Construction of Content Repository based on Water Saving Knowledge

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Abstract: With the continuous development of social economy, water resources have been difficult to meet the water demand of social and economic development. To alleviate the water crisis, saving water is the first step, so that water saving can be implemented in every link of all walks of life and carried out for a long time. Over the years, the whole society water-saving work propaganda is much, but the effect is poor. The existing water-saving policies, systems and technologies are still far from being fully implemented. Advanced technologies and concepts are urgently needed, supported by information technology means, to achieve water-saving socialized services. This paper collects and classifies water-saving technologies, water-saving related laws and regulations and water-saving common sense by industry and classification. The water-saving knowledge is visually described on the visualization platform based on Java EE and SOA architecture. Taking the industrial circulating cooling water system as an example, the knowledge visualization process of related water-saving technology is introduced. According to the expression of water-saving knowledge, the module of water-saving knowledge base is constructed based on the granularity of water-saving knowledge. Using web development technology based on Java language and FTP server, a water-saving knowledge management system is developed and implemented. These findings can greatly improve the efficiency of water-saving work and make the water-saving work visible, feasible and credible. At the same time, the construction of water-saving knowledge base also has great reference significance for other industries to establish knowledge base.

1 INTRODUCTION

Water is not only the source of life for human survival, but also the essential basic element to maintain social development, and also the irreplaceable natural resource (Zhang, 2010). With the continuous expansion of global population and the tension of water resources, water resources have been difficult to meet the needs of social and economic development. Water resources' problems of different degrees have appeared all over the world, and water security has seriously affected many aspects of life, production, and ecology. To alleviate the water crisis, we must first start with water saving. It is particularly important to implement water saving in every link of all walks of life and implement it for a long time. Supported by information technology means and relying on advanced water-saving technologies and concepts, integrate the current water-saving policies, systems, and technologies of various industries, so as to make these contents serve the socialization of water-saving and thus improve the water-saving awareness of the whole society. It is of great practical significance to involve all walks of life in water-saving work, gradually achieve water-saving self-discipline, and study water-saving socialized services and their applications.

Scholars and institutions at home and abroad have carried out a lot of research and Practice on water saving and made considerable research progress. It mainly focuses on water-saving technology and water-saving socialized services. In terms of water-saving technology, Schuck et al. (2005) studied the relationship between drought and water-saving irrigation technology in Colorado, and inferred those farmers will take more effective irrigation measures

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with the aggravation of drought. Ali et al. (2021) analyzed the impact of rainfall change on rainwater control and water saving performance of rainwater collection system. Su et al. (2021) used structural equation model to evaluate and analyze the factors affecting farmers' water-saving behavior in loess hilly area. Surendran et al. (2021) studied the application of high-efficiency water-saving technology in Indian rice production under the scenario of climate change. Liu et al. (2021) studied the impact of expanding the scale of agricultural water-saving facilities on the carrying capacity of Tarim River Resources Based on the system dynamic model. Chen et al. (2021) proposed the optimization method of sleep to irrigation mode for effective utilization of rainfall, so as to make full use of rainfall and tap water-saving potential. At present, water-saving socialized service at home and abroad is mainly carried out from the perspective of water-saving publicity, public participation and knowledge service. In terms of water-saving publicity, in order to do a good job in water-saving publicity, the United States invited more than 100 experts to make a water-saving publicity report and organized students to participate in the water-saving publicity system (Sahin & Manioglu, 2018). In order to solve the problem of lack of water resources, Japan has established a complete set of water-saving publicity system (Schein et al., 2019). In terms of public participation in water conservation, Wali et al. (2005) elaborated on Hungary's legislation on public participation in water resources management. Based on the research of public participation in water pollution prevention and control, Li (2014) analyzed the problems and solutions in public participation in water pollution prevention and control supervision. In terms of knowledge service, Huang and Diao (2007) proposed that the core technology of knowledge service is semantic association, which has guiding significance on how to associate knowledge points and build knowledge base through semantics. Kao and Wu (2012) studied the characteristics of knowledge service objects and divided knowledge services into personalized theme services and personalized customization services.

