Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 88 (2016) 309 – 312

Energy Procedia

CUE2015-Applied Energy Symposium and Summit 2015: Low carbon cities and urban energy systems

Study on Urban Water Security Evaluation Based on the Vague Set Similarity Model

Shibao Lu[a], Jianhua Wang[b], Haijun Bao[c]

[a] School of Urban-rural Planning and Management,Zhejiang University of Finance and Economics, Hang Zhou 310018 , China;
[b]China Institute of Water Resources and Hydropower Research.

Abstract

Urban water security comprehensive evaluation is complex, vague and multifarious. This paper presents a Vague set-based water security evaluation methodology by building a Vague set similarity model. AHP and Delphi methods are used to give weights to indexes and evaluate the urban water security assurance. A western city is used as an example for the empirical study. In the nine indexes for water security evaluation, the values for socio-economic environment and pressure are 0.24 and 0.41 respectively, which indicates that the city has relatively large socio-economic pressures. The WSAI values of the resource index and environment pressure for water are 0.94 and 0.96. The relatively high figures show that water resources are fully exploited and its environment is relatively well-protected. Vague set similarity model can be used to quantitatively evaluate the water security support degree.

Key words: Vague set; Urban water security; Water security support index; Synthetic evaluation

Peer-review under responsibility of the organizing committee of CUE 2015

Keywords:

1. Introduction

With the industrial development, water environment is increasingly polluted,The water security issue is becoming more and more prominent and has attracted a worldwide attention and emphasis. Since the 1990s, some international organizations have implemented a host of water science programs and conferences with water as the subject are frequently held around the world. These conferences aim to achieve the sustainability in water development[1,2], increase political stability, and ensure that everyone is accessible to safe water and lives a healthy and happy life. At an international water conference held in Stockholm, Sweden in March, it was pointed out that the challenges we face in the water security field have seven facets which are the following: basic needs, food supply, ecosystem protection, water resource sharing, disaster control, giving values to water and the reasonable water resources management[3,4].

Currently, China is experiencing the increasing urbanization level, growing city size and urban population, urban water resource shortage, water environment contamination and emergency water security accidents[5]. As the urban water security system is complex, miscellaneous and vague, this paper uses the Vague set similarity model to build a Vague-based similarity model for evaluating urban water security assurance. The model is able to establish a quantitative relation of the water security assurance evaluation system's main indexes and "the urban water security assurance degree". Take a western city as an example. Through water security assurance evaluation system construction in that city, it attempts to use the resulting Vague set similarity evaluation model to conduct a synthetic analysis of the fact.

2. Urban water security similarity model

Peer-review under responsibility of the organizing committee of CUE 2015
doi:10.1016/j.egypro.2016.06.144

2.1. Vague set definition

Definition[6]: suppose that $X=\{x_1, x_2, \cdots, x_n\}$, the Vague set on X is described by the true and false membership functions, namely t_A and f_A. $X \to [0,1], f_A : X \to [0,1]$ Where, $t_A(x_i)$ is the positive membership degree's lower bound derived from x_i supporting evidence and $f_A(x)$ is the negative membership degree's lower bound derived from x_i disproving evidence, with $t_A(x_i)+f_A(x_i) \le 1$. The element's membership degree x_i in the Vague set A is defined by a subinterval $[t_A(x_i)+f_A(x_i)]$ of the [0, 1] interval. In this case, this interval is the x_i Vague value at A, expressed in $v_A(x_i)$.

2.2. Vague set similarity measurement

Sullivan [9] proposed the following formula for the similarity measurement:

$$T_Z(A,B)=1-\frac{|t_A-t_B-(f_A-f_B)|}{8}-\frac{|t_A-t_B+f_A-f_B|}{4}-\frac{|t_A-t_B|+|f_A-f_B|}{4} \quad (1)$$

Whereby, the greater the value of $T_Z(A,B) \in [0,1], T_Z(A,B)$, the greater the similarity between values at A and B.

This method takes into consideration the comparative advantages and comparatively known information, but does not consider the comparatively unknown information. However, the Vague value similarity measurement method proposed by Sullivan covers all information, e.g.: the Vague value A is smaller than B as a comparative advantage, and as far as its comparatively known and unknown information are smaller, the larger will become the similarity between Vague value A and B.

3. Case study

This paper aims to evaluate a medium-sized city's water security assurance in Chengdu where the water resource is plentiful with a presented synthetic evaluation.

3.1. Evaluation index system construction

An urban water security assurance index system should be built in such a way that it can fully reflect and represent water security connotation and characteristics, with high information integration, high reaction sensitivity and simple and reliable data acquisition. Considering this and based on the urban system composition, a water emergency security index system is constructed. See Table 1. Water security support indexes include the water resource, water environment, disaster prevention, ecological environment and socio-economic support indexes.3.2. Evaluation index summation

Individual expert's AHP method has subjectivity and arbitrariness often and multiple experts' can overcome this defect[7]. Different experts' weights are obtained through the clustering analysis so that they become more objective and scientific. The Analytic Hierarchy Process (AHP) and the expert consultation method (Delphi method) are used to obtain index summations as shown in Table 3.

Table 3. Water emergency security Index summations

Index	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
Weight	0.1254	0.2090	0.0418	0.0982	0.1767	0.1253	0.0791	0.0248	0.0116	0.0064	0.0137	0.0465	0.0417
Index	D14	D15	D16	D17	D18	D19	D20						
Weight	0.0415	0.0345	0.3002	0.0687	0.2062	0.1253	0.0131						

3.3. Membership functions and water security assurance calculation