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Support Vector Machine Algorithm Application in the Sustainable Utilization of Regional Water Resources

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Abstract

With the shortage of water resources and water pollution, a series of global water problems have become more and more serious. The development and utilization of traditional water resources can no longer meet the needs of human and social economic development. In this paper, the authors analyze support vector machine algorithm application in the sustainable utilization of regional water resources. We describe the research status of support vector machines and water resources sustainable utilization, and establish the evaluation model of sustainable utilization of water resources based on SVM. By making quantitative analysis and evaluation on the current regional sustainable utilization of water resources, we can understand the existing problems in the development and utilization of water resources, and provides a new basis for the new situation of the development of water resources protection and utilization planning.

Keywords*: Support vector machine, Sustainable utilization, Regional water resources, Prediction model*

1. Introduction

Assessment of sustainable utilization of water resources is an important part of the study of sustainable utilization of water resources, and it is the basic means to judge the level of the sustainable ability of the water resources and the basis for the regulation of water resource s[1-2]. The main evaluation methods include comprehensive evaluation method, fuzzy comprehensive evaluation method, grey clustering method, principal component analysis, factor analysis and projection pursuit evaluation method [3]. All of these evaluation methods need to construct the function relation and the weight value of the evaluation index set and the evaluation grade standard value, and the evaluation model is different with the different evaluation model [4]. The method of sample data modeling of regional system evaluation level generation of sustainable utilization of water resources, and then use the accelerated genetic algorithm interpolation model and the neural network model based on the methods of sustainable utilization of water resources evaluation, and achieved good results [5-6]. However, these methods are not enough, such as the accuracy is not high enough, especially the structure of the neural network model, and it is easy to converge to local minimum in the training process.

Support vector machine (SVM) method as a new machine learning algorithm, with the minimum structure risk instead of the traditional empirical risk, solving the optimization problem is one of the two types, are global minima, solve the local problem cannot be avoided in the neural network method in topology; support vector machine the structure is

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determined by the support vectors, to avoid the traditional neural network topology error method need experience test, showing the unique advantages in solving small sample, nonlinear and high dimensional pattern recognition problems [6]. At present, SVM algorithm has been widely used in pattern recognition, regression estimation and probability density function estimation, and its excellent learning performance is considered as an alternative to artificial neural network method [7]. The sustainable utilization of regional water resources is the premise and guarantee of regional sustainable development, the support vector machine method into the sustainable utilization of water resources, establish the evaluation model of sustainable utilization of water resources. Quantitative analysis and evaluation on the current regional sustainable utilization of water resources development and utilization of water resources, being the problem, reveal the relationship between water resources and coordination sustainable development and utilization and sustainable development and utilization of the relationship between population, society, economy, environment and other resources, to develop water resources protection and utilization planning provides a new basis for the new situation[8-9]. In addition, through the analysis of current situation and forecast of the carrying capacity of water resources, to provide visual information intuitive access to water resources management departments at all levels, which can timely understand information of water resources management in the region, providing the basis for the development of regional sustainable development strategy and implementation plan data. It can support the comprehensive analysis, simulation and prediction, evaluation and planning, but also from the basic elements of the existing data and the spatial relationship between mining and generate new information, to discover and solve new problems, the research has important practical significance to the sustainable utilization of regional water resources.

2. Support Vector Machine

With the rapid development of science and technology, nonlinear and high dimensional data more and more complex needs analysis and processing, how to focus from these data, summarizes the correct useful rules, is more and more important in scientific research. The data based machine learning, which is based on the observation samples as the starting point, explore the potential of the law and the use of the future data, it quickly became the object of many researchers concerned. Although the SVM method was proposed in the middle of the 1990s, it was successfully applied to the classification and regression problems in many fields because of its global optimization and good generalization ability. Water resources system is a nonlinear coupling ecology, economy and society complex system; in practice it is difficult to monitoring layout enough, resulting in the training sample is small; the inherent characteristics of water resources and the sustainable utilization of water resources problems is also an urgent need for a new theory and method for sustainable utilization of water resources. The small sample, nonlinear and other advantages of water resources support vector machine requirements agree without prior without previous consultation has a good application prospect, in the field of water resources.