At this stage, while seeing the achievements of water-saving work, it is not difficult to find that there are still some outstanding problems to be solved. (1) Emphasis on technical water-saving, so the investment in the operation process is large and the effect is not necessarily obvious. Moreover, due to the influence of economic factors, a considerable number of water-saving technologies or appliances have not been well applied. Although some enterprises have installed water-saving and pollution reduction facilities, the utilization rate of facilities is not high due to cost reasons. (2) Systems and policies are frequently introduced, but lack of operability. Since 2016, various ministries and commissions of the Chinese government have issued a large number of laws and regulations and formed a large number of relevant documents, which were finally shelved because they were unable to operate in practice. (3) It emphasizes the leading role of the government in water-saving work, ignoring the contribution of individual psychological cognition, subjective attitude and behavior mode to water-saving. (4) A lot of water-saving publicity has been done, but the effect is not good. The whole society has a unified understanding of water-saving, but the participation in water-saving is still not high. In fact, the current water-saving work in all aspects seems to be a whole, but in fact it is still separate, and there is not much linkage between each other. To change the concept of the whole society, change passive water-saving into active water-saving, and improve water-saving awareness, it is impossible to truly serve the water-saving activities of the whole society without the landing of a perfect water-saving socialized service application.

In view of the above problems, based on the collection of water-saving system, technology, experience and other information, this paper builds a visual platform based on Java EE and SOA architecture, which turns the complex water-saving process into simple and easy visual information to understand, and uses Java Web technology to build a water-saving knowledge base, which can save water in industry, agriculture, life, etc. Unconventional water resources utilization and other water-saving business are packaged into knowledge map and stored in water-saving knowledge base in order to solve the problems of unclear water-saving process and low efficiency in traditional water-saving work.

2 WATER-SAVING KNOWLEDGE COLLECTION

Industry, agriculture, life and other different industries have accumulated a lot of data in water-saving techniques, processes, policies, systems, knowledge and other aspects, but these industry data have not been fully utilized, not fully knowledgeable and systematic. The first step to build a water-saving knowledge base is to collect this knowledge. In this paper, water-saving knowledge is divided into three categories: water-saving technology, water-saving knowledge, water-saving policies, regulations and related systems. On this basis, on this basis, knowledge collection is carried out.

2.1 Water-saving Technology

Water-saving technology comes from all kinds of water-saving knowledge obtained in production and life. According to different ways of water use, it can be divided into industrial water-saving technology, agricultural water-saving technology, domestic water-saving technology and utilization of unconventional water resources (Tang & He, 2005).

2.1.1 Industrial Water-saving

Industrial water-saving can be divided into technical and management water-saving (Wolka et al., 2021). The technical measures include two ways. One is to establish and improve the circulating water system, the other is to reform the production process and water use process. There are two main technologies, one is to adopt new water-saving process, the other is to adopt non pollution or less pollution technology (Li et al., 2015). Management measures include measurement management and key water process management.

2.1.2 Agricultural Water-saving

Agricultural water-saving can be divided into engineering, technology and management. Agricultural water-saving is a system engineering of comprehensive development and utilization of water, soil and crop resources (Zhang et al., 2021).

2.1.3 Domestic Water-saving

In a broad sense, domestic water-saving includes two aspects, one is engineering technology, the other is management means. Engineering technology is mainly to carry out reasonable urban layout, promote the transformation of urban water supply pipe network, improve water supply efficiency and reduce the leakage rate of pipe network. The management means include strengthening water supply and water management, promoting water-saving technology and water-saving appliances.

