flows, water quality changes, water pollution grades, water investment returns and environmental fees for water governance improvements. This study on water environmental accounting aims to assist government agencies in the creation of water accounting standards, calculations, measurements and fair presentations; this will enable the preparation of water-related financial reports that serve as an important tool for users to evaluate, understand and manage resource allocations.

Accounting elements should be categorized into groups based on transactions and other characteristics, so as to express the effects of the transactions and other matters (Chang, 2012). The elements to be measured in water environmental accounting include: water assets, water liabilities, net water assets, variances unexplainable,

environmental assets, environmental liabilities, environmental costs and environmental incomes. Water assets, water liabilities, net water assets and differences unexplainable are used for the measurement of water capacities (volumes). Environmental assets, environmental liabilities, environmental costs and environmental incomes are measured in monetary units. Below is a summary of the definitions of water accounting elements and the principles of estimates.

1. Water assets: The water assets owned by the reporting entity as of the statement date include surface water assets, groundwater assets, soil water assets and other water assets. The increase of water assets for the debit party indicates the decrease of water assets for the credit party, with the balance as the end of the period amount.

(1) Surface water assets: The surface water assets owned by the reporting entity as of the statement date include manmade reservoirs, lakes, rivers, snows and ice on the grounds, and water in glaciers (United Nations Statistics Division, 2012). Given the topological and climate factors in Taiwan, lakes can be classified within man-made reservoirs. The water melted from snow, ice, and glaciers is insufficient to be absorbed by the soils and contribute to the river flows; therefore, these items are not estimated or included within surface water assets.

(2) Groundwater assets: Groundwater assets include the water stored undergrounds (i.e. aquifers), soils or rock pores. Water buried in soils, rock pores, cracks and karsts is collectively known as groundwater. However, the scientific and engineering definitions of groundwater are more robust. Usually only the water contained in aquifers is called "groundwater assets". Such water is easily accessible, as it can naturally flow to the surface or can be pumped out (Tan, 2005). Estimating groundwater assets available for use is a daunting task and the existing technologies cannot fully capture the underground topology of aquifers. Up to now there have been no reference data regarding the groundwater assets available for use in Taiwan. The official statistics only covers the pumped water volumes from the registered wells in different cities and counties (approximately 6 billion cubic meters per annum) and the replenished volumes of underground water each year (approximately 5% of rainfall, or 4.4~5.7 billion cubic meters) (DGBAS, 2016). This paper sources the groundwater data published by the Directorate General of Budget, Accounting and Statistics via the website of the Water Resources Agency regarding the pumped and replenished groundwater volumes.

(3) Soil water assets: Soil water refers to the moisture in the upmost layer of soils, floating above the ground, or retained in rock pores. Soil water is a key parameter in meteorology and hydrology, as well as an important element of water cycles around the world. The seasonal coverage, buildups and melting belts are essential to the big picture of global water cycles. Soil water contents throughout Taiwan are currently not immediately obtainable via surface observations. While it is possible to acquire the most updated information on soil water contents by leveraging the cutting-edge remote sensing technology and extensive coverage of meteorological satellites (Chen, 2009) this is a very costly route for estimating soil water contents on a daily basis. This paper calculates the change of soil water contents by applying the equilibrium concept in water cycles. The water balance equation describes the relationship between the amount of water inflows and outflows in a region over a period of time (Iofin, 2015). It is expressed as follows:

Rainfalls = evaporatranspiration + streamflows +/- change in storage

This can be rearranged into the following:

Soil water contents (evaporatranspiration) = rainfalls - streamflows -/+ change in storage

(4) Items excluded from water resources assets include: (A) non-freshwater resources; (B) marine water and atmospheric water (UNSD, 2012).

2. Water liabilities: This paper defines water liabilities as the current liabilities incurred to the reporting entity as a result of past or ongoing events. The honoring of such obligations will cause a decrease in water resources or

an increase in water liabilities that can be faithfully quantified and expressed in terms of capacities. For instance, the carried forward amount following the declaration of distributions should be recognized as a water liability for the reporting entity. However, the physical flows amount will not be recognized. Water liabilities include the following items:

(1) Total water liabilities: Total water liabilities of the reporting entity on the statement date include the carried forwards (post declared distributions) and other water liabilities. The increase in water liabilities for the credit party indicates the decrease in water assets for the debit party, with the balance as the end of the period amount.

