THE MECHANISM ON THE EFFECTIVE MANAGEMENT OF MULTI-OBJECTIVE WATER RESOURCES

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ABSTRACT

Due to the fast growing demand of water resources, the effectiveness on the management mechanism of multi-objective water resources has become the focus of future water resources management with limited water resources. Hence, the objective of this article is aimed to suggest a management mechanism through the evaluation of regional supply-demand relationships, application of appropriate models, reviewing current water transfer strategies among sectors, and the estimation of probabilistic flow-rates as well as the investigation of prices. This management mechanism should also include the platform for negotiation and a feasible promotion plan.

The preparation of the water transfer strategies has been proceeded by following the topics of (1) the appropriateness of past transfer cases of agricultural irrigation water, (2) the timing of possible transfer (or borrowing) of agricultural water, (3) the aid of irrigation water to other water sectors, (4) the compensation principles, and (5) the estimation of compensation.

From the experiences of water-right management as well as water-market management, while considering the local conditions, a quasi-official water-market arbitration and supervision organization is suggested in this article. This task-force of "Water-Market Management Committee" can be set up by following current regulations without creating new laws or administrations, and is operated by committee members. This Committee performs regular water monitoring during normal conditions, and is initiated when water-shortage or disputes occur.

I. FOREWORD

Due to the fast growing demand of water resources, the mechanism on the effective management of multi-objective water resources with limited water resources has become the focus of future water resources management. The long-term objective of

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this article is to suggest a management mechanism through the evaluation of regional supply-demand relationships, application of appropriate models, reviewing current water transfer strategies among sectors, and the estimation of probabilistic flow-rates as well as the investigation of prices. This management mechanism should also include the platform for negotiation and a feasible promotion plan.

II. WATER RESOURCES IN TAIWAN

The average annual rainfall in Taiwan is 2,515 mm, and the total volume reaches 90.5 billion tons, which is approximately 2.7 times of the world average. Although the amount of rainfall sounds plenty, the water resources management is tough as the annual allocated water per capita is only around 1/8 of the world average due to the uneven distribution both temporally as well as spatially, as seen in Figure 1.

On demand side, the statistics show that the domestic water has increased from 730 million tons in 1976 to 3.53 billion tons in 2004, and industrial water from 1.35 to 1.65 billion tons, while agricultural water has decreased from 15.96 to 12.60 billion tons, and has been remaining almost stable since 1996. According to WRA, the water-resources authority, the projection of long-term demand with medium growth rate on a fire-year interval targeted in year 2021, shows same trend as shown in figure 2.

