Application of Interval Fuzzy Multi - objective Strategy Model in Water Resources Optimal Allocation

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Abstract. Fuzzy multi-objective programming is an important optimization method to solve many complex practical problems. In this work, the applications of fuzzy multi-objective programming modeling for solving the practical problems in regional water resources optimal scheduling are studied. In order to strengthen the planning and management of water resources, the limited water resources are fully and effectively used scientifically. And because of the multi-objective and uncertainties of the regional water resources optimization scheduling problem, this paper adopts the fuzzy multi-objective programming method to deal with this complex practical problem. Based on the fuzzy multi-objective programming technique, the fuzzy multi-objective nonlinear programming model of regional water resources optimal dispatching is established. The multi-objective includes three goals: economic benefit, environmental benefit and social benefit. Then, the establishment and solving steps of the fuzzy multi-objective nonlinear programming model are introduced for the established model. Finally, the proposed scheme is evaluated and sorted. Finally, combined with the actual situation of a city to solve, verify the validity of the model.

Introduction

Regional water resources optimization scheduling problem is such a complex practical problem: in the watershed or a specific area, follow the effectiveness, fairness and sustainability and other principles, the use of various engineering and non-engineering measures, in accordance with the market economic rules and resource allocation guidelines, through the reasonable suppression of demand, to ensure the effective supply, maintenance and improvement of the quality of the ecological environment and other means and measures for a variety of available water sources in the regional water supply between the various departments. And in the current situation, due to the shortage of water resources, regional economic development and population growth, the increasing demand for water, the continuous improvement of regional water resources development and utilization, regional water supply and demand is increasing, so coordination within the system regional, various departments, the contradictions between the various sectors of the water, to study the whole system to meet the economic, social and environmental benefits of the best benefits under the premise of the water supply departments, so that limited water resources to maximize the benefits, and can provide sustainable development momentum for this region, which has important practical significance. Due to the multi-objective and ambiguity of regional water resources optimal scheduling problem and the superiority of fuzzy multi-objective programming in dealing with such problems, the two aspects will be combined to improve the practicality of regional optimal allocation of water resources and scientific nature[1-2].

In the existing water resources optimization model, there are several problems as follows: first, the target is single, and most of them are the economic efficiency maximization model. taking into account the economic, environmental, social and other goals of the model is relatively small. Second, even if the majority of the multi-objective model is also a deterministic model, the fuzzy factors in the optimal allocation of water resources are not taken into account. In terms of model solving, the method of solving single target is relatively mature, but the research method of multi-objective is relatively few. Based on the above-mentioned problems, a fuzzy multi-objective programming model of regional water resources optimal scheduling is proposed, which includes fuzzy linear multi-objective programming model of regional water resources and fuzzy multi-objective

programming model of regional water resources. Compared with deterministic planning, fuzzy target planning does not need to determine the exact expectations of the target, only need to determine the target fuzzy expectations, that is, a range of values, which is clearly more in line with the actual situation[3-6].

Overview of Fuzzy Optimization

The purpose of finding optimizing design is often the pursuit of maximum yield, lightest weight or other performance indicators to establish the "objective function": $y = f(x)$. The "excellent" and "inferior" of the scheme itself is a vague concept, there is no clear boundaries and clear standards, especially for multi-objective problems, often only the pursuit of "satisfactory solution", and solution itself is uncertain. Not all programs in the design are feasible, must meet the conditions $g(x) \leq 0$ specified in the design specifications and standards, which is called a constraint. These constraints often contain a lot of fuzzy factors. In general, the above problem is to solve the conditional extremum of the objective function under fuzzy constraints.