(2) Water liabilities - distribution declared: This refers to the expected distribution of water resources at the beginning of the period to water acquirers or customers. The declared distributions are an increase in water liabilities, via the estimated volumes obligated to be distributed in the future. At the end of the period, it is necessary to check against vouchers so as to measure the delta between actual water consumption and forecasted water consumption. The result can serve as a reference for water resources allocations.

(3) Water liabilities - allocation carry-over: This refers to the water supposedly to be distributed during the reporting period, but not yet delivered by the end of the reporting period and carried forward into the following reporting period. The allocation carry-over is a water liability, i.e. the actual water supplies less the planned water supplies. An increase in the obligatory supplies of water going forward is caused by past or current obligations.

(4) Other water liabilities: This refers to the existing obligations for the reporting entity. The honoring of obligations will cause a decrease in water assets or an increase in water liabilities. Other water liabilities are the liabilities outside the carry-over allocations.

3. Net water assets: This refers to the balance of water assets less water liabilities for the reporting entity. The source of net water assets may come from rainfalls. An increase in the net water asset for the credit party leads to a reduction in the net water assets of the debit party.
4. Differences unexplainable: The use of water assets may not incur financial costs, transactions or items. Water may be used via evaporation or osmosis. Therefore, differences unexplainable may result from the erroneous conditions hidden in the model. The evaporated or osmosed volumes will create data holes in the balance of water assets and liabilities or cause changes to water assets and liabilities. They should be presented in the statement for the change in water assets and liabilities and the measurement for physical water volumes.
5. Water environmental assets: This refers to the assets (e.g. equipment) required for environmental protection or maintenance. Such assets promise future economic income. Water environmental assets should be depreciated or amortized over their useful life. If the assets invested no longer carry economic income, they should be recognized as water environmental costs during the period.
6. Water environmental liabilities: This refers to legal obligations or constructive obligations relevant to the environment and meeting the definitions of liabilities. Environmental liabilities should be recognized during the period where the obligations arise. The timing and amount of recognition should be based on the probability of the occurrence of the liabilities. If the probability is high but it is not possible to reasonably estimate the amount, or the probability is simply there, the liabilities should be disclosed in the footnote as contingent. If the probability is low, there is no need to disclose or recognize contingent liabilities.
7. Water environmental costs: Environmental costs are incurred as a result of a responsible attitude. Organizations recognize environmental costs, voluntarily or as required, for the environmental impacts they create, for the environmental goals set in place or in compliance with regulations in effects (Chang, 2012). The presentation of environmental costs goes beyond monetary terms. As long as the information is

useful, the measurement units can be anything (such as water capacities or any units that can be described with texts). The calculation of water environmental costs involves complex issues in the development, operation and management of water resources infrastructure. In addition, there is a long list of considerations for water quality and pollution. After a review of the literature in Taiwan, this paper suggests the adoption of the conclusions from the paper published in 2004 "Water Costs in Taiwan: in the Context of Green Accounting" to simplify the calculation of environmental costs. The green cost during the construction of a reservoir is approximately 16% of the total investments. The green costs during the operation of the reservoir is 13~17% of the raw water cost per cubic meters (15% in this paper). These reference values are referred to as the basis for environmental costs in this paper (Huang, 2004).

8. Water environmental incomes: This refers to the gains from the treatment of water environmental pollution or investments in water resources assets during a period of time. Water environment incomes include direct incomes (e.g. government subsidies and grants) and indirect incomes (e.g. cost reductions, expense cuts and loss avoidance). Direct incomes can be promptly recognized; however, indirect incomes may not be recognized if the incomes are not specific or have been presented in other items.

2.2. Water Environmental Accounting Treatments

Water environmental accounting is a branch of accounting that registers and records all the economic, social and environmental activities related to water, in the form of transactions and items in the accounting information system. The impact (namely the value and volume of water) will be recognized with the following accounting treatments:

1. Volumes: The accounting treatment of water resource volumes is mainly about the recording of the inventories and flows of water resources. The outcome is the presentation of the information about the inventories and flows of water resources.
2. Values: The accounting treatment of water resources values is mainly about the recording of the achievements in water resources management, and the items associated with environmental activities in monetary terms. The outcome is the presentation of the information on the income statement and balance sheet of water resources accounting, as well as the basis for information recording or disclosure.

