Conceptual framework of hierarchical water demand

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Abstract. Water resources demand analysis is one of the basic and core contents of water resources planning, allocation and management. Its mechanism analysis is the focus, hot spot and difficult point of future social water cycle research. Aiming at the problems of lack of mechanism of water resources demand analysis and the large forecasting results, Maslow's hierarchical theory of demand is introduced into the field of water resources demand. Based on the characteristics of individual water demand mechanism, the mechanism and characteristics of human demand for water resources in the process of life, production and ecological construction are analyzed, and the hierarchical theory of water resources demand is established accordingly. The theory divides water demand from low to high into three levels: rigid demand, elastic demand and luxury demand, and combines water demand at each level into three levels: basic water demand, reasonable water demand and representational water demand. Finally, based on this theory, the water demand forecasting method is discussed. The research results enrich the theory and method of water demand prediction, and lay a theoretical foundation for scientific prediction of future water demand.

1. Introduction

Water resources demand analysis is one of the basic and core contents of water resources planning, allocation and management. At present and in the future, with the implementation of new urbanization, industrialization and national energy and food security strategy, China will still face strong pressure of water demand growth, which puts forward higher requirements for water resources planning, management and rational allocation. It is of great theoretical and practical significance to analyze the relationship between water resources demand and economic and social development, to identify the mechanism and evolution of water resources demand, and to scientifically predict the development trend of water resources demand in the future, so as to strengthen water demand management and rational allocation of water resources, and to realize sustainable economic and social development and ecological security supported by water resources.

With the rapid development of the world economy and the emergence of water resource crisis, how to accurately predict future water demand in order to avoid waste of investment or reduce the occurrence of future water crisis has become an important research topic [1-3]. Extensive research has been carried out at home and abroad [4,5], water demand forecasting methods are also various. According to different standards, there can be different classifications. According to the research scope of prediction, it can be divided into macro-prediction and micro-prediction; if the accuracy of
prediction results is used, it can be divided into qualitative prediction and quantitative prediction, in which qualitative prediction is based on personal or collective experience and knowledge, with poor objectivity and poor reliability; quantitative prediction methods are also varied, and can be divided into time series according to different data processing methods. Method [6,7], Structural Analysis [8], Systems Analysis [9-11], Intelligent Algorithms [12-14] and mechanism forecasting methods [15], which basically cover the current water demand forecasting in various industries. But through the comparison, we can see that all kinds of methods have certain advantages and disadvantages. At the same time, considering the regional differences and the non-linear characteristics of the water demand process, it is difficult to accurately predict the water demand process. With the increasing trend of global warming, considering the possible impacts of climate change, it has become an important issue for water resources planning and management to propose practical methods to accurately predict future water demand [16,17].

It is worth noting that in many water resources forecasting projects carried out in China, it has been believed that the quota of domestic water use will be in an increasing state; as the forecasted population is also growing, the forecast of future water consumption has been much larger than the base year [18,19]. With the passage of time, the results of water demand forecasting in different periods in China have been gradually confirmed: facts have proved that some of the forecasting results are generally higher than the actual water consumption in corresponding periods [20]. On the one hand, there may be some misunderstandings in the prediction, such as mistaking that with the development of economy and society, water consumption will inevitably increase [21]; mistaking that the development of industry will inevitably increase water consumption; mistaking that urbanization will inevitably increase urban water consumption, etc., in essence, the law of water demand growth for economic and social development is not well understood, and the mechanism and rules of water demand are not clear [22,23]. Laws, not from the perspective of water users to explore its real water demand; on the other hand, the actual water use value is low, it may also be that the actual water demand has not been met, water users have been in a state of water shortage [24].

From the above analysis, we can see that the future water demand prediction and management should start from the water users’ own water demand, meet their reasonable rigid demand, regulate their unreasonable water demand, and realize the matching of water resources and economic and social development. This study will draw lessons from Maslow's hierarchical demand theory, try to establish a theoretical framework of hierarchical demand for water resources, and lay a theoretical foundation for scientific prediction of future water demand.

2. Method
The influencing factors include weather factors (temperature, precipitation, etc.), economic development standards (income, water consumption devices, etc.), household size and composition, water conservation awareness levels, etc.

![Figure 1. The pyramid of Maslow's hierarchy of needs.](image-url)
In the 19th century, Marx and Engels divided human needs into three levels: survival, enjoyment and development. The satisfaction of people's needs for survival, enjoyment and development depends not only on the level of productivity, but also on a certain economic system (as shown in figure 1).