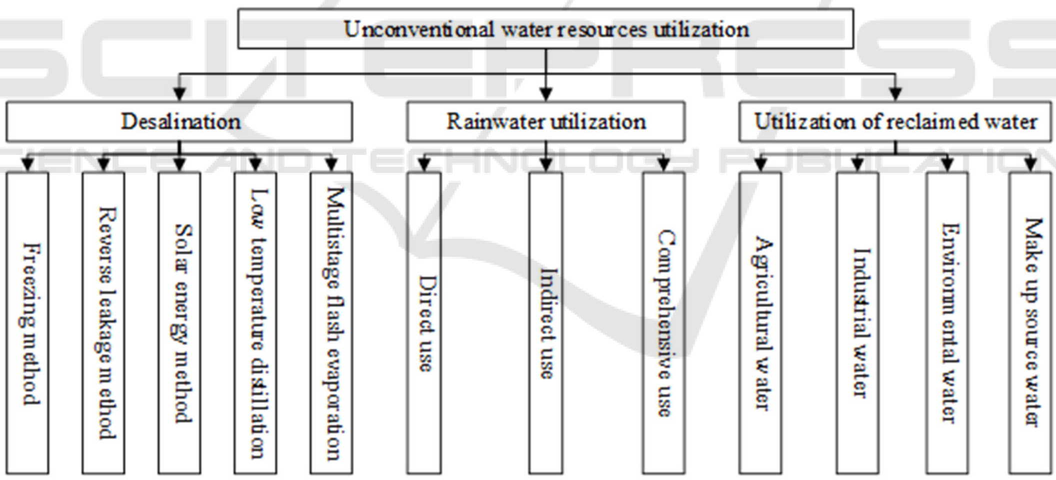

Figure 1: Classification chart of unconventional water resources utilization

2.2 Unconventional Water Resources Utilization

Unconventional water resources refer to (conventional) water resources which are different from surface water and groundwater in the traditional sense, mainly including rainwater, reclaimed water (reclaimed sewage and wastewater), seawater, air water, mine water, brackish water, etc. The characteristics of these water resource are that they can be recycled after treatment. The development and utilization of unconventional water resources can replace conventional water resources to a certain extent, accelerate and improve the circulation process of natural water resources, and make the limited water resources play a greater role (Qu et al., 2005; Xia & Sun, 2015; Gao et al., 2018; Wang, 2017). The categories of unconventional water resources utilization are shown in Figure 1.

2.3 Common Sense of Water-saving

Different from water-saving technology, water-saving common sense is a knowledge system formed in people's daily life, which is basically unstructured knowledge and tacit knowledge. This common sense of water-saving can be transformed into useful knowledge by using the idea of regulation to guide the practice of individual water-saving behavior. This method can attract more personal attention than other water-saving technologies.

2.4 Water-saving Policies, Regulations and Related Systems

Water-saving policies and regulations are not only the major policy guiding water-saving work, but also the reference basis for formulating water-saving work. In principle, they define the basic rules that the whole society must follow in water-saving work. At the same time, policies and regulations can guide the public's water use behavior and adjust individual ideology to a certain extent. In this sense, policies and regulations can also enhance the awareness of water conservation of the whole society. Policies and regulations can be divided into major central policies, national policies and regulations, local policies and regulations, and other policies and regulations according to their levels. Water-saving technical standards can be divided into national technical standards, local technical standards or divided into different industries according to the industries.

3 VISUALIZATION OF WATER-SAVING KNOWLEDGE

Water-saving knowledge is different from other knowledge which has formed a system. Relatively speaking, it is more complex and has a wide range of sources. The knowledge description methods and structures of different sources are also different. In this paper, through the visual platform built by Java EE and SOA architecture, the water-saving knowledge is displayed in the form of components on the platform. Different modules can transmit data through arrows, so as to enhance the recognition of knowledge and realize the visualization of knowledge. Compared with the traditional visualization, knowledge visualization has the following characteristics: various forms, continuous expansion; Fast build, easy to use; Easy to understand and intuitive to show; it supports the evaluation and decision-making.

3.1 The Connotation of Water-saving Knowledge Visualization

The ultimate goal of water-saving is to open up sources and reduce expenditure. Specifically, it is to control the total amount of water resources and expand available water sources. The whole process management of water-saving business can be realized by visualizing the knowledge of water-saving technology and water-saving process through knowledge graph, which makes the whole water-saving process visible and credible. In the description of visual process, we can find the irrationality of water use process, find the water-saving potential, and realize the integrated service of "water management water-saving evaluation water-saving potential mining". The integrated service can strengthen the collection and processing ability of water-saving information, thus greatly improving the efficiency of water-saving work.

3.1.1 Water Management

In water-saving work, water management is the premise of water-saving evaluation and water-saving potential mining. Through water management, the total amount of water supply, water demand and water consumption in the process of water use is controlled. The water-saving management based on knowledge map can be more intuitive to show the water management, and can also make a horizontal comparison of water, water and consumption.

3.1.2 Water-saving Evaluation

On the basis of water management, the water-saving technology is evaluated. Different from the previous results evaluation, only the overall results of water use can be evaluated. So, the results of the evaluation cannot put forward targeted decision-making suggestions for improving water use process, process and water use technology. Therefore, process evaluation is needed. Knowledge graph provides a good representation for process evaluation. The whole water-saving process can be represented by a series of node units on the knowledge graph. The process evaluation of water use and water-saving process can analyze the water use efficiency of each link, and quickly locate the links that need to be improved.

3.1.3 Tap Water-saving Potential

After the water-saving evaluation, the water-saving potential is calculated. On the basis of the process evaluation, the water-saving potential of each water use link and water use process is excavated. According to the water-saving potential, reasonable suggestions for water-saving transformation are put forward.