2.3. Water Environmental Accounting Reports

In the confirmation, measurement and recording of all the elements in water environmental accounting, this paper refers to the principles of AWAS and SEEA-Water, and constructs the Balance Sheet of Water Resources, the Statement of Change in Flows of Water Assets, the Balance Sheet for Water Environment Accounting and_Income Statement of Water Environmental Accounting by making modifications on the basis of the government system and hydrological and geographic specifics in Taiwan.

The balance sheet of water assets and liabilities and the statement of the change of water asset flows are the reports on the volumes of water; the balance sheet of water assets and liabilities and the statement of the change of water asset flows are the records of the values in water environmental accounting. The purpose is to present information in a fair, consistent, comparable, unambiguous and pervasive manner, and to prepare accounting reports so that it is easy to understand, compare and grasp the specifics. These statements present the information during the two consecutive reporting periods to facilitate comparisons. The reporting period is one year, the same as financial accounting, although the contents of the reports differ. Information on two consecutive periods is presented for comparability.

Water environmental accounting reports should present information in tables and charts, in order to enable users to readily understand and apply the information. Footnotes and comments should be made to supplement the

information relevant to the requirements of users. This paper suggests the additional disclosures in the reports of water environmental accounting, as follows.

1. Basic data, environmental protection policies and goals of the organization.
2. Laws and regulations regarding environmental protection.
3. Changes in water environmental policies and the impact of such changes.
4. Changes in water environmental accounting estimates and the impact of such changes.
5. Major damages to the hydro environment from the organization and the treatment/prevention measures taken during the reporting period.
6. Significant environmental investments and returns during the period.

While the water accounting framework in Australia quantitatively reports the inventory, flows and changes of water resources, it is lacking in the disclosure and the tally of the depletion of water resources, the destruction to the natural water environment, and the quality of water. Further studies and modifications are in order for Taiwan, given its serious water pollution and poor water and soil retentions. In order to construct a theoretic framework and system of water environmental accounting for Taiwan, this paper draws on the theory and methodology of the water accounting standards in Australia, the concepts advocated by UNSD on the integration of water environment and economic accounts, and adjusts where necessary depending on the water resources and geographic characteristics in Taiwan. The purpose is to provide a uniform measurement and template for the administrators and operators of water resources for the effective management of water resources.

3. SIMULATIONS AND APPLICATIONS OF AN INFORMATION SYSTEM FOR WATER RESOURCES AND ENVIRONMENTAL ACCOUNTING IN TAIWAN

Taiwan has not implemented a management system for water resources on the basis of river drainage basins; therefore, the management of water resources is handled by different groups and organizations. In other words, there is no centralization of water resources governance or common goals for all the parties involved. In Taiwan, water resources include reservoirs, ponds, river dams, underground water and soil water. To facilitate the establishment of the water environmental accounting system, this paper conducts a case study on Liyutan reservoir for the following three reasons:

(1) By the end of 2016, there were over 100 dams and reservoirs in Taiwan. The management information on dams and reservoirs is more comprehensive than other data resources. As the management of dams and reservoirs is the focus of water resources management in Taiwan, they are sufficiently representative.

(2) Liyutan reservoir is a large reservoir completed in 1993. Its data are more complete compared to Shihmen Reservoir and Zengwen Reservoir coming online before the 1960s.

(3) A new reservoir only operates to full capacity after a trial period (about 10 years) in order to ensure its operational safety.[1] Liyutan reservoir was completed 20 years ago. Its operational history is more indicative compared to other newer or smaller reservoirs.

The environment costs associated with the construction and operations of Liyutan reservoir are sourced from Water Costs in Taiwan (Huang, 2004) in the Context of Green Accounting, and summarized as follows:

The total construction cost for Phase 1 and Phase 2 of Liyutan reservoir was NT$ 15.43 billion (excluding the environmental cost of NT$ 12.88 billion during the construction period. The total environment cost during the construction period was NT$ 2.55 billion and NT$ 142.97 million for each year of operation. The environmental costs during the construction period should be capitalized over the useful life of the reservoir. The assets classification table published by the Directorate General of Budget, Accounting and Statistics, Executive Yuan,

[1]To ensure the safe operations, retention levels should be gradually increased each year for newly completed dams and reservoirs.

states that the useful life of a reservoir is 50 years. Hence, the environmental costs during the construction period should be depreciated over a period of 50 years. The environmental costs during each year of operation should be expensed.

