Policy Analysis on Different Water Management Systems in China: Utilizing a CGE Model on Drought Simulation

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1. Introduction

The water management system plays an important role in coordinating water use and economic growth. However, the reform of the water management system in China is still in progress. Accordingly, competition for water among farming and industrial users as well as households becomes one of the key concerns in the context of the limited quantity of water under various water management systems. The key question is that which system is superior for agricultural production and rural households in the case of drought? This study will answer this question by utilizing a computable general equilibrium (CGE) model with different water management systems.

2. Water Parallel Pricing System and Water Pricing System

Water price in China is determined politically and by top-down administrative commands rather than by the market. The present pricing processes for irrigation water and pipe water are parallel due to the fragmented water management system, where the total supply of irrigation water is regulated by the government and that of pipe water is dependent on the pipe water production (namely, the water parallel pricing system, or WPP). However, this system caused significant price distortions between the irrigation water price and the pipe water price[1] (see Figure 1).

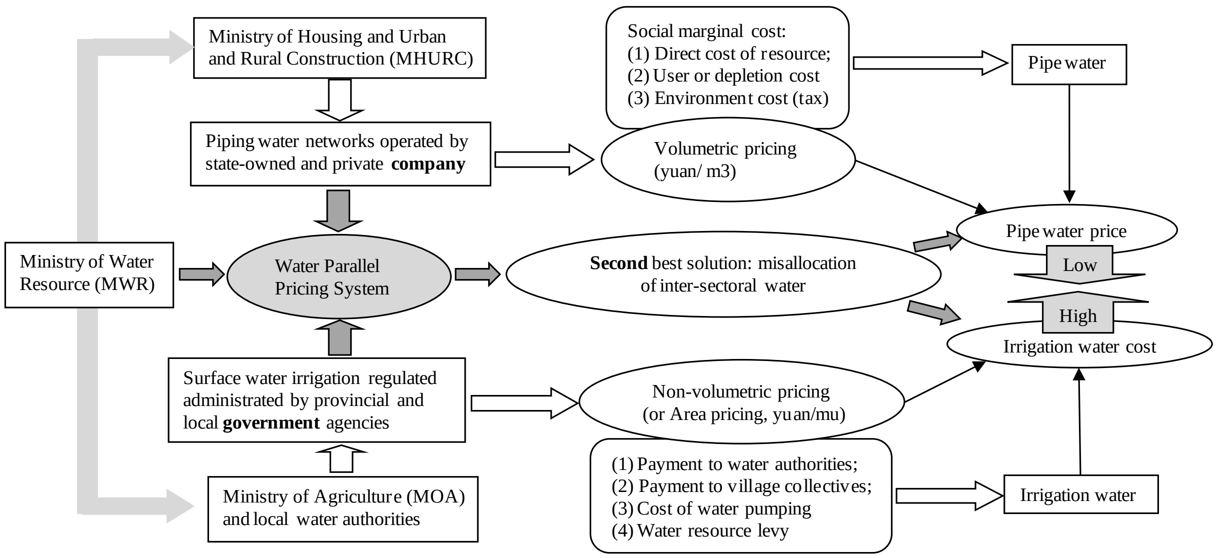


Figure 1 Fragmented water resource management and water parallel pricing system

Source: made by the authors according to the literature review.

China's integrated urban and rural water affairs management reform was planned to restructure the water management by setting up the Water Affairs Bureau (WAB) to incorporate part of all of the functions of resources management, service regulation and environment management, or re-designing

[1] The detailed discussion about water parallel pricing system can be found in Zhong, Okiyama and Tokunaga (2014a), Xie (2009) and Nitikin *et al*. 2012.

the functions of the current pricing system. And then a volumetric pricing reform should be promoted for both of irrigation water and pipe water such that both irrigation water and pipe water are priced according to their social marginal costs [1] (namely, the water pricing system, or WP, see Figure 2).