SVM is the development of the optimal classification surface from the linear separable case, the basic idea can be illustrated in Figure two of the 1 dimensional case. In the figure, the solid point and the hollow point are representative of two kinds of samples, H for the classification line, H2, H1, respectively, for all kinds of the nearest sample and parallel to the classification line of the line, the distance between them is called the classification interval. The so-called optimal classification line is not only the classification line can be divided into two categories (the training error rate of 0), and can make the largest classification interval.

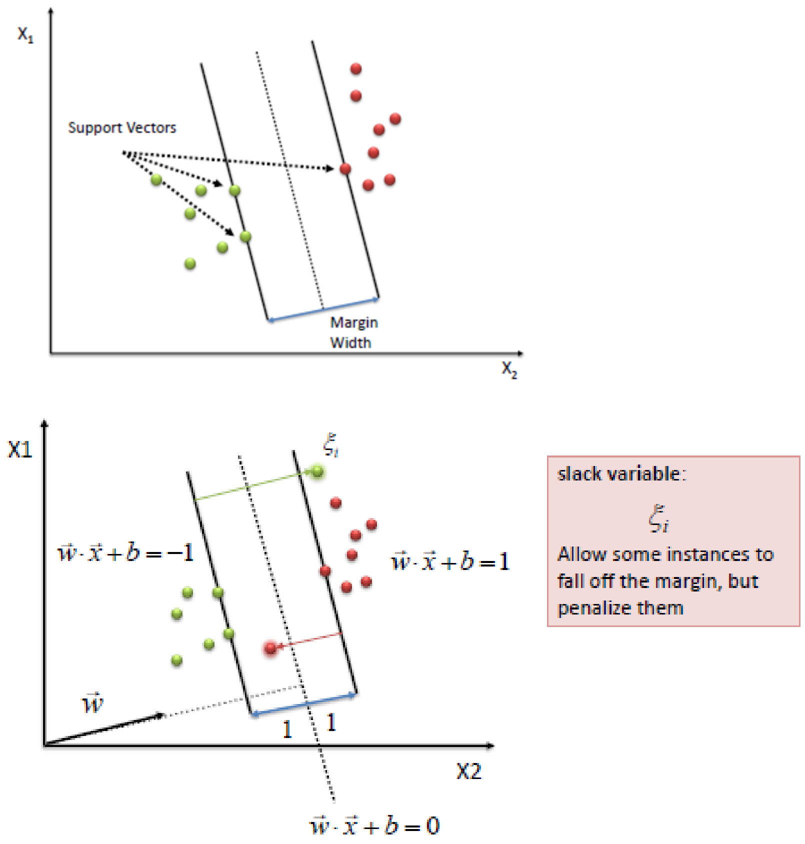

Figure 1. The Optimal Separating Hyperplane

In the linear separable model, classification of SVM in a H inner space structure for super plane:

$$\langle w,x\rangle + b = 0, \qquad w \in H, b \in R$$

For linearly separable sets of samples, the total can be adjusted by w and b:

$$\langle w,x\rangle + b \geq 1, y = 1$$

$$\langle w,x\rangle + b \leq -1, y = -1$$

The maximum spacing of the idea is to solve the following variables W and B optimization problems:

$$\min \quad \frac{1}{2}\|\omega\|^2$$

Introducing the Lagrange function:

$$L(w,b,a) = \frac{1}{2}\|w\|^2 = \sum_{i=1}^{l} a_i\left(y_i\left(\left(w\cdot x_i\right)+b\right)-1\right)$$

By the extreme conditions:

$$\nabla_b L(w,b,a) = 0$$

$$\nabla_w L(w,b,a) = 0$$

We can get:

$$\sum_{i=1}^{l} a_i y_i = 0$$

$$w = \sum_{i=1}^{l} y_i a_i x_i$$

By introducing Lagrange multipliers, the original constrained optimization problem is transformed into a dual problem:

$$\min \quad \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} y_i y_j \alpha_i \alpha_j \left(x_i \cdot x_j\right) + \sum_{i=1}^{n} \alpha_i$$

$$s.t. \quad \sum_{i=1}^{n} y_i \alpha_i = 0$$

In reality, there are more and more nonlinear cases, which must be extended to the linear case.The training sample characteristics by mapping function ∅(x) mapped to high dimension linear space and put the ∅(x) into the optimization problem:

$$\min \quad \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} y_i y_j \alpha_i \alpha_j \left(\phi(x_i) \cdot \phi(x_j)\right) + \sum_{i=1}^{n} \alpha_i$$