3.2 Visualization Process of Water-saving Knowledge

In the process of knowledge visualization, determine the theme as "water-saving". According to the theme of water-saving, analyze the business processes and functions that you want to achieve, draw the knowledge graph on the platform, complete the service customization and component development according to the business requirements, and add the completed components to the drawn knowledge graph to realize the specific business functions. This paper takes the industrial circulating cooling water system as an example to illustrate the visualization process of water-saving knowledge.

The water use process of industrial circulating cooling water includes three links: Firstly, part of the return water through the circulating water is injected into the cooling tower and the pool under the tower, and then flows into the suction pool. The other part is filtered through the filter, and the filtered produced water is injected into the suction pool, and the backwashing drainage is injected into the waste pool. Secondly, various water purification substances, such as corrosion inhibitor and sulfuric acid, are added to the suction tank to supplement the purified water to the circulating water supply pipeline through the pump. Lastly, the water in the wastewater tank is pumped into the reuse water treatment station. The process can be displayed in the form of flow chart, but this method cannot display the data of each process and process, and there is a certain gap between the performance effect and the knowledge chart. The above process flow diagram is reconstructed in the form of knowledge diagram. The visual knowledge diagram of industrial circulating water system is shown in Figure 2.

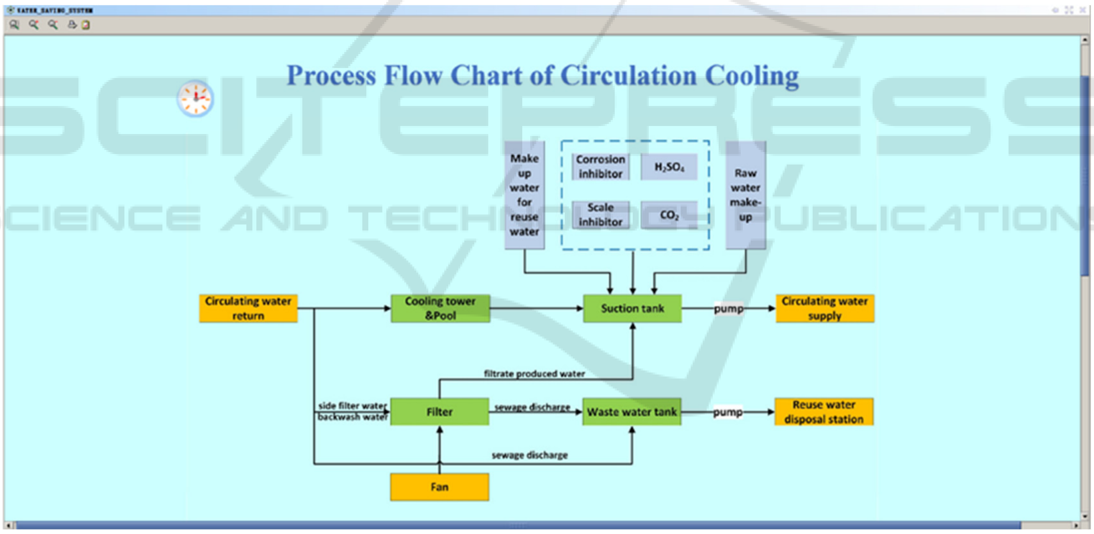

Figure 2: The visualization knowledge map of industrial circulating water system.

In Figure 2, each process unit is made into a component, which can not only explain the process of the industrial circulating water system, but also provide detailed data display for the operation of different time scales, so that users can master the operation status of the industrial circulating water system, and provide decision-making services for the later system upgrading and transformation according to the data and information. Each process unit is connected by an arrow. The flow direction of the arrow represents the flow direction of the data. Each process unit corresponds to the corresponding process method. After the data is transferred by the arrow, the calculation data of the current node can be transferred to the next node for display or calculation. Click the time selection box icon to pop up the time selection box. After selection, click OK to transfer the data of the selected date into the knowledge diagram, and click to view the basic data information of each sub process on the selected date. The results are shown in Figure 3.