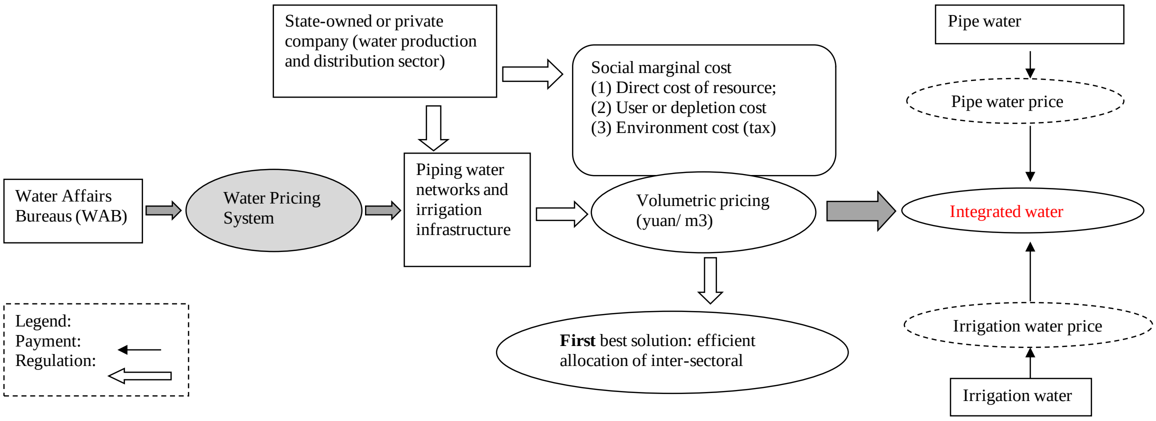


Figure 2 Reform to the integrated water management and water pricing system

Source: made by the authors according to the literature review

3. SAMs and SCGE models with Different Water Management Systems

Based on the literature review and a survey for rural households, we constructed two social accounting matrixes (SAM) with two different water management systems: a SAM with the water parallel pricing system (SAM-WPP) and a SAM with the water pricing system (SAM-WP). These two SAMs are used in three static CGE models: the SAM-WPP is for the model with water parallel pricing system (SCGE-WPP), where the subsidy is imposed on the irrigation water price; the SAM-WP is for other two models with the water pricing system under two cases: the system under current reform (SCGE-WP_A), where the subsidy is on the price of integrated water; and the system under further reform (SCGE-WP_B), where the subsidy is undertaken by the producer price of farming products.

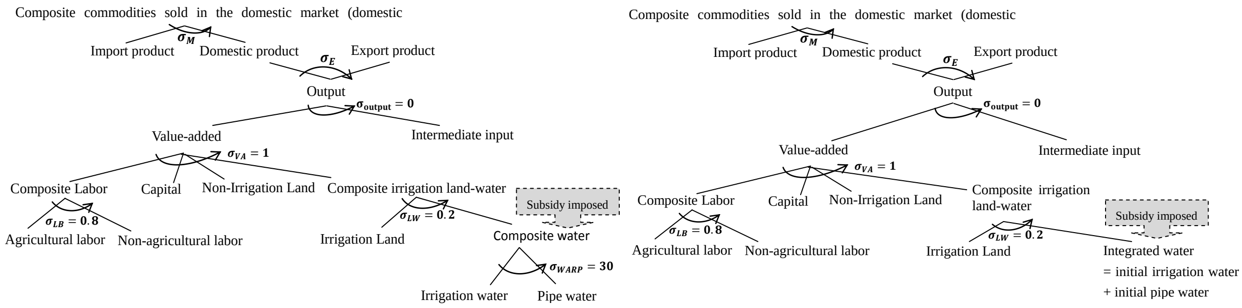


Figure 3 Nesting CES production structure of farming sectors in the SCGE-WPP and SCGE-WP_A