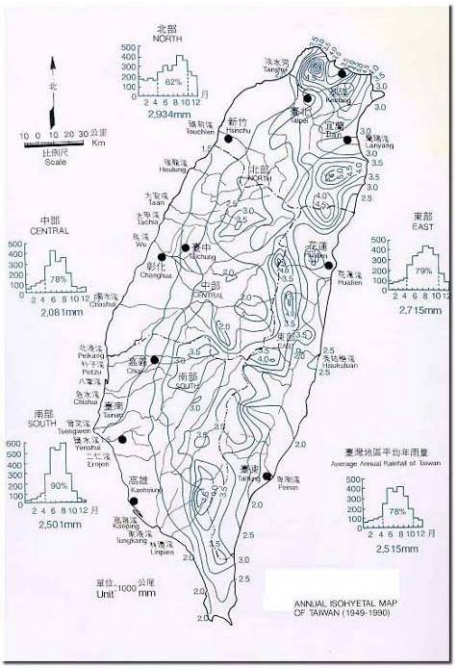

Figure 1 Annual Isohyetal Map of Taiwan

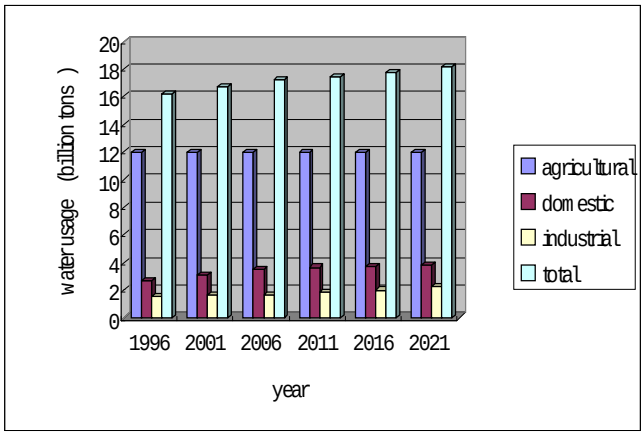

Figure 2 Trends of Water Demand for Various Sectors in Taiwan

III. PREPARATION OF WATER TRANSFER STRATEGIES

Most often cases of water transfer in Taiwan are from agricultural sector to domestic.

However, industrial sector has been facing frequent water shortage problems as well, and similarly, transfer or borrowing from agricultural has become sole and important solution before specific water sources intake systems are completed. As a result, it is necessary to setup a water transfer strategy among sectors in order to reach a win-win state.

1. Discussion on the appropriateness of past transfer cases

After reviewing past cases regarding transfer of agricultural water, following facts can be summarized:

1) Despite the fact that agricultural sector also faces water shortage, it is considered to be transferred whenever needed.
2) There is yet no reasonable compensation for the transfer of limited agricultural water resources.
3) The "value" of agricultural water resources is yet to be established.
4) Agricultural water right is seemingly abolished when frequent transfers are requested.

2. Types of transfer (or borrowing) of agricultural water

1) Permanent transfer,
2) Partial transfer, and
3) Temporary transfer.

3. Basic principles on the aid of agricultural water to other sectors

Based on past experiences of water transfer, following rules as well as basic principles are concluded:

1) During severe drought, the water resources is first re-allocated according to adjusted distribution. The first ranked domestic sector is eligible to transfer water from other lower ranked sectors when the necessary amount of water to sustain life and living needs is not acquired, and agricultural sector is always the one. However, proper compensation is needed as agriculture itself is also damaged from drought.
2) As the second ranked sector, the agricultural water is eligible to request transfer from lower ranked sectors. Although it rarely occurs, it is possible under food shortage conditions. In very few cases, it did happen when agricultural water requested aid form local deep wells of other sectors. However, the aid did not quite follow the priority order, and the compensations were based on negotiations.
3) Industrial water ranks third behind domestic and agricultural. Nonetheless, in order to protect industrial development, which has higher production value and is more vulnerable to water shortage, the transfer from agricultural sector often occurs. And most of the cases were proceeded through negotiations with agricultural sector, yet the reasonable compensation for the damage loss of farmers is yet to be determined.

IV. ESTABLISHMENT OF WATER QUANTITY MODELS

1. Assessment of suitable models

A number of mathematical or empirical models have been applied in various case studies of water-resources management in Taiwan, such as the Deterministic Optimal Operation Model, the Real-Time Optimization of Reservoir Operation Model, the Dynamic Reservoir Planning Model, the Delft Analysis Model, the Stochastic Dynamic Planning Model, the Stochastic Operation Model for Multi-objective Reservoir Operation Model, Fuzzy Stochastic Dynamic Planning Model, and Grey-Fuzzy Dynamic Planning Model, etc. However, it is difficult to determine a general model which can be applied in various cases. It is clear that the need for local water distribution occurs basically only when there is inconsistency between supply and demand. As a result, the difference between supply and demand becomes critical in the determination of proper measure as well as corresponding model to be adopted.

2. Measures corresponding to supply-demand analysis

In this article, it is suggested that the appropriate water quantity model can be established by proposing suitable measures with various corresponding supply-demand conditions, as shown in Figure 3.

