Supplementary

S1. Experts in fields

Table S1. Experts in fields

Item	Fields	number
1	Sediment management	5
2	Flood control	7
3	River ecology	4
4	Water resources	7
5	Water quality	4
6	Social benefit	3
7	policy	6

Note: some experts have background in two fields.

S2. Lower and upper values of indicators

Table S2. literatures for lower and upper values of indicators

Sediment management	Water Resources Agency, Ministry of Economic Affairs. Reservoir Sediment Releasing Countermeasures Cope with Climate Change(1/2), **2010**.
	Water Resources Agency, Ministry of Economic Affairs. The 2009 Evaluation Study of the Sediment Deposition Potential for Taiwan's Reservoirs, **2010**.
	Graf, W.L.; Wohl, E.; Sinha, T.; Sabo, J.L. Sedimentation and sustainability of western american reservoirs. *Water Resour Res* **2010**, *46*.
	Halcrow. Sedimentation in Storage Reservoirs, Final Report to Department of the Environment, Transport and the Regions, **2001**.
	Atkinson, E. The feasibility of flushing sediment from reservoirs. **1996**. , HR Wallingford Report OD137.
	Thompson, H A., Pitt, K J Lewin, W P Longmire, Jr (1984). "Sclerosing cholangitis and histiocytosis X. " Gut **1984**; 25:526-530 doi:10.1136/gut.25.5.526.
Flood control	Water Resources Agency, Ministry of Economic Affairs. Enforcement Rules for Water Act, 2011, Article 139.
	Geng, L.H.; Liu, H.; Zhong, H.P.; Liu, C.S. Indicators and criteria for evaluation of healthy rivers [j]. *Journal of Hydraulic Engineering* **2006**, *3*, 253-258.
	Hsieh, C.L. Flood early warning model in real-time reservoir operation. Doctor Thesis. National Taiwan Ocean University, Keelung, Taiwan, **2010**.
River ecology	Ladson, A. R., White L.J., Doolan J.A., Finlayson B.L., Hart B.T., Lake P.S., and Tilleard J.W. Development and Testing of an Index of Stream Condition for Waterway Management in Australia. Freshwater Biology. **1999**, 41: 453-468.
	Ohio Environmental Protection Agency. 1989. Biological Criteria for the Protection of Aquatic Life
	United States Environmental Protection Agency，1989,Rapid Bioassessment Protocols
Water quality	https://www.epa.gov.tw
	Ouyang, C.H., Liao, S.L., Lin, K. C., Lian, Y. C., Methods of evaluation River pollution, Environmental Protection Agency, **1995**.
	Zhou, J. C., Wen, Q.G. Development of river water quality index in Taiwan, Master thesis, National Cheng-Kung University,1990.
	Weiss, S. J., Peppin, G., Ortiz, X., Ragsdale, C. & Test, S. T. Science **1985**, 227, 747-769.
Water resources	Water Resources Agency, Ministry of Economic Affairs. The assessment and computation of the indicators on sustainable development of water resources in Taiwan(in Chinese); Taipei, Taiwan, **2004**.
	Huang, W.C.; Chou, C.C. Risk-based drought early warning system in reservoir operation. Adv Water Resour **2008**, 31, 649-660.
	Water Resources Agency, Ministry of Economic Affairs. drought disaster planning (in Chinese); Taipei, Taiwan, **2008**.

S3. Weight Distribution Analysis Survey

"Integrated evaluation on the sustainability and decision-making support system of reservoirs" weight distribution analysis survey

Objectives

In recent years, natural causes and anthropogenic activities have collectively compromised the functionality of reservoirs in Taiwan, resurfacing the already precarious situation of water resources. Reservoirs, one of the main water supplying resources, account for the supply of one fourth of the total water consumption nationwide in Taiwan. They are indispensible in supporting economic development as well as promoting the conservation of ecological environment of downstream area. This leads to several concerns crucial to the future of water resources in Taiwan that need to be considered: are existing reservoirs able to supply water sustainably? Are the designs of new reservoirs in line with the sustainability agenda? While acknowledging the importance of these issues, there is much to be done, through quantitative evaluation index and analysis, to determine if reservoirs are able to support the goal of sustainability, and how existing and newly built reservoirs differ in terms of sustainability evaluation.

We envision a sustainable reservoir as "in its design and management, operate on a basin-to-basin basis, to fulfill the present and future social needs while maintaining the ideal condition of it surrounding ecology, environment and hydrology." It is necessary to take environmental protection, economic development and social justice into account when evaluating the sustainability of reservoirs. The analysis will be carried out focusing on regional sediment management, systemic flood control, river ecology conservation, regional distribution of water resources, maintaining optimal water quality, effectiveness and fairness. With these six focused areas comes twelve sub-areas as analytical indexes. To look into the complex relations of the competition, cooperation and dependency between these areas and indexes, we proposed, besides considering the overall model development, to also use ANP survey to engage diversified opinions from experts.