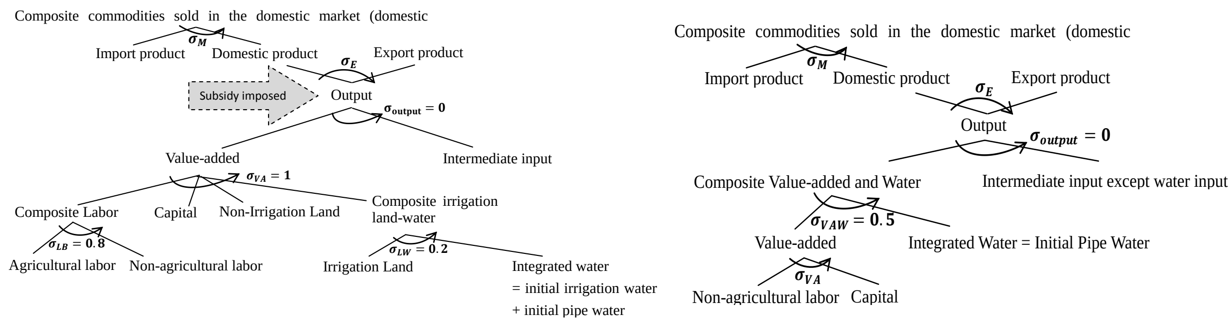


Figure 4 Nesting CES production structure of farming sectors in the SCGE-WP_B and other sectors

The production sectors are separated into two categories: i) farming sectors, which include paddy, wheat, corn, vegetable, fruit, oil seed, sugarcane, potato, sorghum and other crops(see Figure 3 and the left side of Figure 4); and ii) other sectors, which include the non-farming agricultural, industrial and service sectors (see the right side of Figure 4). The production function type is defined by the nested constant elasticity of substitution (CES) function. Moreover, in the CGE-WP_A and the CGE-WP_B for farming sectors, the values of integrated water are equal to the sum of the initial irrigation water and the initial pipe water; for other sectors, it is same as the initial pipe water.

4. Simulation Design and Results

In simulations, we fix the total water supply. In the water parallel pricing system, the total irrigation water supply is fixed by introducing the market clearing equation of irrigation water. In both the water parallel pricing system and the water pricing system, we fix the output of the water production sector (water supply), $\overline{XD}_{"WAP" \ or \ "WAT"}$: within the water parallel pricing system, it is the output of the pipe water production sector (*WAP*); within the water pricing system, it is the output of the integrated water production sector (*WAT*). For faming commodities, their outputs defined in these three models cannot be compared. Thus, the following analysis will focus on their domestic supply.