3. Water Resources Carrying Capacity

3.1. Re Exploitation of Water Resources

The urban water resource is the natural fresh water resource and the renewable utilization water which can be used by the city, which is the foundation of the city's formation and development, and the source of the city water supply. The main problems of urban water resources in our country are the small amount of water resources per capita, the serious shortage of water resources, the development and utilization of strength, and the environmental problems caused by the unreasonable use of water resources. As the city is the main gathering area of population and social wealth, the population density is large, the average water resources per capita is much less than the national average level. Because of the economic and environmental problems caused by the water resources problem, the problem is becoming more and more serious:

- ***City water environment worsening:*** in a long period of time, our country in the development and utilization of water resources, only pay attention to the pursuit of economic efficiency and benefit of water conservancy, protection and improvement of the water environment is not enough, resulting in a series of environmental problems. At present, the national total discharge of wastewater, more than 80% without treatment directly into rivers and lakes, water pollution is becoming more and more serious. More than 90% of the city's water environment has deteriorated significantly; urban rivers have been seriously polluted.

- ***Excessive exploitation of underground water:*** leads to the groundwater level decreased year by year, water resources are gradually depleted. China has had 56 regional groundwater funnel, a total area of 2 8.7xlo4 in the lung, resulting in a single reduction of water, water supply costs increase, a large number of electromechanical wells scrapped, even water disposal; the underground water level continues to decline the environmental engineering geological problems of ground subsidence, subsidence and ground fissures in the coastal city;, also caused the seawater intrusion;

- ***Deterioration of the ecological environment:*** the deterioration of the ecological environment caused by excessive surface water and groundwater, most of the waters near human activities, the environment is destroyed; the diversity of ecological population decreased or even disappeared. On the one hand, for the serious water shortage situation, on the other hand, the phenomenon of waste water is very common, only in the case of Beijing, 13 times a year for the car wash water equivalent of Kunming lake water storage capacity; only the city life waste water a year to lose billions of cubic meters. Strengthen awareness of water conservation has reached a point where cannot be ignored.