Trappey et al. first studies the fuzzy nonlinear programming (FNLP) problem, and uses the linear membership function to describe the fuzzy target and constraint of the system. Ali et al. proposed to use the differential equation method to solve the nonlinear programming problem with fuzzy parameters. Tang Jiafu et al. discussed the quadratic programming problem and the nonlinear programming problem with fuzzy objective and fuzzy resource constraints. The basic idea is to find a neighborhood of the optimal solution, so that each solution in the neighborhood is the solution that the decision maker can accept, that is, the optimal solution in the fuzzy environment. And proposes an interactive method to obtain the fuzzy optimal solution needed by the decision maker, so that the decision maker can make different decisions under different criteria[7-9].

The establishment and solution of the model

The regional optimal allocation model of water resources is a fuzzy multi-objective non-linear programming model. By solving this model, we can get the optimal allocation of water resources under the coordinated and healthy development of this system, including the economic objectives, environmental objectives and social objectives of the three objectives[10].

(1) Economic Objectives: The economic benefit of water use in different industries in each sub-district is the largest.

$$Max \tilde{f}_1(x) = \sum_k \sum_j \left[\sum_i (b_{ij}^k - a_{ij}^k)x_{ij}^k + \sum_p (b_{pj}^k - a_{pj}^k)x_{pj}^k \right] \tilde{\geq} z_{1g} \tag{1}$$

$f_1(x)$ is the economic net benefit objective function for regional water supply, and x is the decision variable.

(2)Environmental objectives: The minimum level of COD emissions in each sub-district.

$$\min \tilde{f}_2(x) = \sum_k \sum_j (\sum_i P_{ij}^k x_{ij}^k + \sum_p P_{ij}^k x_{ij}^k) \tilde{\leq} z_{2g} \tag{2}$$

$f_2(x)$ is regional target for significant pollutant emissions.

(3)Social goals: Residents living water consumption at the least deviation.

$$\min \tilde{f}_3(x) = \sum_k \left[D_j^k - (\sum_i x_{ij}^k + \sum_i x_{pj}^k) \right] \tilde{\leq} z_{3g} \tag{3}$$

$f_3(x)$ is water shortage of water supply and demand system

Constraints for the above objective functions:

Supply constraints independent water:

$$\sum_k x_{ij}^k \leq W_i \tag{4}$$

Supply constraints of public water:

$$\sum_k \sum_j x_{pj}^k \leq W_p \tag{5}$$

Non-negative constraint:
$$x_{ij}^k \geq 0 \tag{6}$$

Coordinated development constraints:
$$\sqrt{u_1 u_2} \geq 0.08 \tag{7}$$

Based on the genetic algorithm to obtain the fuzzy optimal solution, the general fuzzy target and fuzzy resource constrained nonlinear programming has the following form:
$$\max f(x) = f(x_1, x_1, \ldots\ldots x_n) \tag{8}$$
$$g(x) \leq b \tag{9}$$

Where $g(x)$ is function vector of constraint.

Based on the genetic algorithm, the fuzzy optimal solution is not to find a precise optimal solution, but to find the neighborhood of an optimal solution, so that each solution in the neighborhood is the solution that the decision maker needs and the optimal solution of the decision maker in the fuzzy environment. The basic idea is to first determine an acceptable fuzzy optimal membership by the decision maker. Randomly generate a population of NP (population size) individuals, each individual according to the size of its adaptive function to move in the direction of increasing (to produce sub-individual), for membership less than a_0 sub-individual, the small membership is such that the chance of being smaller in the iterations of the subsequent sub-individual than the child of the higher membership is selected to produce the child. In this way, the sub-individuals whose membership is less than a_0 are gradually eliminated and are sub-individuals with large membership. So after a certain number of iterations, each individual is the solution that the decision maker wants [11-12].
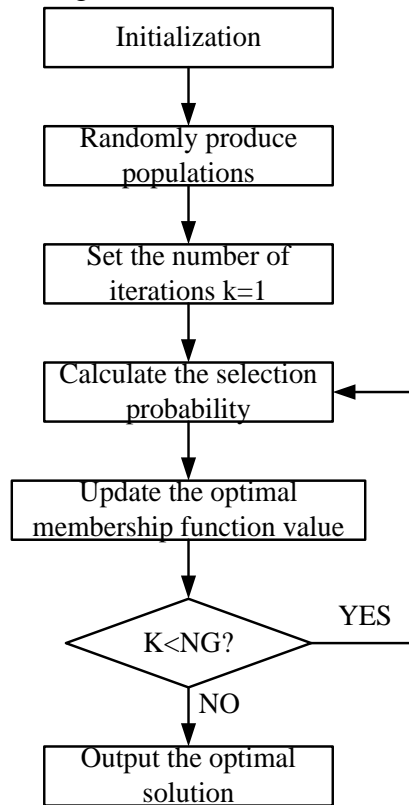
Genetic algorithm steps is shown in Figure 1：