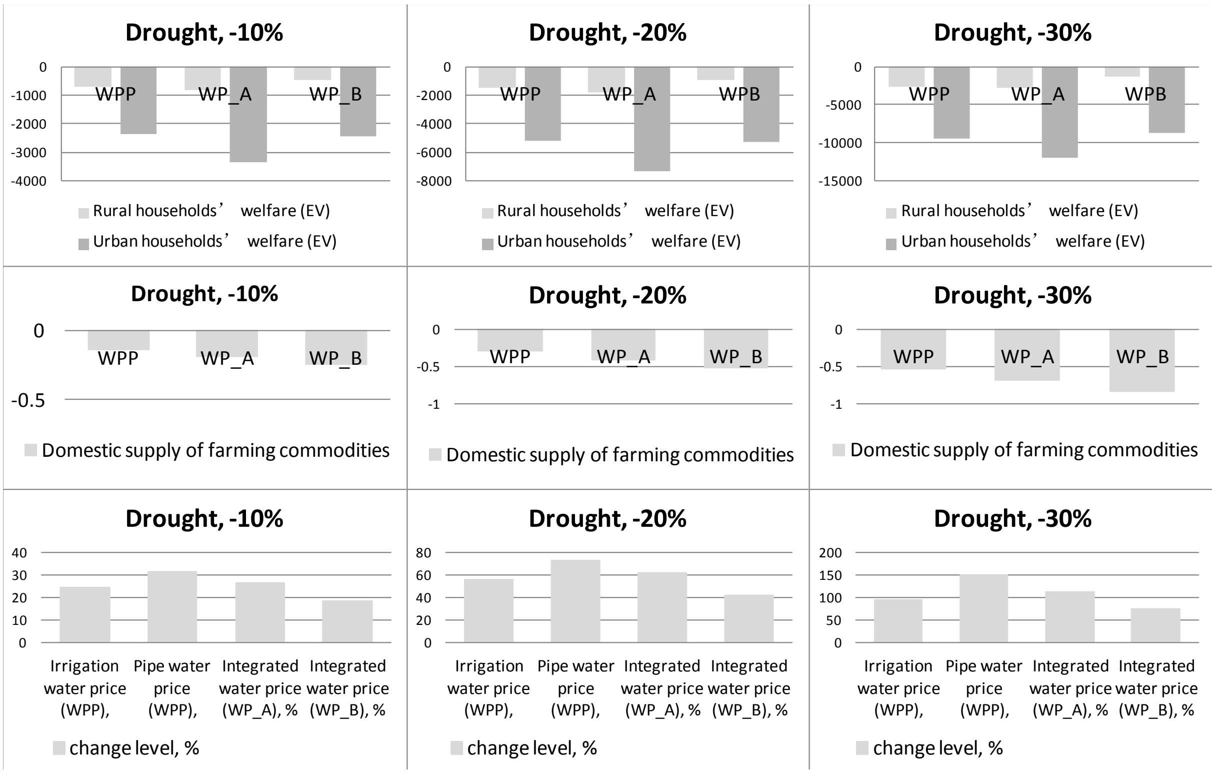


Figure 5 Results on households, farming commodities and the water prices

Source: derived from model simulations.

Figure 5 shows that the WPP is still better than the WP_B in protecting the domestic supply of farming commodities from the severe drought because the decline in this supply is less. However, the losses in welfare for rural households in the WPP are worse than those in the WP_B.

Table 1 Results of the Drought-30% on water distribution

Unit, %	WPP	WP_A	WP_B
Total water demand in farming sectors	-30.09	-33.25	-36.52
Total water demand in industrial sectors	-28.28	-28.12	-22.64
Total water demand in service sectors	-35.88	-31.62	-24.52
Total water consumption of households	-17.20	-15.60	-12.68
Total water supply	-30.00	-30.00	-30.00

Source: derived from model simulation.

Table 1 shows that the decline in the water demand of farming productions in the WP_B is lower than in the WPP and the WP_A, which is the reason for the more significant decreases in the domestic supply of farming commodities in the WP_B than in the WPP and the WP_A. However, households' water consumption decreases by 17.20% in the WPP, which is lower than that in the WP_A and the WP_B (where it decreases by 15.60% and 12.68%, respectively). Accordingly, the WP_B is the best option for households because it provides more water for consumption with the lowest increase in the water price. Moreover, the WP_A is the worst case for rural households because the loss of their welfare is worse than in the WPP and WP_B.

The flow charts for the impact of Drought on the WPP, WP_A and WP_B are shown in Figure 6, 7 and 8 respectively. These flow charts are focus on the total level of farming production and consumption rather than a specific crop. The story is similar but the changing level is different among these three systems. For example in WPP, Figure 6 shows that the domestic supply of farming commodities will be narrowed and their selling price would be higher in the case of a severe drought which decreased the total water supply. Accordingly, farmers must employs more capital, labor and non-irrigation land, and then the wage of non-agricultural labor and the returns of capital and non-irrigation land would be higher, which would increase households' income, especially rural households. However, higher income could not compensate for the losses in households' welfare.

For the simulation of the WP_A and WP_B as shown in Figure 7 and Figure 8, the irrigation water supply and the pipe water supply should be changed to the integrated water supply. In particular, the total imports of farming commodities increase in the WP_B but decrease in the WPP and the WP_A, which means that based on this system, it is more likely to increase the imports of farming commodities to protect households' welfare from the drought by relying on the highest increases in the price of farming products.