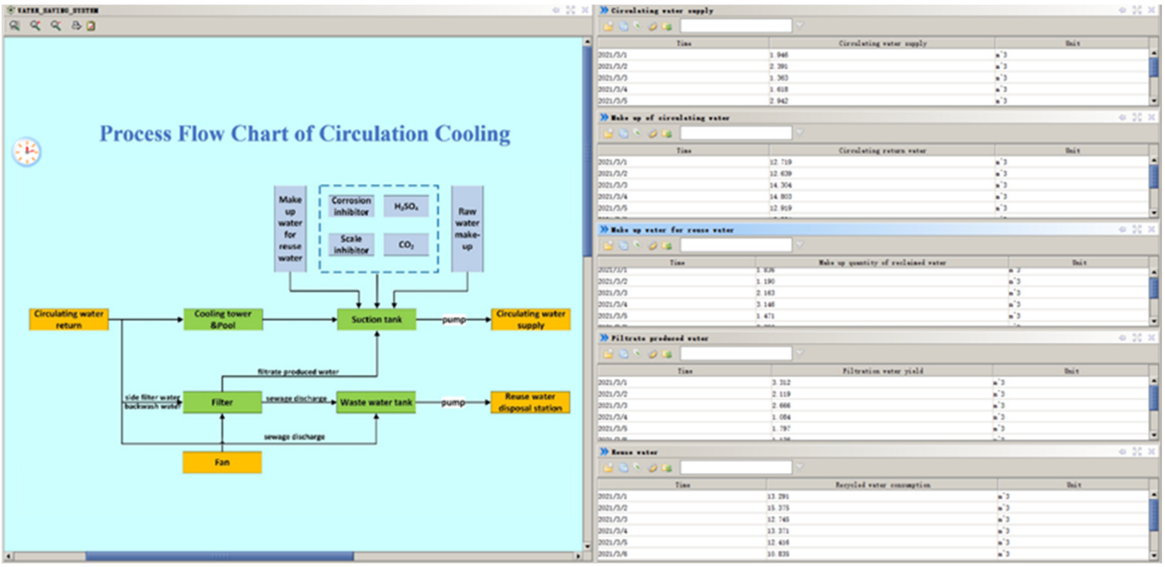

Figure 3: Basic data information of water quantity in each process link.

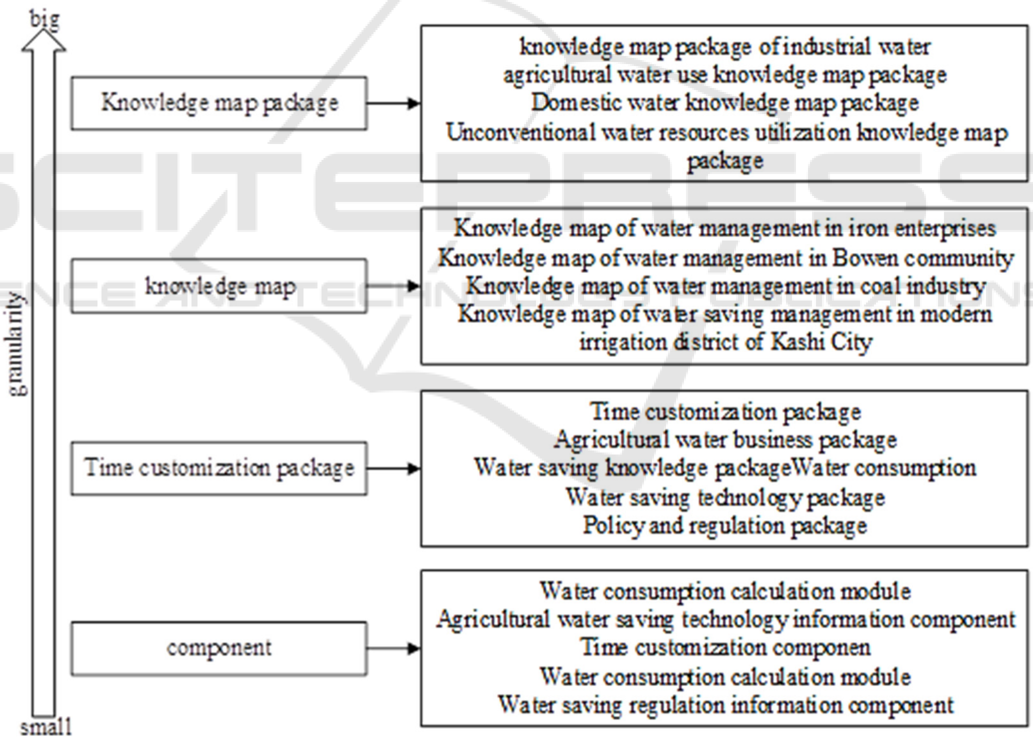

Figure 4: Graph of knowledge granularity.