3.1. Environmental Accounting Report for Liyutan Reservoir

This paper produced the environmental accounting report for Liyutan reservoir on the basis of relevant transactions and matters in 2015 and 2016. Four statements and relevant disclosures have been produced accordingly: (1) Balance Sheet of Water Resources (Table 1); (2) Statement of Change in Flows of Water Assets (Table 2); (3) Balance Sheet for Water Environment Accounting (Table 3); (4) Income Statement of Water Environmental Accounting for Liyutan reservoir (Table 4).

(1)Balance Sheet of Water Resources:

Table-1. Balance Sheet of Water Resources for Liyutan Reservoir

31st of Dec 2015 and 31st of Dec 2016
Unit: M³ million

	2015	2016
Total Water Assets	417.45	528.08
Surface Water Assets	348.45	446.18
Ground Water Assets	-	-
Soil Water Assets	69.00	81.90
Other Water Assets	-	-
Estimated Inflow of Water	360.00	360.00
Inflow Differences	57.45	168.08
Total Water Liabilities	387.76	525.06
Water Liabilities -Agricultural water	31.43	81.86
Water Liabilities -Industrial water	-	-
Water Liabilities -drinking water	257.25	270.70
Other Water Liabilities - Into the Ocean	30.08	90.60
Other Water Liabilities - Soil Evaporation	69.00	81.90
Estimated Outflow of Water	360.00	360.00
Outflow Differences	27.76	165.06
Can Not Explain the Difference	(2.28)	(2.35)
Net Water Assets Changes		
Beginning of Water Assets	61.71	89.12
End of period of Water Assets	89.12	89.79
Net Water Assets Changes	27.41	0.67

Source: 1. Data sourced from operational statistics for dams and reservoirs in Taiwan in 2015 and 2016.
2. The major source of water resources for dams and reservoirs is rainfalls from the catchment areas. Underground water is not a source of water for dams or reservoirs, and is only included when it comes to drainage basin management or regional administration (e.g. cities, counties or the country). In this paper, it is indicated with the symbol "-".

3.2. Statement of Change in Flows of Water Assets:

Table-2. Statement of Change in Flows of Water Assets for Liyutan Reservoir

1st of Jan 2015 ~ 31st of Dec 2016
Unit: M³ million

	2015	2016
Beginning water stock	61.71	89.12
Total Inflow of Water	417.45	528.08
Surface water inflow	348.45	446.18
Rainfall inflows	348.45	446.18
Other sources of inflows	-	-
Groundwater resources inflow	-	-
Soil water inflow	69.00	81.90
Total Outflow of Water	390.04	527.41
Provide downstream units of water		
The amount of water for each standard	288.68	352.56
Agricultural water consumption	31.43	81.86

Industrial water consumption	-	-
Domestic water consumption	257.25	270.70
Other water consumption	69.00	81.90
Environmental water consumption	-	-
Evaporation of water	69.00	81.90
Power generation water	-	-
Other water consumption	-	-
Invalid water volume	30.08	90.60
Flow into the sea	30.08	90.60
Other invalid water	-	-
Cannot explain the difference number	2.28	2.35
Net change in stock of water	27.41	0.67
The end of the water stock	89.12	89.79

Source: 1. Data sourced from operational statistics for dams and reservoirs in Taiwan in 2015 and 2016.
2. The major source of water resources for dams and reservoirs is rainfalls from the catchment areas. Underground water is not a source of water for dams or reservoirs, and is only included when it comes to drainage basin management or regional administration (e.g. cities, counties or the country). In this paper, it is indicated with the symbol "-".