Figure 1. The calculation steps of the genetic algorithm

Verification of examples

Take A city as an example, the COD emissions in 2010 of the base year are 36 thousand and 900 tons, and the per capita GDP is 15326 yuan. Other parameters are entered, and the target parameters are as follows:

The water supply guarantee rate is 90%，and the target upper and lower limits are as follows:

Tab.1 The target upper and lower limits when the water supply guarantee rate is 90%

Parameter class	Parameter meaning	Parameter value	Unit
Target expectation	Total economic goals	16.06	Million yuan
	Total environmental objectives	32555	Ton
	Total social goals	0	Cubic meter
Upper and lower limits of Target	Lower limit of total economic target	13.2	Million yuan
	Upper limit of total environmental objective	36000	Ton
	Total social objective ceiling	850000000	Cubic meter

Using genetic algorithm, the water supply guarantee rate is 90%, and the results of each target are shown in Tab.2 :

Tab.2 The optimal solution of the target when Comprehensive optimum when the water supply guarantee rate is 90%

Project	Economic goal(Million yuan)	Environmental objective (Ton)	Social goal(Cubic meter)
Comprehensive optimum	14.934	33910	335000000
Social goal is optimal	14.46	33490	7000000
Economic goal is optimal	15.31	34790	595000000
Environmental objective is optimal	14.391	32750	595000000

When the water supply guarantee rate is 90%, the optimal combination of water resources in different regions is shown in Tab.3

Tab.3 Optimal operation results of water resources when Comprehensive optimum

Region	Source of water	Industrial water(Ton)	Agricultural water(Ton)	Urban water(Ton)	Rural water(Ton)	Ecological water(Ton)
Area A	Surface water	8230000	8620000	1840000	1210000	790000
	groundwater	16860000	45170000	31500000	2190000	5210000
Area B	Surface water	4550000	6130000	2010000	550000	160000
	groundwater	9690000	99920000	7340000	1150000	740000
Area C	Surface water	7040000	7800000	1560000	1090000	10000
	groundwater	30560000	81360000	3960000	1910000	3030000
Area D	Surface water	7270000	7440000	1460000	1710000	780000
	groundwater	20510000	205190000	3460000	4090000	5220000

From the results of fuzzy multi-objective nonlinear programming of regional water resources, it can be seen that the planning results are reasonable. Compared with the fuzzy multi-objective linear programming of water resources, the non-linear model not only fully considers the relationship between social, economic and environmental objectives, but also the social and economic - environmental and environmental objectives of the system to achieve the coordinated development and sustainable development, so the establishment of fuzzy multi-objective water resources planning is more realistic.

Summary

Based on the maximum benefit of economy, environment and society, this work establishes a multi-objective non-linear programming model for regional optimal allocation of water resources. The non-linear model takes full account of the relationship between social, economic and environmental objectives, also considering the factors of sustainable development, so that the overall benefits become maximize Through the case verification of A city, the genetic algorithm is used to solve the problem, and a comprehensive optimal solution is obtained to prove that the fuzzy multi-objective non-linear programming model of water resources is more realistic.

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