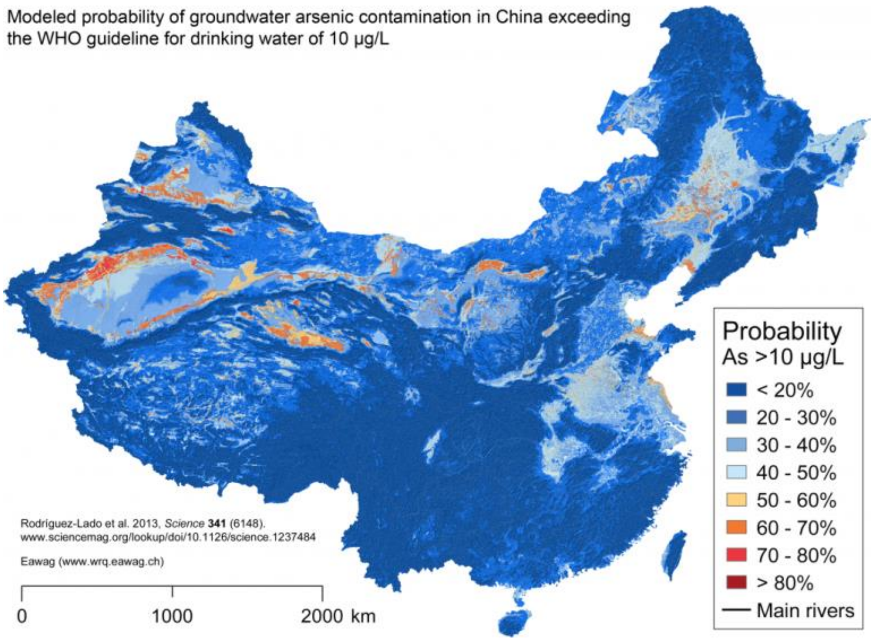

Figure 2. Risk of Water Resources in China

3.2. Water Resources Carrying Capacity

Water, is the source of life, is an indispensable human survival of a valuable resource, but also an important part of the natural environment, is the basic conditions for sustainable development. With the passage of time, the coordinated development in the "water" on the performance is very prominent. For example, there is a shortage of water resources, water quality deterioration and other issues. In the twenty-first Century, the sustainable development of water strategy is a major issue in the future and destiny of mankind. Water resources carrying capacity is from the point of view of water resources, water resources to support the economic development to what extent. Water environment carrying capacity is from the point of view of sewage discharge, the water body can bear the number of emissions. And the two are complementary and closely related. When studying the carrying capacity of water resources, it is necessary to consider the use of water in the ecological environment, and it is necessary to study and analyze the water environment carrying capacity. In the concept of "water resources carrying capacity", the main body is the water resource, the object is the social economic system and the environment system of human being and survival. "Water resources carrying capacity" is to meet the needs of the object to the subject and the pressure, that is, the support of water resources to social and economic development. Water resources carrying capacity has spatial attribute. It is in a certain region, because of the amount of water resources in different regions of the available water resources, water demand and social development level, economic structure and conditions, ecological environment problems may be different, the water resources carrying capacity may be different. Water resources carrying capacity of the social and economic development of the support criteria should be "to carry" as the criterion. In the concept and calculation of water resources carrying capacity, it is necessary to answer: what is the standard of water resources for social and economic development to support the maximum. Only after the definition of this standard, in order to further calculate the carrying capacity of water resources.

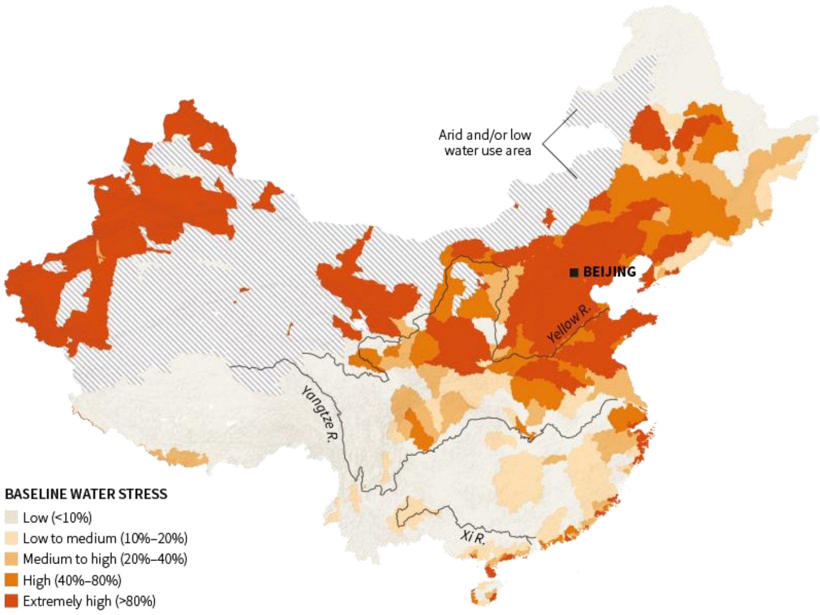

Figure 3. Status of Water Resources in China

Water resources system and social economic system, ecological environment system is a complex relationship between interdependence and mutual influence. Not isolated calculation supporting role of water resources system on one aspect, but the water resources system and social economic system and ecological environment system combined research in water resources, social economy, ecological environment composite system, seeking to maximize the scale of development of water resources can meet the bearing condition, it is water the bearing capacity of resources. From the above analysis of the connotation of water resources carrying capacity, the main factors which can influence the carrying capacity of water resources are analyzed, which can be divided into three categories:

- ***The characteristics of water resources system:*** water resources system is the main body of water resources carrying capacity. That is to say, the size of water resources carrying capacity is determined by the amount of water resources provided by the system.
- ***Human activity ability and ideology:*** human being is the object of water resources carrying capacity, which affects the water resources carrying capacity to a great extent. The utilization ratio of water resources, which is an important index to determine the amount of water resources per unit of water to feed or to bring more economic benefits, is the key indicator of the calculation of water resources carrying capacity. Scientific and technological

progress can improve the carrying capacity of water resources by increasing the utilization rate of water resources, recycling rate, sewage treatment rate and so on. Regional development strategy, which reflects a country or region's development planning or development model, the allocation and utilization of water resources have an important impact, thereby affecting the water resources carrying capacity. The management system and the legal system, people reflect water, basic idea of flood control, water resources protection, some management system or the legal system of the use and protection of water resources has a positive effect, some even have a negative effect. To a great extent, it affects the water resources carrying capacity.

- ***Whether it can bear the goal difference:*** in the calculation of water resources carrying capacity before, to determine what kind of standard, the maximum capacity is the capacity of water resources". This is an important aspect of calculating the size of water resources carrying capacity.