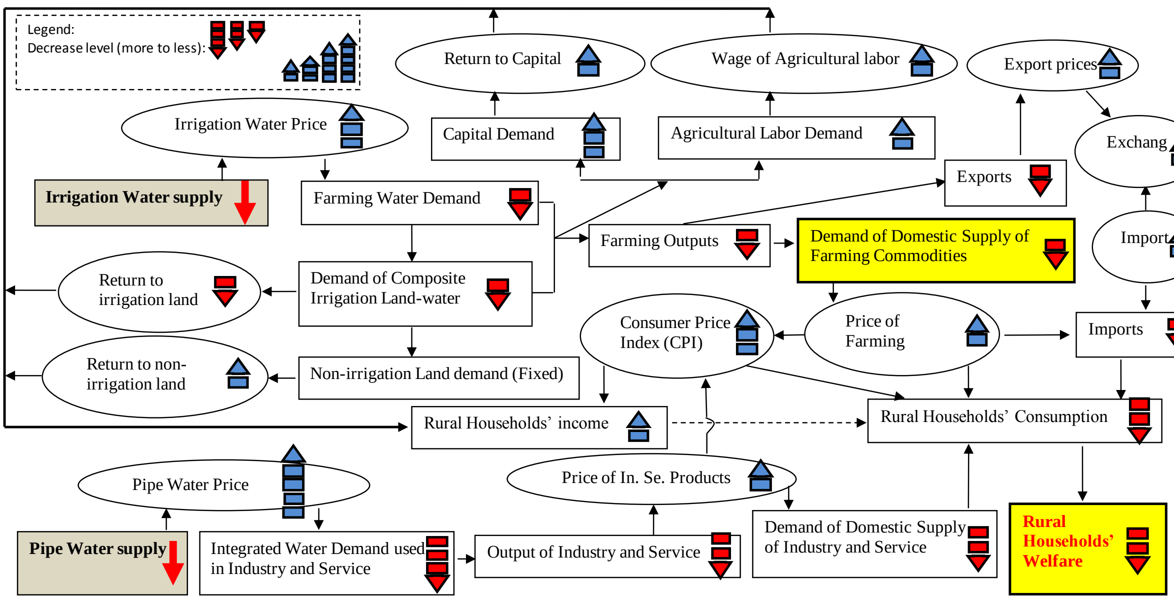


Figure 6 Flow chart of the impact of drought on the water parallel pricing system (WPP)

Source: constructed by author

Moreover, we can still find that the losses in the rural households' welfare in WP_B are less than in the WPP and the WP_A. That's because they benefit from highest increase in their income and less decrease in their consumption in the WP_B. Precisely, highest increase in their income in this system results from more significant increases in the returns of the capital and to non-irrigation land and in the wage of agricultural labor. The increases in the return and the wage in the WPP and the WP_A, however, are less; thus the decrease in their welfare will be more significantly.