3.3. Balance Sheet for Water Environment Accounting:

Table-3. Balance Sheet for Water Environment Accounting (Water Environmental Accounting section) for Liyutan Reservoir
31st of Dec 2015 and 31st of Dec 2016
Unit: NT$ million

	2015	2016
Water Environmental Assets		
Bank deposits or receivables	1.00	0
Water Environmental Assets - Land	381.84	381.84
Water Environmental Assets - Land Improvement	1,403.44	1,403.44
The cumulative depletion of environmental assets - land improvement	(645.58)	(673.65)
Water Environmental Assets - Equipment	92.76	92.76
The cumulative depletion of environmental assets - equipment	(42.67)	(44.52)
Water Environmental Assets - Others	671.56	671.56
The cumulative depletion of environmental assets - others	(308.92)	(322.35)
Total	1,553.43	1,509.08
Water Environmental Liabilities		
Accrued Water environmental liabilities - Number of realization	212.32	209.73
Accrued water environmental liabilities - Contingent	5.00	20.00
Accrued Water environmental liabilities - others	-	-
Total	217.32	229.73
Water environmental rights and interests		
Water Environment Capital	2,549.60	2,549.60
Water environment accumulated losses	(1,213.49)	(1,270.25)
Total	1,336.11	1,279.35
Total Liabilities and Equity	1,553.43	1,509.08

3.4. Income Statement of Water Environmental Accounting:

Table-4. Income Statement of Water Environmental Accounting (Water Environmental Accounting section) for Liyutan Reservoir
1st of Jan 2015 ~ 31st of Dec 2016
Unit: NT$ million

	2015	2016
Sales of Water	228.96	270.70
Sales of Agricultural water	-	-
Sales of Industrial water	-	-
Sales of Domestic water	228.96	270.70
Costs of Water	(216.09)	(259.87)
Costs of Agricultural water	-	-
Costs of Industrial water	-	-
Costs of Domestic water	216.09	259.87

Gross Profit	12.87	10.83
Operation Expense	(5.15)	(5.41)
Operation Income	7.72	5.42
Add: Water Environmental Income	1.00	0
1. Water Environment Income - Direct		
2. Water Environmental Income - Bonuses	1.00	-
3. Water environment Income - subsidies (stickers)	-	-
4. Water Environmental Income - Others	-	-
Less: water Environmental Expenses	(217.33)	(229.73)
1. Water depletion Expenses	26.00	23.40
2. Water Environmental Expenses - governance costs	81.26	81.26
3. Water Environmental Expenses - to improve the process	61.71	61.71
4. Water Environmental Expenses - Amortization	43.36	43.36
5. Water Environmental Expenses - Others	5.00	20.00
After add Water Environmental Income and Expenses the Loss	(208.61)	(224.31)

Note-1. The selling prices for the supply of water per cubic meter in 2015 and 2016 were NT$ 0.89 and NT$ 1.00, respectively. The costs of sales per cubic meter were NT$0.84 and NT$0.84 in 2015 and 2016, respectively. The operating expense was NT$0.02 per cubic meter, as estimated on the basis of the Water Resources Operation Fund's financial statements for Liyutan reservoir in 2015 (Central Region Water Resources Office, 2016) and 2016 (CRWRO, 2017).
2. Water supplies for agriculture are free of charge. Therefore, the cost of sale and environmental expenses were ignored for this segment.

3.5. Disclosure in the Environmental Accounting Statements for Liyutan Reservoir

A.Basic data, environmental protection policies and goals of the organization (Liyutan Reservoir Webpages, 2017):

(a) Basic data of Liyutan reservoir: omitted.

(b) Environmental protection policies and goals:

(i) Review of the forestation plans for national forest lands and hills, increase in the incentives for forestation on mountain hills; encouragement of forestation and forest protection; enhancement of the conservation and management of hilly lands and water catchment basins;

(ii) Integrated management of water catchment basins by breaking away from the existing mold of budgeting and governance; comprehensive investigation and planning, appointment of tasks and responsibilities to achieve the equilibrium of sediments in the water catchment basins;

(iii) Proposal for the restrictions on logging and offering of reasonable compensation in environmentally sensitive areas such as ecological conservation zones, potential debris flow torrents and protective forests along river banks.

B. Laws and regulations regarding environmental protection (bridged):

(a) Water Act and Enforcement Rules for Water Act;

(b) Regulations on Reservoir Area Management;

(c) Appropriation Ratio of Engineering Costs of Water Resources Development Plan for Afforestation Fund;

(d) Water Pollution Prevention and Control Law;

(e) Soil and Groundwater Pollution Remediation Act.

