Opinion

Agricultural water demand with its cost

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In Taiwan, we have the annual precipitation 2,504mm and it is corresponding to 9 billion cubic meters water. Because of the steep slope watershed with uncertain rainfall both on time and space, the effective water volume for good distribution on utilization for people's livelihood, industrial and agricultural demands will become trouble. In this article we just discuss on agricultural water demand with its cost, this cost is not including the raw water cost because it is another serious issue we will reinforce future. There 17 irrigation associations in Taiwan (Figure 1).

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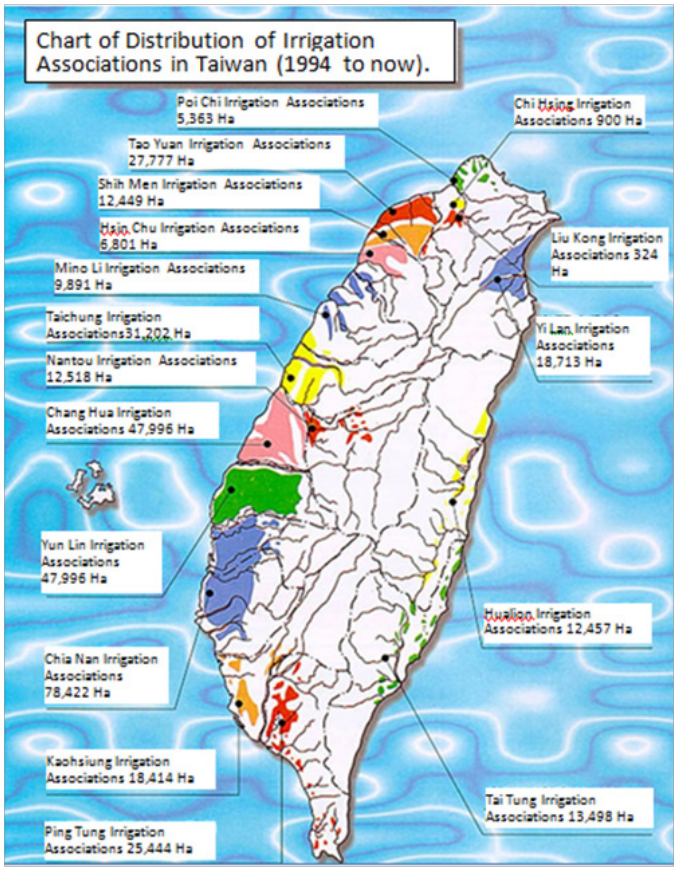

Figure 1 Chart of distribution of irrigation association in Taiwan (from 1994 to now).

The research results as in Table 1. In which data of the quantities of water consumption, rice production, pumping electricity fee and staff costs are supplied by government while else fee are collected from the real field data and analyzed based on the agricultural and economic methods.[1–5] Due to the steep terrain, the riverbed in Taiwan is greatly reduced. In the case of rain, the flash floods are soaring and flooding, and the drought is bottoming out. The lack of water is the only way to build a reservoir dam to achieve effective river management. Water, increase the use of water such as irrigation, power generation, industrial and public water supply, and combine flood control and disaster relief, increase agricultural production, and develop tourism. In the early years of Taiwan, there were reservoirs.

By 2010, there were 258 reservoirs and dams in Taiwan, with a total storage capacity of 2,130.7 million cubic meters and an effective capacity of 1,999.22million cubic meters], the largest in Zengwen Reservoir, with a total capacity of 71.27million cubic meters and an effective capacity of 475.55 million cubic meters. Others are located in the outlying islands, one in Taitung County, eight in Wuhu County, 13 in Jinmen County and seven in Lianjiang County (Figure 2).