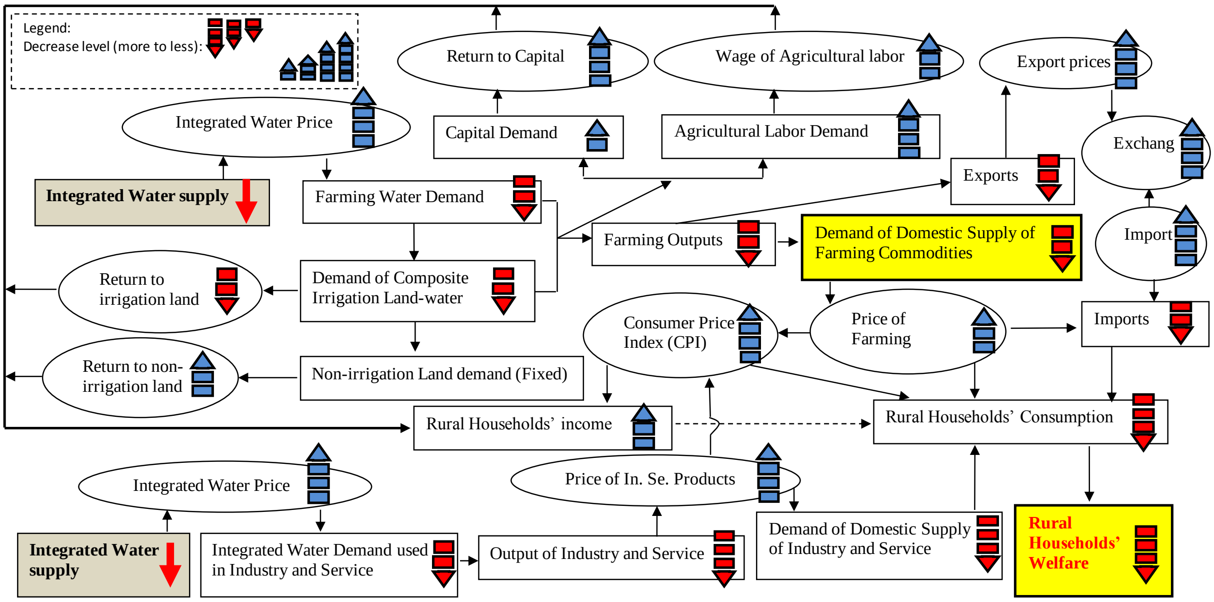


Figure 7 Flow chart of the impact of drought on the water pricing system under current reform (WP_A)

Source: constructed by author

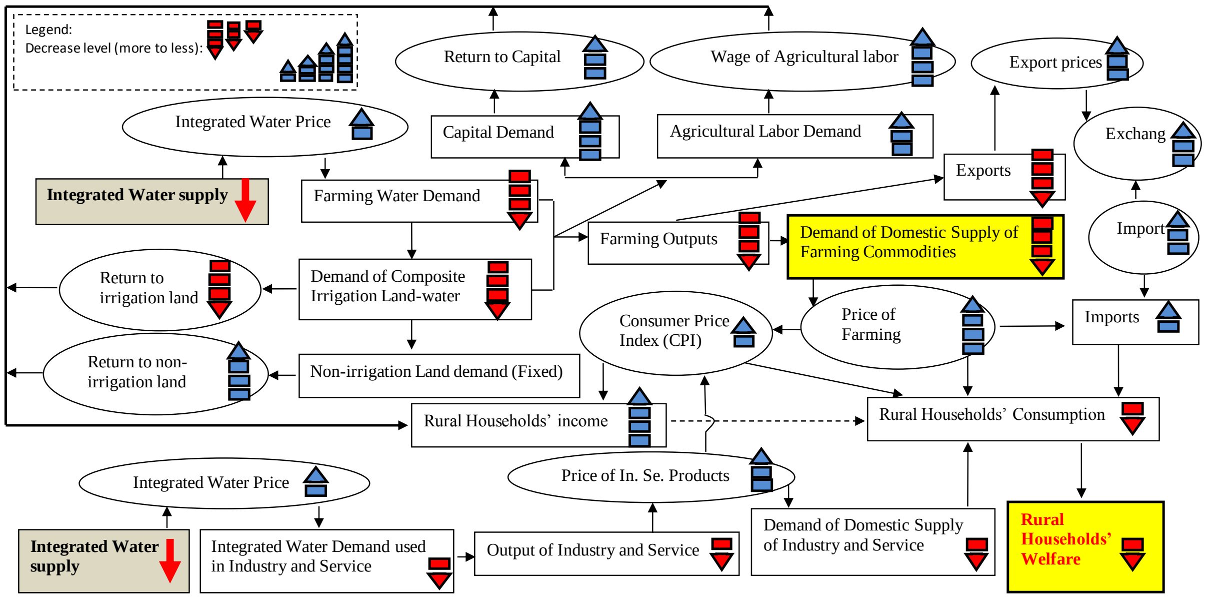


Figure 8 Flow chart of the impact of drought on the water pricing system under further reform (WP_B)