4 CONSTRUCTION OF KNOWLEDGE BASE

In a broad sense, knowledge management refers to the process in which the managers of an organization manage and utilize the acquisition, storage, transmission and application activities of internal and external knowledge in order to improve the ability of knowledge and value creation. Due to the form of knowledge representation will affect the form of knowledge management, the knowledge management studied in this paper mainly focuses on knowledge storage and management (Iyengar et al., 2021). Effective knowledge management can improve the utilization of knowledge, which is an important basis to build knowledge services. The existing knowledge base is often aimed at the storage of knowledge, just to classify and store the knowledge, and ignore the effective management of knowledge, cannot combine knowledge with practical work closely, cannot produce the effect of knowledge service. The construction of water-saving knowledge base needs to consider the characteristics of water-saving knowledge and the objects of water-saving knowledge service, and must meet the characteristics of practicality, integration, scalability and openness.

4.1 Construction Ideas and Steps

The core of water-saving knowledge base construction is to adopt different management methods for different granularity knowledge. The knowledge constructed in this way can be divided into knowledge package, knowledge map, component package and component according to the granularity. According to the granularity of knowledge, file storage can effectively ensure the organization and query of knowledge. In the aspect of file storage, knowledge graph and components have the unity of file format, so it is convenient to store and use. Figure 4 is the knowledge granularity partition of knowledge graph.

The construction steps of knowledge base are as follows: (1) All kinds of analysis methods involved in water-saving business are split according to their functions, and then the independent components with standard input and output are packaged successfully, and various business functions are realized through customized components (Yang et al., 2020). (2) All kinds of components of water-saving business are encapsulated into standard web service components, and the registration and publishing platform of web service is built by using UDDI, so that the components can be published through web service to provide services to users (Mitrovic et al., 2016). (3) The specific water-saving business is generalized as a process unit, and drawn in the form of knowledge graph on the visual platform based on SOA and Java EE architecture, and the packaged functional components are added to the knowledge graph. Through the drawing of knowledge graph, the water-saving business process, logic and calculation process can be clearly expressed, and the water-saving business simulation system can be built (Li et al., 2020; Xie et al., 2010). (4) The paper uses Java Web technology to build web management system, stores knowledge map files of different granularity in FTP server. Java provides commons-net package to provide FTP tools and file server to connect, and realizes the management of knowledge map of different granularity (Jing, 2019).

4.2 Module Division and Construction

Based on the representation method of water-saving knowledge, water-saving knowledge is divided according to knowledge granularity. Based on this method, water-saving knowledge base includes two modules: component package management module and knowledge map (package) management module.

4.2.1 Management Module of Component Package

Management module of component package can be divided into two forms for management. One is to organize components according to the theme of knowledge graph to form component package. The other is to organize components according to specific business functions to form component packages. When users need a theme based component package, they can download the corresponding theme based component package. When users need a function based component package, they can download the corresponding function based component package. When drawing the knowledge map, they can flexibly customize the required services and components.

4.2.2 Knowledge Map (Package) Management Module

The knowledge map (package) management module stores the knowledge map in different topics according to the theme, draws the knowledge unit into the knowledge map, and stores the file in. KGZ format in the water-saving knowledge base. Similarly, the knowledge graph is stored according to the topic, and the version of the same knowledge graph will be iterated correspondingly during the development and use of the same knowledge graph, so as to facilitate the reuse of sub knowledge graphs or components by different knowledge graphs. The management interface of the knowledge map (package) management module is shown in Figure 5.

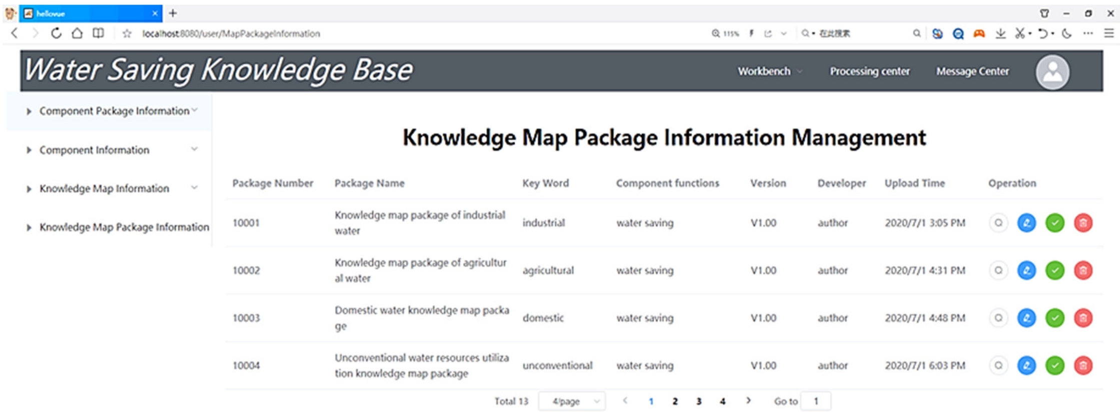

Figure 5: Interface of knowledge package management module.