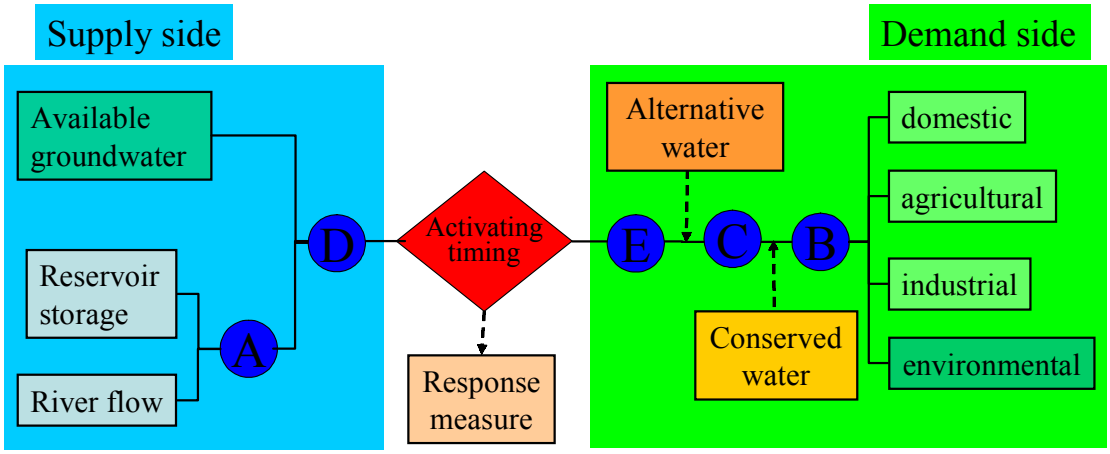

Figure 3 Supply-Demand analysis for water resources management

In Figure 3, the supply and demand sides are placed on both sides. On the left supply side, there are three water sources, namely available groundwater, reservoir storage, and river flow. On the right demand side, there are four water use sectors, namely, domestic, agricultural, industrial, and the important environmental. The starting timings to take corresponding measures are according to the difference between supply and demand conditions, and are classified into stages as follows.

Stage 1: When A>B, i.e., reservoir storage and river flow are able to satisfy

demand needs, then strict groundwater conservation measure is enforced.

Stage 2: When A<B, the water-saving measure is first activted. Each water-use sector has its own duty to reduce its own demand in order to keep A>C.

Stage 3: When A<C, groundwater is introduced for conjunctive use in order to sustain D>C.

Stage 4: When D<C, measures for different water sectors are activated. For agricultural sector, fallow or crop change are conducted, while for domestic and industrial sector, alternative water sources, such as desalination water, recycled water, or reclaimed water, are introduced, in order to keep D>E.

Stage 5: When D<E, i.e., any or some of the water sectors are not capable of satisfying it or themselves, then transfer among sectors are required.

V. ESTABLISHMENT OF ECONOMIC MODELS

In this article, the assessment of economic models has focused on the compensation principles and the estimation of compensation. The CVM (Contingent Valuation Method) of on-site questionnaire has been adopted on the determination of compensation prices for the transfer of agricultural water to other sectors, and Chia-Nan area has been selected as the simulation area for validation. The rice farmers with the pressure of water being transferred were sampled according to 5 thousandth ratio.

The results show that the valuation of agricultural water, as converted to the willing-to-accept (WTA) price as the function of released water quantity per unit area land, is requested according to growing stages and different crops for 2.37 NT$/ton for the first crop made fallow before plantation while 1.56 NT$/ton for the second crop, 4.58 NT$/ton for the first crop during land-preparation while 3.82 NT$/ton for the second crop, and 8.06 NT$/ton for the first crop during blooming stage while 4.43 NT$/ton for the second crop.

As for the conception of farmers concerning the sources of budget, regardless of the sectors that agricultural water is been transferred to, the idea of “pay by the users” is accepted by the farmers, meanwhile, the government as well as the authority administration should be involved in the support of budget.