C. Change of water environmental policies and the impact of such changes: none.

D. Change of water environmental accounting estimates and the impact of such changes (simulations): In 2015, there were local protests against pollution from Liyutan reservoir, and residents demanded compensation of NT$ 50 million. A recognition of a token amount of contingent liabilities for NT$ 5 million was provided given a high probability of Liyutan reservoir winning the case in court; A conservative approach was taken to recognize a contingent liability of NT$ 20 million despite a relatively high probability of Liyutan reservoir winning the case in court, given the rising awareness in environmental protection and the sensational media report in 2015. As a result, the contingent liability in 2016 saw an increase of NT$ 20 million.

E. Major damages to the hydro environment from the organization and the treatment/prevention measures taken during the reporting period: enhancement of integrated management of water catchment basins and the avoidance of forest destruction, sediment and water pollution.

F. Significant environmental investments and returns during the period: CRWRO (2017)

(a) Maintenance of soil and water retention and improvement of drainage for the area surrounding the water catchment basin of Liyutan reservoir.

(b) Greenness and aesthetic improvement projects for the areas in proximity to the Liyutan reservoir.

(c) Maintenance and improvement of electric machinery and earthquake detection facilities for Liyutan reservoir.

4. ANALYSIS OF ENVIRONMENTAL ACCOUNTING REPORTS OF LIYUTAN RESERVOIR

4.1. Cost (Value) Analysis of Water:

The calculation of water is highly complex. More often than not, it is not possible to acquire accurate data. In fact, data collections alone may cost a fortune. The data variances are inevitable as a result of different locations and environmental information (UNSD, 2012).

Water is an essential necessity. Most governments subsidize water to ensure stable prices, by intentionally ignoring the costs in relation to the environment, the economy and society; however, this causes resource misallocations, policy biases and artificially low water prices. It is hoped that the water environment accounting and information system developed by this paper can provide accurate and useful information for the analysis of water costs, as well as a reference information users. Based on the Water Resources Operation Fund's financial statements for Liyutan reservoir, the costs of raw water in 2015 (CRWRO, 2016) and 2016 (CRWRO, 2017) were NT$ 0.84 and NT$ 0.96 per cubic meter, respectively.[2] However, this paper estimated that the true costs of raw water should be NT$ 2.68 and NT$ 2.76 per cubic meter, respectively, if costs to the environment, the economy and society, construction costs, and environmental costs during the construction period and in each year of operation are all taken into account. The delta of over 200% is a strong indication of underestimates of the true value of water given the current policy regarding water resources. The information derived under the existing system leads to a bias in government policies and decisions by consumers and information users. The analysis on water costs is show in Table 5.

Table-5. Costs of Raw Water Analysis of Water for Liyutan reservoir

Unit: M^3/NT

Item	2015	2016
Costs of Raw Water	0.84	0.96
Reservoir construction cost sharing*	1.00	0.95
Environmental cost sharing (environmental costs / water consumption of each subject)	0.84	0.85
Total cost of raw water after construction and environmental costs	2.68	2.76

4.2. Environmental Costs Analysis of Water

The water environment accounting and information system aims to provide the managers of water resources and the users of environmental accounting reports with useful information for an understanding of the strain on water resources as a result of our water consumption, and hopefully encourage the effective supply of water, as well as accurate estimates of water cost and pricing. Table 6 shows the analysis of water information based on the accounting report generated from the framework of water environmental accounting information created by this paper (CRWRO, 2017).

[2] Water companies classify their water resources costs into raw mater costs, water acquisition costs, water purification costs and water supply costs. Raw water costs are the cost of water paid to dams and reservoirs, i.e. the price paid by water companies to dam and reservoir operators. The total costs for water companies are the aggregation of raw water costs, water acquisition costs, water purification costs, water supply costs and operating expenses (including administration, financing, sewage treatments and water transmission pipes).