Index Definition

Table S3. Definitions of indices

Area	Evaluation index	Goal
Sediment management	Effective reservoir capacity	Calculate the reservoir volume availability and observe the volume changes to see deposit condition, function debilitation, and sediment removal.
	Sediment supply	By calculating the reservoir sediment-shifting rate, analyze if the sediment is provided steadily to maintain river and coastline intact, and be account for the deposit condition in reservoirs.
flood control	Flood reduction	To evaluate if the reservoirs are designed to lower inflow peak volume in terms of reservoir total volume and flood control mechanism
	Safe flooding flow	To evaluate if the downstream river is able to accommodate the outflow peak volume from reservoirs
River ecology	Ecological baseflow	To analyze the level of species diversity in catchment area, and predict water volume and quality trend in that area
	Change in *WUA*	To analyze habitat changes before reservoirs are

		built or after water is discharged and determine if reservoirs in upstream area discharge water properly and meet demands for ecological conservation.
Water quality	Eutrophication	To analyze total phosphorous and estimate possible eutrophication trend in reservoirs
	Water pollution	To analyze how water discharge from reservoirs influences the BOD level and SS in downstream river
Water resources Allocation	Water supply	To determine if the reservoirs supply as much water as designed
	Water allocation	To determine if reservoirs reasonably distribute water among targets, and if it is capable of providing water to other areas
Social Effectiveness and fairness	Social benefits	To analyze the efficiency of water used in different sectors (agriculture, industry, general use)
	Social fairness	To analyze water distribution by Gini index and evaluate the fairness among different users (agriculture, industry, general use) and time slots

II. Survey Instruction

There will be two dimensions, values or items in one question, each placed on one side. The numbers in between signify the relative importance between the two dimensions regarding to the survey question. While the "1" in the middle means you consider the two dimensions of equal importance or value, number closer to the right means you consider the dimension placed on the right side of relatively higher importance, and vice versa.

Example: From the question below, if you consider "environmental" more influential than "social" with a ratio of 5:1, mark the "5" on the left.

Environmental			Rate ratio						Social
	9	7	5	3	1	3	5	7	9
			✓						

When social dimension is the criterion and equality is taken into account, you consider "watershed residents acceptance" more important than "stability of water supply" with a ratio of 5:1, mark the "5" on the right.

Index				Rate ratio						Index
Stability of water supply	9	7	5	3	1	3	5	7	9	Watershed residents acceptance
							✓			

S4. Calculations of indicators

Table S4. Calculations of indicator C_2

Category	Indicator	Calculated Index
C_2	I_3 (%)	80.11 (49.61) * (**Table S5**)
	I_4 (%)	62.25 (13.5) * (**Table S6**)

Table S5. Effective reservoir capacity

Year	Without desilting		With desilting	
	Available capacity (10^4 m^3)	reservoir capacity ratio	Available capacity (10^4 m^3)	reservoir capacity ratio
1	6977.20	99.49%	6999.00	99.80%
10	6655.60	94.90%	6873.10	98.01%
20	6298.80	89.82%	6733.30	96.01%
30	5942.70	84.74%	6593.60	94.02%
40	5587.30	79.67%	6453.90	92.03%
50	5232.70	74.61%	6314.40	90.04%
60	4879.20	69.57%	6174.90	88.05%
70	4526.80	64.55%	6035.60	86.06%
80	4175.90	59.55%	5896.30	84.08%
90	3826.50	54.56%	5757.20	82.09%
100	3479.10	**49.61%***	5618.20	**80.11%***

Table S6. Sediment supply ratio

Year	Without desilting		With desilting	
	Sediment to downstream (10^4 m^3)	Sediment supply ratio	Sediment to downstream (10^4 m^3)	Sediment supply ratio
1	4.20	10.50%	26.00	65.00%
10	4.30	10.75%	26.00	65.00%
20	4.30	10.75%	26.00	65.00%
30	4.40	11.00%	26.00	65.00%
40	4.50	11.25%	26.00	65.00%
50	4.60	11.50%	26.00	65.00%
60	4.70	11.75%	26.10	65.25%
70	4.80	12.00%	26.10	65.25%
80	5.00	12.50%	26.10	65.25%
90	5.10	12.75%	26.10	65.25%
100	5.40	**13.50%***	26.10	**65.25%***

Table S7. Daily water supply volume estimates of reservoir operations (Unit: 10^4 Cubic meter)