VI. MANAGEMENT ORGANIZATION OF MULTI-OBJECTIVE WATER SECTORS

The feasibility analysis of water-market management or water-transaction, which is recommended in this article, has been proceeded following the items of (1) the ideas and experiences of foreign countries, such as the United States, Australia, Germany, Mainland China, and Japan, as well as the system and operation principles of initiation point, such as Holland, and France, (2) current regulations and mechanism by the Water Resources Agency during droughts, (3) the concept of the water-transaction systems, and(4) the preparation of the initiation mechanism of water-market or water-transaction.

From the experiences of water-right management as well as water-market management, while considering the local conditions, a quasi-official water-market arbitration and supervision organization is suggested in this article. This task-force of "Water-Market Management Committee" can be set up by following current regulations without creating new laws or administrations, and is operated by committee members.

The committee members should be included from representative units, such as the water-right management authority, agricultural administration agencies, domestic water units, water-supply units, farmers representatives, related beneficiaries, and law as well as financial experts, etc., and may be further grouped into four units, namely authority agencies (e.g., Water Resources Agency, Council of Agriculture), water-right holders (e.g., Irrigation Associations, Reservoir Management Bureaus), water-use beneficiaries (Water Companies, Industrial Sectors), and professional staff (e.g., financial, accounting, legal, fair trade, or environmental) as shown in Figure 4.

The major objective of the Committee is to reach management, arbitration, negotiation, and supervision purposes on water transaction. The formation of the Committee is suggested to be promoted by government authorities, in order to creatively participate in the effective water distribution and rational price negotiations of water markets at the right time.

Regarding the mechanism of the operation of the organization, this Committee performs regular water monitoring during normal conditions by collecting and integrating water information, including data from supply side, demand side, as well as future forecasts, and is activated by a warning system when water-shortage or disputes occur, and the mediation of water quantity as well as pricing is started, as briefly shown in Figure 4.

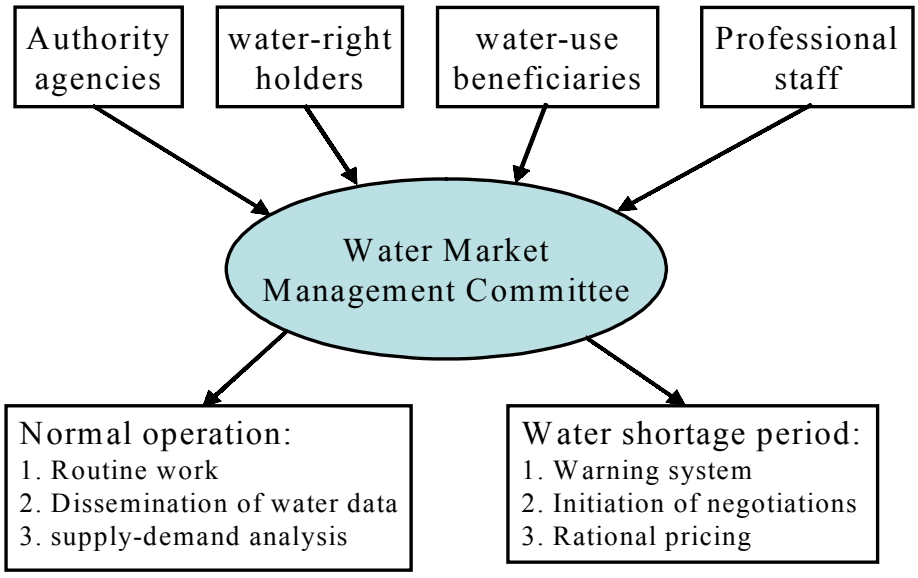

Figure 4 Conceptual platform of suggested management organization

More specifically, the challenging tasks of this Committee are the determination of

rational prices on the transferred water, the effective allocation as well as distribution of the water resources, to resolve water-use disputes and panic during water shortage, and to mediate doubts on the uncertainty of water-right for the agricultural sector, as well as water supply for the industrial sector.

The timing on the activation of the Committee, in other words, can be set by the time when a party filed the request. According to past experiences in most water-use dispute cases, the requests are normally filed by following parties: (1) water resources authority agencies, (2) agricultural administrations, (3) central government, which calls assembly meeting based on water information analysis, and (4) industrial sector.