According to the specific needs of water-saving services, the corresponding knowledge package can be downloaded by selecting the corresponding knowledge package in the knowledge package management interface. The downloaded knowledge package in .KGZ format can be opened on the built visualization platform. According to the specific business needs, the specific business functions can be deleted by adding and deleting the corresponding node units in the knowledge map. On the knowledge map management interface, click "water-saving technology and efficient water management of iron and steel enterprises" to download the knowledge map, which can be opened on the integrated platform, as shown in Figure 6. According to the new demand of water-saving, the knowledge map can be modified.

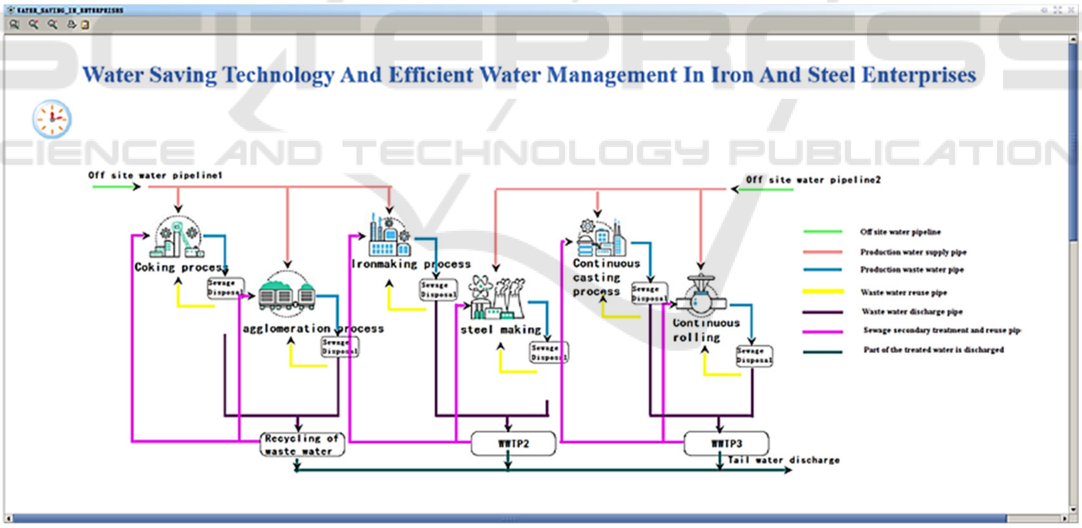

Figure 6: Water-saving technology and efficient water management in iron and steel enterprises.

5 CONCLUSION

In this paper, the use of information technology, based on water-saving knowledge of different industries to build water-saving knowledge base, and to cycle cooling water process for case analysis, found that the following conclusions: compared with the traditional water-saving services, the establishment of water-saving knowledge base has great advantages. In the practical work, users only need to download the corresponding knowledge map (package) from the water-saving knowledge base according to the specific business needs, then they can carry out the research on the related water-saving business. After modifying the knowledge map according to the business needs, they can carry out the application of the corresponding water-saving business, which greatly simplifies the operation process and improves the efficiency of water-saving work.

The construction of water-saving knowledge base can greatly improve the efficiency of water-saving work, and make the water-saving knowledge service visible, feasible and credible. At the same time, based on the integrated platform, different business needs can customize different components, draw different knowledge maps, and build a knowledge base on the basis of collecting industry knowledge. Therefore, the research results of water-saving knowledge base construction in this paper also have great reference significance for other industries to establish knowledge base.

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REFERENCES

Ali, S., Zhang, S., & Chandio, F. (2021). Impacts of rainfall change on stormwater control and water-saving performance of rainwater harvesting systems. *Journal of Environmental Management*, *280*(5), 111850.

Chen, M., Yang, L., Wu, G., et al. (2021). Optimization of paddy rice irrigation schedule considering effective utilization of rainfall. *Water*, *15*(5), 145-153.

Gao, X. R., Chen, Q. Y., Lu, S. B., Wang, Y. B., An, T. L., Zhuo, L., & Wu, P. T. (2018). Impact of virtual water flow with the energy product transfer on sustainable water resources utilization in the main coal-fired power energy bases of Northern China. *Energy Procedia, 152*(5*)*, 293-301.

Huang, N., & Diao, S. H. (2007). Ontology-based enterprise knowledge integration. *Robotics and Computer Integrated Manufacturing*, *24*(4), 562-571.