Table-6. Environmental costs analysis of Water for Liyutan reservoir

Item/Year	2015	2016
The environmental costs during the construction period account for approximately of the total construction costs	16.53%	16.53%
Environmental expenses for the operations per annum of the total construction costs	0.93%	0.93%
Environmental costs during the operation of the total cost of the environment ratio	65.79%	62.24%
Environmental assets (net of depreciation) to total assets ratio	10.07%	9.78%
5. Environmental liabilities as a percentage of total assets	1.41%	1.49%
6. Environmental costs in the total operating income ratio	94.92%	84.87%
7. Operating costs excluding environmental costs as operating income ratio	3.37%	2.00%

The analysis suggests the following:

(1) The environmental costs during the construction period account for approximately 16.53% of the total construction costs. This is a significant portion of the development costs.

(2) Environmental expenses for the operations per annum are 0.93% of the total construction costs.

(3) The environmental expenses during the operational periods of 2015 and 2016 accounted for 65.79% and 62.24%, respectively, indicating that the environmental costs for operations are more important than those for construction. In short, about 1/3 of the environmental costs during the year should be allocated to construction and 2/3 to operations.

(4) The environmental assets, net of depreciation, are approximately 10% of the total environment assets. This ratio will further go down due to continued depreciation.

(5) The environmental liabilities per annum are about 1.5% of the total assets. This ratio for Liyutan reservoir is relatively high compared to other companies.

(6) Environmental costs are about 90% of the total revenues.

(7) The operating margins (excluding environmental expenses) in 2015 and 2016 were 3.37% and 2%, respectively. Given the low pricing of water resources and, if environmental expenses are taken into account, the operating margins would have been negative 91.57% and 82.87% in 2015 and 2016, respectively.

5. CONCLUSION AND SUGGESTIONS

We are facing climate change and challenging resources sustainability; it is essential for the governments around the world to establish a water resources environmental accounting and information system. It is a discipline that combines accounting theories and further research on water environmental management.

This paper refers to the water accounting standards in Australia and the water environmental accounting system developed by the United Nations, and takes into consideration the specific geographic and climate conditions in Taiwan. The purpose is to develop a structure of the water environmental accounting system suitable to Taiwan by designing and constructing a theoretic framework for water environmental accounting in Taiwan based on the concepts of financial accounting and the theories of sustainable development. An example has been drawn by using the data on Liyutan reservoir. By following the structure developed for water environmental accounting and information, the water environmental accounts, statements and analyses for Liyutan reservoir have been prepared. This paper reaches the following conclusions:

1. This paper conducted a case study on Liyutan reservoir to demonstrate the theories and treatments of water environmental accounting suitable to Taiwan. This covers the deployment items, data sources and acquisition methods, the mechanism for data processing, recognition and recording, and the preparation of open and transparent water environment accounts. These efforts aim to provide consistent, reliable and useful environmental information about water resources in order to improve the traditional approach in water resources reporting and statistics.

2. This paper records the water environmental information in the accounting system, categories and processes transactions and various matters, so as to prepare the water environmental accounts. All these accounting reports are produced on the basis of accounting concepts in a detailed and accurate manner in compliance with both the AWAS and SEEA-Water principles. The users are able to access the water resources and environmental information consistent with international standards.
3. The main purpose of water environmental accounting is to protect the natural environment's water resources and ensure the sustainability of water resources. This paper adopts the management and control techniques of financial accounting in order to present useful and transparent information on the water environment, and to provide a reference for decision makers in the formation of water resources protection and development policies and strategies.
4. This paper prepared water environmental accounts and conducted an analysis accordingly. It is hoped that the research findings can serve as a template for the management and decision-making regarding water resources.

The objectives are as follows:

(1) to enhance the understanding and usability of water resources;

(2) to gauge the strain of human activities and water consumption on water resources; (3) to improve water utilization efficiency;

(4) to encourage effective water supplies; (5) to assist in the cost estimation and pricing of water resources.

A few research limitations and suggestions are provided as follows:

1. Water environmental accounting and information is a new research domain in Taiwan. In fact, this paper only makes a start by creating a conceptual framework. The pollution, emissions, and calculation of environmental costs are also important elements of the framework for water environmental accounting. Due to space limitations, this paper cannot go deeper. It means that follow-up studies should incorporate the calculations of pollution emissions and environmental costs. This will make water accounting theories more accurate, and water resources policymaking more transparent.
2. This paper finds that some statistics from government agencies are not sufficiently accurate and in fact sometimes conflict with each other. The government is advised to improve the collation of numbers and figures so as to create a precise database of water environment statistics. This will be valuable to future studies and information users.

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