A flow chart on the activation mechanism for the negotiation of the Committee as well as the water market is suggested in Figure 5.

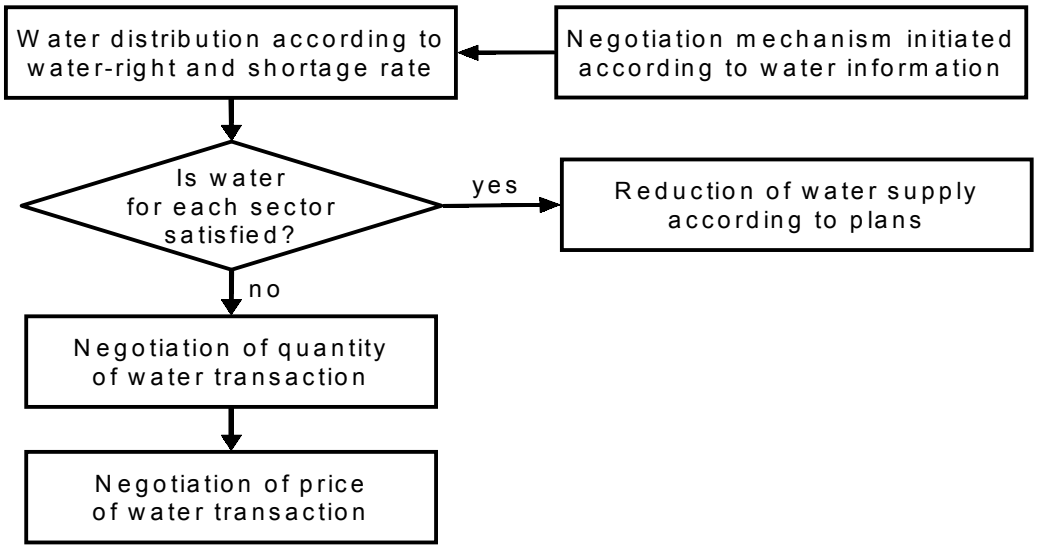

Figure 5 Suggested flow chart on the activation mechanism for the negotiation of water market

VII. CONCLUSIOONS AND SUGGESTIONS

1. Conclusions

1) On the effective use of water resources, a number of local applications of major models are briefly introduced, and the conceptual qualitative principles on the regional water distribution are suggested. As for further quantification of water distribution, the corresponding regulations and measures should be followed based on current water supply-and-demand conditions, and there should be an organization to take care of.
2) The preparation of the water-transfer strategies are performed by following the discussion on the subjects of: 1) the appropriateness of past transfer cases of agricultural irrigation water, (2) the timing of possible transfer (or borrowing) of

agricultural water, (3) the aid of irrigation water to other water sectors, (4) the compensation principles, and (5) the estimation of compensation. The application of these strategies is based on the fairness and justice of water transaction as well as transfer mechanism, and is significant on the promotion of the system as well as the establishment of water resources database.

3) From the experiences of water-right management as well as water-market management, while considering the local conditions, a quasi-official water-market arbitration and supervision organization is suggested in this article. This task-force of "Water-Market Management Committee" can be set up by following current regulations without creating new laws or administrations, and is operated by committee members. This Committee performs regular water monitoring during normal conditions, and is activated when water-shortage or disputes occur. The objective of effective water distribution as well as rational pricing is thus reached by the reasonable management on the supply and demand of water resources.

2. Suggestions

1) In order for further promotion, an "Organization regulations of the Water Market Management Committee" in correspondence with the "Water Market Management Committee" should be prepared. And in order to fully abide by current institutional systems, corresponding laws and regulations regarding water resources management during droughts or water shortage should be further compiled. It is also suggested that the test arbitration and negotiation should be carried out first in between quasi juridical persons (such as Irrigation Associations and Science Parks), and is gradually extended to other types of water transaction or transfer as experiences are accumulated.