Study on the quantitative analysis method of water resources management

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Abstract

The sustainable water resources management thought is deeply rooted in the hearts of the people. However, the discussion of the management of water resources are mainly concentrated in the formulation of the concept of and qualitative analysis, which is lack of quantitative and scientific criteria for new sustainable water management specification techniques and tools. Based on the quantitative analysis model of water management at home and abroad and applications in practical engineering, this paper mainly introduces a few kinds of water resources management theories and methods of quantitative analysis as well as analyze its advantages and disadvantages respectively. This paper provides different Angles of quantitative analysis method for the planning,projecting and evaluation of water resources.

Keywords

Water resources management, sustainable development, qualitative analysis.

1. Introduction

Water resources management is a series of specific service activities that guarantee water system can meet the current and future goals[1], It solves water contradiction between all regions and departments by setting up a corresponding comprehensive policy system, laws and regulations, and organizations[2].Only on the basis of deep understanding of the water resources distribution characteristics and cycle, can scientific and reasonable configuration and efficient utilization of water resources be easy.

However, the discussion of the management of water resources are mainly concentrated in the formulation of the concept of and qualitative analysis, which is lack of quantitative and scientific criteria for new sustainable water management specification techniques and tools.In order to make the water management plan to to achieve the optimal effect, it is necessary to quantitatively analysis management solutions and its influence to the water resources

2. The quantitative analysis methods

2.1 The risk analysis method

Because of the complexity of the water resources system itself and the existence of many uncertain factors, make planning in the design and operation management, and many other links are to assume a certain risk. Water resources system risk refers to the unexpected events occurred in the water resources system under a specific time and space environmental conditions.It also refers to the potential harm to the person's property, health and life safety, and environment[3].This method introduced generalized load(λ) and generalized damping (p) to define the relationship of systematic risk. Generalized load reflects the behavior of the system under the action of an external pressure, and generalized damping describes system ability to overcome the external load characteristic variables. When the system load is over damping ($\lambda > p$), system crashes. Systematic risk is the possibility when system load is greater than the damping: $P = p(\lambda > p)$[4].

Uncertainty is a major cause of system risk. The quantitative evaluation of uncertainty of the system is the main content of risk assessment and management. Sustainable research needs to forecast system's change process under the influence of the long-term uncertainty.

2.2 The index system method based on the concept of pressure - state - response

Index system provides people with the change of environment and natural resources and the information of the interaction results between the environment and social economic system. Stress refers to the human activities that affect the environment changes, answering questions of why this happens. State is the natural state of the nature's physical or ecological condition and social and economic development caused by it, answering what changes have taken place in the system; Response refers to the policies and measures taken by all kinds of problems, answering the question what should do and what have done[5]. On the basis of the conceptual framework, we can establish indicators of water resources system, including the pressure on the water resources system, the state of the water resources system and response measures under those press.

The index system of management framework includes descriptive indexes and the evaluative indexes. The descriptive indexes are: (1) pressure indexes: the water resources demand for development and utilization ; (2) status indexes: the quality and quantity of water resources system and its changes; (3)response indexes : water resources scheduling management for, protection of water resources and water price adjustment, etc. Evaluating indexes are: (1) bearing capacity index: reflects the interaction between the pressure indexes and state indicators. In the other word, the demand of water resources can't exceed the bearing capacity of water resources system. The bearing capacity of water resources system can be measured by the state index. the development and utilization of water resources should guarantee the benign circulation of water resources, ensure the integrity of their water quantity, water quality and ecological environment under the current conditions and future changes. (2) performance indicators: reflect the interaction between pressure index and response index. We satisfy the needs of users, and protect the interests of the managers through reasonable scheduling management, pollution treatment and water price policy and measures to ensure the development and utilization of water resources. (3) the configuration indexes: reflect the interaction between state index and response index. Response is to protect the system state (water quantity, water quality, etc.) from damaging, ensure that the use of contemporary and future generations.