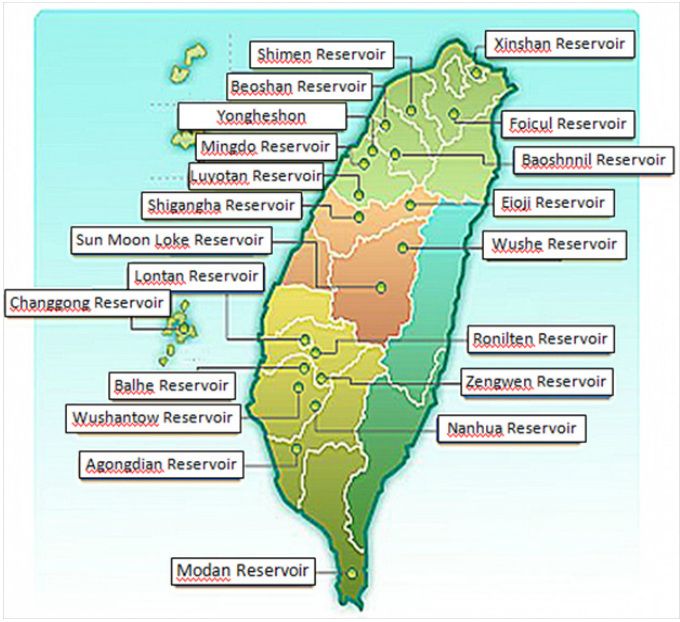

Figure 2 Reservoirs of Taiwan.

Taiwan reservoir management related units include the Water Resources Department of the Ministry of Economic Affairs (North, Central and Southern Water Resources Bureau), Taiwan Water Supply Company, Taiwan Power Company, Taipei City Government Taipei Jade Reservoir Administration, Miaoli County Farmland Water Conservancy Association, and Jianan County Farmland Water Conservancy Will wait for the unit, the jurisdiction of the Republic of China, Total water discharge from reservoirs includes consumable and non-consumptive water. Consumable water consumption includes irrigation, production and industrial water. In the whole year of 1990, the reservoir supplier counted 4.79billion cubic meters. Non-consumption water refers to power generation. Among them, the supply part of the reservoir is 9.48billion cubic meters. In the past

90 years, the water discharge of the reservoir was 11.9billion cubic meters. Because of the repeated use of the two, the total water discharge is not the sum of the two.

For analyzing the raw water cost (C), the effective volume (X) and the year of construction (T) of each reservoir will be the key factors. The regressing formula could be the form as following, and it is necessary to define the coefficients with the real data with statistics:

$$lnC = a + blnX + cln(T - 1911) \quad (1)$$

Referencing Figure 2 & Table 2, the coefficients of a, b, and c are:

a= -15.0211, b=0.8415, and c=4.00297 with $R^2 = 0.8114$

Here C: the annual Reservoir Cost in Million NT; X: the Annual Operation Water Volume of Reservoir; T: the Established Year of Reservoir. In Eq. (1) we can clearly see that the water resources has the time and space characteristics and it is limited. The later the building and the larger the scale, the higher the cost.

Table 1 First period rice harvest (March to June total 122 days) with its corresponding fundamental cost analysis for each irrigation association

Irrigation Association	Farming area(ha)	Water consumption (Tons)	Rice production (kgs)	Pumping electricity fee (USD/Ton)	Staff costs (USD/Ton)	Else fee (USD/Ton)	Total fee (USD/Ton)
Yilan	15,175	254,911,888	71,493,000	--	0.02	0.19	0.221
Pewichi	1,063	93,114,518	4,784,000	--	0.19	0.032	0.084
Taoyuan	22,645	2,089,897,863	107,807,000	--	0.017	0.026	0.077
Shihmen	10,516	731,551,594	41,097,000	--	0.018	0.025	0.079
Hsinchu	6,445	95,612,861	30,614,000	--	0.02	0.053	0.281
Miaoli	8,490	128,741,184	46,865,000	0.001	0.021	0.095	0.34
Taichung	29,249	5,398,536,269	150,632,000	--	0.017	0.02	0.055
Nantou	9,522	262,658,880	48,195,000	--	0.019	0.037	0.177
Changhua	37,308	414,189,274	211,677,000	--	0.022	0.063	0.417
Yunlin	25,108	179,253,389	135,585,000	0.005	0.036	0.153	0.685
Chianan	33,588	2,470,311,994	217,589,000	--	0.018	0.027	0.103
Kaoshiung	7,872	1,638,480,125	46,528,000	--	0.177	0.032	0.068
Pingtung	8,806	219,835,613	48,433,000	0.003	0.022	0.056	0.255
Taitung	4,716	264,831,999	22,165,000	--	0.019	0.037	0.11
Hualian	6,513	468,146,333	28,006,000	--	0.018	0.028	0.085
Chishing	860	58,891,882	4,386,000	--	0.021	0.182	0.252
Liukong	216	5,272,790	756,000	0.005	0.08	0.171	0.349