Iyengar, K., Sweeney, J., & Montealegre, R. (2021). Pathways to individual performance: Examining the interplay between knowledge bases and repository kms use. *Information &Management*, *58*(7), 103498.

Jing, K. (2019). *Research on construction of water-saving knowledge base and application of social service.* Xi'an University of Technology.

Kao, S. C., & Wu, C. H. (2012). PIKIPDL: A personalized information and knowledge integration platform for DL service. *Library Hi Tech*, *30*(3), 490-512.

Li, M., Lu, X., Chen, L., & Wang, J. (2020). Knowledge map construction for question and answer archives. *Expert Systems with Applications*, *141*(5), 112923.

Li, W., Wang, H., & Du, H. (2015). Efficient utilization of water resources and water-saving technology. *Agriculture and Technology*, *35*(22), 218+227.

Li, Y. (2014). *Research on public participation in water pollution prevention and control*. Jilin University.

Liu, X., Zhang, M., Xu, J., Guo, Y., Duan, W., & Shen, Y. (2021). Study on water resources carrying capacity of Tarim River Basin Based on system dynamics model. *Geography of Arid Area*, *3,* 1-14.

Mitrovic, D., Ivanovic, M., Visakovic, M., & Budimac, Z. (2016). The Siebog multiagent middleware. *Knowledge-Based Systems*, *103*(5), 56-59.

Tang, R., & He, L. (2005). Policy Outline of water-saving technology in China. *Resource Conservation and Environmental Protection*, *4,* 9-11.

Qu, W., Zhao, J. H., Fan, W. Y., & Xue, Y. (2005). Countermeasures for development and utilization of unconventional water sources based on productivity of reclaimed water facilities. *Water Economy, 33*(4), 53-56+65+79-80.

Sahin, N. I., & Manioglu, G. (2018). Water conservation through rainwater harvesting using different building forms in different climatic regions. *Sustainable Cities and Society*, *44*, 367-377.

Schein, J., Chan, P., Chen, Y. T., Dunham, C., Fuchs, H., Letschert, V., McNeil, M., Melody, M., Price, S., Stratton, H., & Williams, A. (2019). Methodology for the national water savings models– indoor residential and commercial/institutional products, and outdoor residential products. *Water Supply,19*(3), 879-890.

Schuck, E. C., Frasier, W. M., Webb, R. S., Ellingson, L. J., & Umberger, W. J. (2005). Adoption of More Technically Efficient Irrigation Systems as a Drought Response. *International Journal of Water Resources Development*, *21*(4), 651-662.

Su, H., Zhao, X., Wang, W., Jiang, L., & Xue, B. (2021). What factors affect the water-saving behaviors of farmers in the Loess Hilly Region of China. *Journal of Environmental Management*, *292*(5), 112683.

Surendran, U., Raja, P., Jayakumar, M., & Subramoniam, S. R. (2021). Use of efficient water-saving techniques for production of rice in India under climate change scenario: A critical review. *Journal of Cleaner Production*, *309*(5), 127272.

Wali, A., Ma, X. J., & Zhao, S. X. (2005). Experience of public participation in water resources management in Hungary (Part I). *Water conservancy and hydropower Express*, *8,* 1-4.

Wang, X. (2017). Analysis on the present situation and Prospect of the development and utilization of extraordinary water resources in Gansu Province. Groundwater, *39*(02), 40-41.

Wolka, K., Biazin, B., Martinsen, V., & Mulder, J. (2021). Soil and water conservation management on hill slopes in southwest Ethiopia. II. Modeling effects of soil bunds on surface runoff and maize yield using AquaCrop. *Journal of Environmental Management*, *296*(5), 113187.

Xia, J., & Sun, X. (2015). Calculation and analysis of rational water allocation for unified management of water resources in Dezhou City. *Research on Water Conservancy Development,15*(07), 57-59.

Xie, J., & Luo, J. (2010). Water conservancy information integrated service platform and application mode. *Water Conservancy Informatization, 4,* 18-22.

Yang, R. B., Du, B., Yang, C., Jiao, P. F., & Zhou, G. (2020). Design of general command system framework based on Component Technology. *Information Technology and Network Security, 39*(09), 79-82.

Zhang, H., Zhou, Q., & Zhang, C. (2021). Evaluation of agricultural water-saving effects in the context of water rights trading: An empirical study from China's water rights pilots. *Journal of Cleaner Production*, *313*(5), 127725.

Zhang, J. (2010). *Optimal allocation model of water resources in Taiyuan city and its application*. Taiyuan University of Technology.