2.3 WEAP model method

WEAP(water resources evaluation and planning system) model is a comprehensive model considering water resources development and water supply project on the background of demand side problem, water quality and ecological system protection, which is developed by the Swedish environment institute of the Stockholm. The goal is to maximize the satisfaction of all demand (the percentage of the demand be satisfied). When there is no enough water to meet the the same priorities of all requirements, we can meet all requirements with the same percentage of demand. The demand points of the real into-flow is:$\sum$into-flow =demand $\times$ demand satisfaction. WEAP model uses month as the time step to calculate every "node" and "link" of the water resources, each "node" and "link" must meet the following mass balance equation: into-flow = out-flow + flux loss. WEAP model uses linear programming method to establish preferred order of priority by demand and supply, mass balance, and other constraints (such as satisfaction, water quality constraints, etc.) of the simultaneous equations to distribute water.

2.4 harmonious theory

Harmony theory is the study of the method of realizing the harmonious behavior with many participants[6]. For the quantitative description of harmonious theory, professor Zuo Qiting presented five elements of theory of "harmony". They were harmonious participants involved in a harmonious, (generally two or more sides, known as the "harmonious party"), the harmonious goal (the target in order to achieve a harmonious state), harmony rules (all the set of rules or constraints), harmonious factors (harmony participants factors to consider), harmonious behavior (specific behavior floorboard according to the harmonious factors) [7].

The model established a single objective model with the goal of maximizing the harmony degree of water resources management function, with water quantity, water consumption, emissions as constraint conditions[8]. That is, within a certain period of time T, in order to satisfy certain conditions, it achieves the maximum of its overall harmonious degree. The objective function can be expressed as

$$Max(WRMHD) = Max(SHD^{\beta_1} \cdot RHD^{\beta_2} \cdot DHD^{\beta_3})$$
$$= Max\left[(\sum_{p=1}^{m} \omega_p HD_p)^{\beta_1} \cdot (\sum_{i=1}^{n} \omega_i HD_i)^{\beta_2} \cdot (\sum_{j=1}^{k} \omega_j HD_j)^{\beta_3} \right]$$

The index SHD, RHD,and DHD respectively refers to the system of harmonious degree, regional harmony degree, department of harmonious degree, the values is between 0 and 1. β1、β2、β3 are their index weights, HDp, HDi, HDj are different levels of harmony factor p, i and j in the harmony degree,ωp 、ωi、ωj are different levels of harmonious factors weights of p, i, j. The values of WRMHD (T) is between 0 and 1, When the values of SHD (T), RHD (T), DHD (T), WRMHD(T) tend to be closed to 1, the harmony degree of water resources management in the level is higher, On the other hand the closer to zero, it is the worse management level.

3. Comparison of the various methods

Risk analysis considers the influence of uncertainty factors. Compared with the deterministic model, it has more advantages on solving such problems with uncertainty, incomplete information. The general definition of risk, however, did not fully reflect all of the characteristics of water resources system under the condition of risk running, it only describes safety degree and the system behavior characteristics of the system under the uncertain conditions. The elasticity, vulnerability, reliability, availability, service quality indicators are still needed for a detailed description of water resources system behavior characteristics [9 ~ 10].

The index system method based on the concept of pressure - state - response reflects the basic content and the goal of sustainable water resources management. It has the theoretical and practical, and especially suitable for the project of water supply and water resources evaluation.

WEAP is unique because it can set up a scenario for the future based on the policy, cost, technology progress and influence demand, pollution, supplies and other hydrological factors. It was able to get more intuitive management solution caused by the change of water resources in space, And it is of high sensitivity to simulate management solution for the corresponding effects of each related area. Both at home and abroad, WEAP model is widely used to simulate projections for river basin water resources management. However, WEAP model needs a large amount of data and the simulation precision is poor, model structure also need to continuously improve in order to accurately predict the influence of various management scheme.

Theory of harmonious management system has the target layer, criterion layer, engaging subjects and factor layers, a total of 20 indicators. these indicators can effectively evaluate the harmony degree of water resources management in the different levels, making water management solutions and measures more targeted. But this approach only uses harmonious degree for the harmonious degree as the objective function for the management of water resources without taking into account the harmonious degree as the constraint condition.

4. Conclusion

With the rapid increase of agriculture and industry and residents living water, efficient management is very important to the rational development and utilization of water resources. Quantitative analysis for water management can accurately find the interests of the conversion relationship between the target and various demand and avoid unnecessary loss. Meanwhile, Through the related evaluation index, we can get optimal equilibrium solution for decision makers and make the final result conforms to the actual situation.

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