4. Sustainable Utilization of Regional Water Resources

4.1. The Evaluation Index

The evaluation of sustainable utilization of regional water resources, first select the factors associated with the regional water resources as the evaluation index, and then based on the analysis of the supply and demand of water resources, establish the corresponding evaluation index system, establish the evaluation index system of the level of the standard, the measured value of each index and the corresponding level compared with the standard value, according to the water resources the sustainable utilization degree to determine the corresponding level. The result not only reflects the relationship between sustainable development and utilization in the area of population, social and economic sustainable development and water resources, the relationship between sustainable development and utilization of other resources and the environment, between the reflected, laid the foundation for future work coordination.

At present, many researchers at home and abroad were studied to different degrees, including the evaluation method of grey clustering method, principal component analysis, factor analysis, fuzzy comprehensive evaluation method, projection pursuit evaluation method and comprehensive evaluation method etc.. These are the basic methods to construct the evaluation index and grade value between the corresponding complex functions or weights are calculated according to the evaluation index to quantify the value of district level and sustainable evaluation standard, evaluation model, evaluation of regional evaluation if not the same as the corresponding model is not the same, there are many deficiencies and the calculation workload. The support vector machine method by solving a convex optimization problem two times, eventually reach the global optimum, avoids the local extremum problem of neural network, and support vector determines its topology, there is no experience of trial, can solve the small sample, nonlinear and high dimensional pattern recognition problems. In this paper, based on the premise of the sustainable utilization of water resources, the basic evaluation model based on SVM is established, and the sustainable utilization of water resources in the study area is evaluated according to the actual situation. In fact, the evaluation criteria have been defined, only the evaluation index of the area is selected and the corresponding data set is formed, and the grade value of the sustainable utilization of water resources is found. If in accordance with the known evaluation criteria, using stochastic simulation technology to generate the evaluation index to a sufficient number of sequences, sequence and corresponding evaluation indicators for evaluation value for establishment of evaluation model, it will save a lot of work. Based on the above ideas, this paper establishes a support vector machine model for sustainable utilization of regional water resources by using the SVM classification algorithm.

Through the evaluation of sustainable utilization of water resources, the evaluation criteria are shown in Table 1. According to the range of value and the evaluation grade of the index in Table 1, the evaluation index value of each evaluation grade is evaluated. Put the data into the trained model, to study and calculate the evaluation results, the results show that the evaluation on Sustainable Utilization of water resources for the 4 class, namely the sustainable utilization of water resources in the lower level, the comprehensive evaluation is the development and utilization of water resources has a certain level, but the utilization rate of water resources relative low, it is necessary to take relevant measures to further improve and strengthen the management of water resources. In addition, development has entered the depth, and agricultural water consumption, the water consumption economy replaced water-saving economy, alleviate the crisis of water resources, and promote the sustainable development of water resources.

Table 1. Evaluation Criteria

Evaluating indicator	Assessment level of sustainable utilization of water resources			
	1	2	3	4
Irrigation rate	≥ 60	45	35	20
Utilization ratio of water resources	≥ 60	45	35	20
Development degree of water resources	≥ 75	60	50	35
Water supply modulus	≥ 100	80	60	40
Modulus of water demand	≥ 100	80	60	40
Per capita water supply	≤ 1000	1500	2000	2500
Water rate of ecological environment	≤ 2	3	4	5

Firstly, the regional water resources sustainable utilization evaluation index set is xij, and the corresponding evaluation grade standard is yi:

$$y_i = f(x_{ij})$$

It can be seen that the input layer of the SVM model has M units, and the output layer has only one unit. According to the regional water resources Table 1 sustainable utilization evaluation criteria, using stochastic simulation technology to generate the evaluation index sequence in sufficient quantities, due to different levels of value is determined by the lower indicators, so these indicators constitute the model sequence generating sequence and evaluation of the level of value in the evaluation index of stochastic simulation formula:

$$x_{ij}^p = RAND(x) \cdot (b_j - a_j) + a_j^p$$

In order to avoid the randomness of the output of the model, the evaluation index should be normalized before modeling.