1. Rice Unit Cost(80$)□0.65 USD/kg
2. Staff costs=(annual fee) $\times(\frac{122}{365}) \div$ Water consumption
3. Else fee={(Pipeline depreciation fee)+(Pipeline equipment maintenance fee)+(Irrigation fee)+(Service fee)+(Research fee)+(fee of management)+(Miscellaneous)} $\times(\frac{122}{365}) \div$ Water consumption
4. Total fee={(Rice production) × 0.65} ÷ Water consumption + Pumping electricity fee+ Staff costs + Else fee.

□The mean agricultural water fundamental cost is 0.212USD/Ton with maximum value 0.685USD/Ton (Yunlin) and minimum value 0.055USD/Ton(Taichung), all the cost is without consideration of raw water cost, it means the civil engineering construction cost is not yet included.

Table 2 Unit primary water cost with different reservoirs or weirs in Taiwan

Name of reservoir (Weir)	Established year	Total cash (10 thousand NT$)		Annual cash (10 thousand NT$) (2)=(1)×9.55%	Annual water supply (3) (10 thousand tons)	Unit primary water cost (2)/(3) (NT$/Ton)	
		Cash of Established year	(1)Cash flow of 1991				
Shimen	1964	318,300	1,099,408	104,933	68,100	1.54	
Balhe	1965	22,852	82,791	7,906	2,745	2.88	
Mingdo	1970	21,735	71,727	6,850	3,329	2.06	
Zengwen	1973	603,842	1,281,172	122,352	73,049	1.67	
Xinshan	1979	24,690	30,221	2,886	542	5.32	
Fengshan	1984	83,000	89,267	8,525	15,431	0.55	
Yonghe	1984	126,000	135,513	12,941	6,826	1.9	
Beoshan	1985	63,000	69,048	6,594	1,665	3.96	
Ronilten	1987	156,000	166,717	15,921	4,278	3.72	
Foicul	1987	1,145,464	1,145,464	109,391	20,800	5.26	
Luyotan	1997	1,060,000	1,060,000	101,230	30,483	3.32	
Nanhua	1993	995,700	995,700	95,089	29,200	3.26	
Modan	1995	780,000	780,000	74,490	3,710	20.08	
Chichi (Weir)	1999	3,265,000	3,265,000	311,808	47,400	6.58	
Baoshnnil	1998	1,860,000	1,860,000	177,630	7,416	23.95	
Menueng	2001	5,330,000	5,330,000	509,015	40,600	12.54	*
Penlin	2001	4,980,000	4,980,000	475,590	34,100	13.95	*
Geinmin	2001	3,050,000	3,050,000	291,275	24,000	12.14	*
Coast Res.	2001	4,500,000	4,500,000	429,750	30,000	14.32	*
Da-ching (Weir)	2001	400,000	400,000	38,200	5,000	7.64	*
Kaoping Downstream (Weir)	1996	500,000	500,000	47,750	10,000	4.78	

* Planning 1USD=30NT$

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None.

Conflicts of interest

The author declares that there are no conflicts of interest.

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