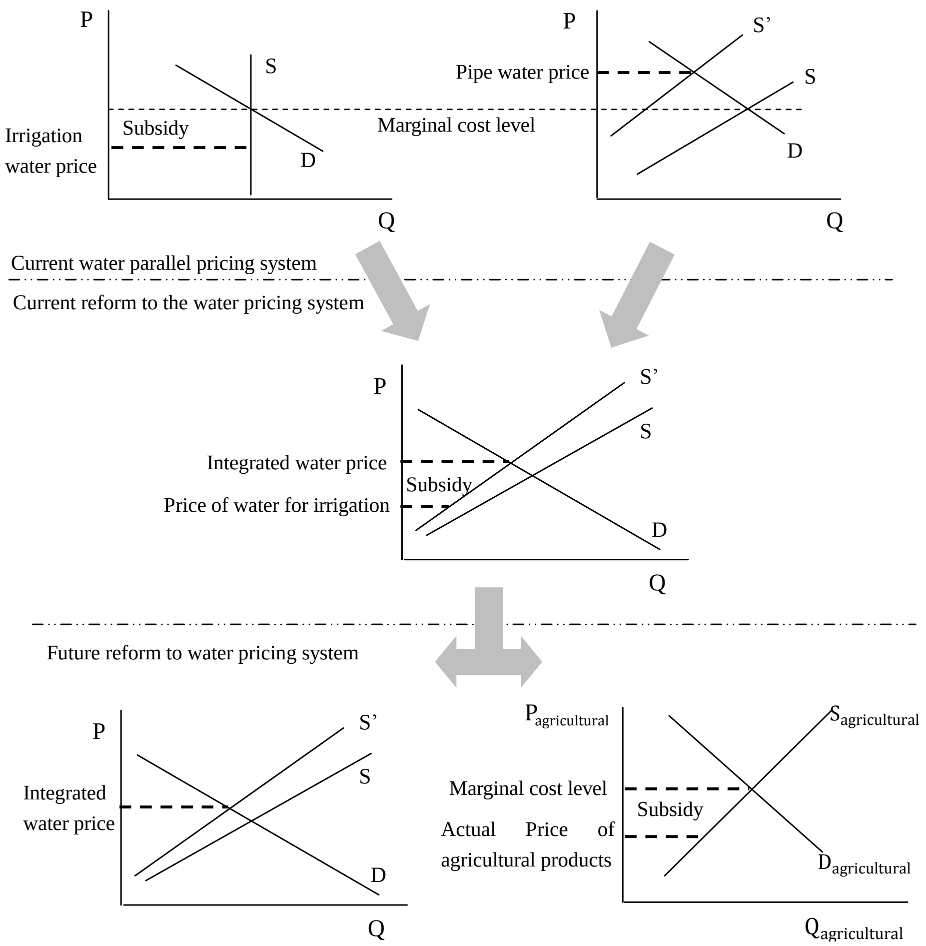
Source: constructed by author

5. Conclusion

Based on three SCGE models with different water management systems, the simulations aimed to select the superior policy option between the water parallel pricing system and the water pricing system when a severe drought occurs. The results showed that the domestic supply of farming commodities would be decreased and then their selling price would be raised. Accordingly, farmers the demand for labor, capital, and non-irrigation land would be increased, and thus the wage of agricultural labor and the returns of capital and non-irrigation land would be higher, that would increase households' income, especially for rural households, while higher income could not compensate for the losses in households' welfare. Furthermore, the water pricing system under the case of further reform was better for rural households. This was because households in this system would benefit from a higher increase in income and less decrease in consumption. However, the decrease in the farming water demand was more significant, and thus the decline in the domestic supply of farming commodities was more severe. In addition, water users in this system would benefit from the lowest increase in the water price.

Endnote:

[1]: In the current water parallel pricing system, the supply curve of irrigation water is depicted in the right side of the upper half of the following figure as a vertical line, and the irrigation price is determined by the government, which involves the subsidy. The right side of the upper half of the following figure shows the determination of the pipe water price, where the pipe water price is higher than the marginal cost and equal to the social marginal cost when the environment cost is included. In the current reform of the water pricing system (see the middle part of the following figure), the integrated water price contains both the irrigation water price and the pipe water price, which means that both irrigation water and pipe water will be priced with the volumetric method. Thus, their prices will be equal their social marginal costs, and the price of water for irrigation will still contain a subsidy to protect the agriculture and farmers. In the further reform of the water pricing system (see the bottom half of the following figure), the integrated water will be priced at its social marginal cost level as undertaken by all water demand sectors, and the subsidy will be imposed on the prices of agricultural products so that the actual prices of agricultural products will be lower than their marginal costs level.



Note:
Q = water amount;
P = water price;
S = water supply curve;
S' = water supply curve with the externalities;
D = water demand curve;
$P_{agricultural}$ = price of agricultural products;
$Q_{agricultural}$ = amount of agricultural products;
$S_{agricultural}$ = supply curve of agricultural products;
$D_{agricultural}$ = demand curve of agricultural products