$$x'_{ij} = \frac{x_{ij} - x'_{\min}}{x^j_{\max} - x^j_{\min}} \alpha + \beta$$

In the same way, it is needed to do the normalization processing, that is, to evaluate the grade value:

$$y'_i = \frac{y_i - y^j_{\min}}{y_{\max} - y_{\min}} \alpha + \beta$$

The 4 evaluation grades were randomly generated 10 evaluation index values and the corresponding evaluation grades, which constituted 40 samples as the training sample of SVM. The weights of the model evaluation indexes are obtained by training the sample which is in accordance with the evaluation standard, which has good objectivity, comparability and fairness. Using the parameter optimizing method based on shuffled frog leaping get the optimal combination of the parameters, the radial basis function as the kernel function, the corresponding output of the y model is the normalized value, so it is necessary to carry out anti normalization, then forecast the output of y, i.e.:

$$y_i = \frac{(y' - \beta_i)(y_{\max} - y_{\min})}{\alpha} + y_{\min}$$

4.2. Regression Prediction Model of Water Resources Carrying Capacity

In general, the demand and supply of water resources is composed of regional water resources carrying capacity, this paper proposes a forecasting model based on support vector machine, to realize water resources from the perspective of supply and demand of water resources carrying capacity, and provide scientific basis for the future economic development of Minqin oasis. Based on the actual situation of industrial structure, and finally select the total agricultural output value (100 million yuan), the total industrial output value (100 million yuan), the total cultivated area (MU), total population (million), urban residents' disposable income (yuan), per capita GDP (yuan) a total of 6 impact factor, y the annual water consumption.

Table 2.Numerical and Load Carrying Capacity of Impact Factor

Year	X1	X2	X3	X4	X5	X6	Y
2010	4.22	1.25	92.23	30.12	3753	2753	7.59
2011	4.68	1.32	93.19	31.05	3658	3034	7.67
2012	5.13	1.57	94.58	31.30	3754	3598	7.35
2013	4.93	3.64	94.72	30.86	4248	4214	7.02
2014	6.23	3.23	95.30	31.15	5135	6152	6.57
2015	8.32	4.15	96.14	30.29	5563	7235	6.64

The accuracy of the model depends on the proper selection of the parameters. Parameter optimization based on shuffled frog leaping algorithm, after several iterative optimization, the training set as input SVM training, will enter the SVM test set of fitting test, so as to get the prediction results of water resources carrying capacity, as shown in Table 3.

Table 3. Predictive Value and Error of SVM Model

Year	Measured value	Predicted value	Absolute error	Relative error%
2010	7.57	7.5737	0.0037	0.05
2011	7.69	7.6522	0.0378	0.5
2012	7.32	7.3224	0.0024	0.03
2013	7.05	7.0542	0.0018	0.02
2014	6.57	6.5812	0.0112	0.22
2015	6.14	6.1528	0.0128	0.23

As can be seen from Table 3, the maximum absolute error is 0.0378; the maximum relative error is only 0.5%, relatively small. Analysis of the 2015 data found that the relative error was 0.23%, the average relative error of 0.22%, in line with the accuracy requirements. The predictive value of SVM value fitting effect is quite good and the actual, visible region of SVM in water regression prediction model can well forecast the trend of water consumption is based on an effective prediction method, and also show that the water use and the selected effect has a very high correlation between factor.

5. Conclusion

With the shortage of water resources, serious water pollution and deterioration of the ecological environment, a series of global water problems have become increasingly prominent, the traditional water resources development and utilization is no longer meet the needs of human and social economic development. With the deepening of sustainable development thought in the field of water resources, it is very urgent and necessary to seek the sustainable utilization of water resources. The sustainable utilization of water resources evaluation and prediction of bearing capacity of water resources sustainable utilization of water resources as two important content of the research, its purpose is to accurately reflect the degree of sustainable utilization of water resources and to predict the future development trend of water resources carrying capacity is the basis of study on the sustainable utilization of water resources work. At present, there are many methods to evaluate the sustainable utilization of water resources and the prediction of water resources carrying capacity, but also have a good effect, but they also have obvious disadvantages.

The application of support vector machine in the field of sustainable utilization of water resources is not a lot. This paper expounds the present situation of research on Sustainable Utilization of water resources, support vector machine, this paper introduces the principle of SVM classification and regression algorithm, and use it to establish evaluation model and prediction model of water resources carrying capacity of sustainable utilization of water resources. Finally, the example application, the status and development trend of the bearing capacity and the degree of sustainable utilization of water resources, but also enriches the research methods and contents of the research in the field of sustainable utilization of water resources, expand the scope of application of the theory of support vector machine.

Acknowledgments

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