Year	Reservoir runoff	Water for desilting	Available water	Release flow			ET	Overflow	Shortage	Days of shortage	Water storage
				Domestic	Agriculture	Baseflow					
1962	16,186	7,660	6,754	6,527	1,622	225	115	0	773	41	3,391
1963	8,862	1,835	5,438	6,859	1,381	239	106	0	441	24	1,865
1964	8,079	0	6,099	5,427	1,735	245	75	0	1,893	98	2,461
1965	13,057	3,470	7,654	6,487	1,740	240	113	0	813	42	3,516
1966	20,144	8,967	9,274	7,300	1,721	248	160	737	0	0	4,592
1967	11,303	0	9,053	7,300	1,998	253	179	803	0	0	5,363
1968	20,525	8,897	9,487	7,320	1,991	255	179	2,255	0	0	5,096
1969	12,217	1,480	8,767	7,300	1,730	255	173	1,379	0	0	5,011
1970	10,200	2,293	5,764	7,300	1,916	258	149	0	0	0	3,326
1971	13,115	3,439	7,906	7,255	1,565	250	125	0	45	3	3,852
1972	27,984	14,956	11,399	7,320	1,509	245	159	3,677	0	0	4,095
1973	15,167	5,920	7,176	7,300	1,944	215	147	0	0	0	3,824
1974	26,044	3,956	19,788	7,300	2,107	226	174	10,207	0	0	5,931
1975	16,849	1,998	12,525	7,300	2,102	254	188	5,711	0	0	5,257
1976	17,057	9,953	5,510	7,320	1,442	252	166	0	0	0	3,282
1977	22,515	5,199	15,233	7,300	1,914	231	163	6,142	0	0	4,909
1978	10,029	939	7,531	7,300	1,328	246	160	486	0	0	4,495
1979	14,446	3,984	9,014	7,300	1,274	220	155	1,662	0	0	4,392
1980	3,507	0	2,570	6,862	751	187	99	0	458	24	0
1981	17,995	10,275	5,897	4,023	1,673	244	69	0	3,277	164	1,805
1982	16,630	5,543	9,480	6,821	1,428	270	125	159	479	24	4,180
1983	13,334	1,607	10,114	7,300	1,345	271	182	2,619	0	0	4,193
1984	7,782	0	6,417	7,320	1,129	237	147	0	0	0	3,142
1985	19,625	2,442	15,360	7,300	1,624	216	161	6,265	0	0	4,777
1986	13,519	755	11,264	7,300	1,257	259	181	4,006	0	0	4,553
1987	16,334	3,083	11,616	7,300	1,454	225	171	3,310	0	0	5,388
1988	11,788	2,664	7,468	7,320	1,436	265	180	604	0	0	4,752
1989	11,487	1,120	8,759	7,300	1,375	247	168	1,349	0	0	4,695
1990	19,009	3,600	13,684	7,300	1,516	257	180	6,192	0	0	4,707
1991	13,729	887	11,062	7,300	1,525	256	173	3,240	0	0	5,056
1992	13,078	4,751	6,642	7,320	1,474	272	168	0	0	0	4,211
1993	2,819	0	1,978	6,096	606	235	92	0	1,204	62	0
1994	15,462	2,030	11,849	4,860	1,364	251	109	2,523	2,440	123	4,357
1995	6,668	0	5,476	7,300	960	232	147	0	0	0	2,385
1996	10,822	3,421	6,081	6,904	1,158	209	94	0	416	23	1,469
1997	19,053	5,304	11,933	6,428	1,592	271	131	1,938	872	45	4,905
1998	14,206	3,301	9,300	7,300	1,335	271	186	1,372	0	0	5,347
1999	18,866	2,504	14,411	7,300	1,749	248	187	7,296	0	0	4,975
2000	16,045	2,790	11,354	7,320	1,673	272	176	3,277	0	0	5,556
2001	25,731	9,220	14,532	7,300	1,811	267	190	7,740	0	0	4,858
2002	8,500	0	7,116	7,300	1,119	266	172	439	0	0	4,063
2003	12,564	1,674	9,363	7,300	1,275	269	166	915	0	0	5,045
2004	11,139	1,729	7,926	7,320	1,274	241	166	0	0	0	5,485
2005	22,528	10,790	9,957	7,300	1,590	256	185	3,132	0	0	4,826
2006	13,758	2,776	9,420	7,300	1,355	253	175	2,741	0	0	4,030
2007	18,970	2,803	14,356	7,300	1,614	228	160	5,265	0	0	5,660
Average	14,755	3,696	9,343	7,020	1,510	246	153	2,118	285	15	4,110

Note: ET: Evapotranspiration. Once the planned water supply is 20.0x10^4 Cubic meter/day (CMD), the shortage Index (SI)=1.0.

$$SI = \frac{100}{N} \times \sum_{i=1}^{N} \left(\frac{SA_i}{DA} \right)^2$$

where AS_i is water volume of shortage in ith year; and DA is the planned water supply.