In 1943, Abraham Maslow, an American psychologist, put forward in his paper Human Incentive Theory that people achieve self-development in the process of satisfying their needs constantly, and at the same time promote the progress of human society [25]. Needs can be divided into five levels according to their priorities: physiological needs, safety needs, social needs, respect needs and self-realization needs, that is Maslow's needs. Maslow's Hierarchy of Needs, also known as "the hierarchy theory of basic needs", is one of the theories of behavioral science. Five kinds of needs are from low to high, and they are rising step by step according to the level. After the realization of the low-level needs, the demand still exists, but it is no longer the main incentive factor. The next-level high-level needs are replaced by the main driving force to motivate people's behavior. In this process, people's enthusiasm is fully mobilized, people are engaged in purposeful and objectified practice activities constantly to meet the needs. And efforts. Maslow's hierarchy of needs theory takes healthy people as the research object, takes people as the basis, starts from the realization of individual's psychological needs and values, reflects the universal law of human behavior and psychological activities, and has been widely used in psychology, enterprise human resources management, clinical medicine and other fields [26]. Demand is the motive of human practical activities. Demand stimulates human's conscious and purposeful objectified practical activities. Therefore, through the study of human needs, the law and direction of human practical activities can be revealed [27].

Most people's demand structure is very complex, whenever there are many demand-influencing behaviors, people are always trying to meet a certain demand, once one demand is met, there will be another need to replace it; generally speaking, only after the lower demand is met, the higher demand will have enough dynamic driving behavior; to meet the higher demand. There are more ways to meet the needs of lower levels. Maslow and other behavioral psychologists believe that the hierarchy of needs of the majority in a country or region is directly related to the level of economic development, scientific and technological development, culture and education of the people in that country or region.

According to Maslow's five-level theory of demand, management theory is divided into X theory and Y theory. X theory is an authoritarian management theory, which assumes that people's work is driven by physiological and safety needs, that work is only a means to meet low-level needs, and that people are naturally disgusted with work. Therefore, managers must adopt guidance, control, coercion and even punishment for workers. McGregor opposed this theory and put forward his Y theory, which is based on Maslow's needs of belonging and love, respect and self-realization.

Since 1959, Maslow has been increasingly involved in the Eastern perspective. The study of Oriental Culture prompted Maslow to reflect on his own concept of human nature, and combined with his in-depth study of the spiritual life and behavior of self-fulfilling people, he found that there is also an inherent spiritual dimension in human nature, that is, self-fulfilment or self-fulfilment beyond the spiritual level of the highest need. Maslow felt that the hierarchical structure of five-tier needs was not complete and self-fulfilment could not be the ultimate goal of human beings. More and more he realized that the emphasis on the level of self-realization would lead to unhealthy individualism and even self-centered tendencies. Fifteen years later, before his death, Maslow published an important article, Theory Z, in which he rethought the demand theory he had developed over the years and added the sixth level of demand, self-transcendence, to three levels of theory, namely, X theory, Y theory and Z theory. Z theory is based on X theory and Y theory, emphasizing transcendental needs. Management based on this need should take into account the incentive function of superpersonal value, existential value or cosmic value, assuming that people have the need to dedicate themselves to greater goals than themselves and the spirit of self-sacrifice.

Maslow's hierarchy of needs theory has had a far-reaching impact after it came out. It has been applied in human resources industry, education industry, floating population management, young teacher's management, management psychology, enterprise salary formulation and so on.
3. Conceptual framework of hierarchical demand for water resources

3.1. Analysis of water demand behavior based on Maslow’s demand hierarchy theory

Based on research, it was found that the primary categories of water needed by residential households are: water for drinking, cooking, washing, bathing, laundry, toilet flushing, home cleaning, home maintenance and sports & recreation (the water needs categories might not be applicable to every household). The characteristics of the different water needs categories are mainly independent, where each water category exists on a parallel basis and generally does not overlap with other categories.

Water is the source of life, and all kinds of human physiological activities need water. Water is the key to production, and economic development cannot be separated from water. Water is the basis of ecology. Water plays an important role in the process of ecological environmental protection and construction.

For individual human beings, living is for survival, production and ecology are for better living and better survival. Therefore, according to the specific functions of needs, they can be divided into drinking water demand, food demand, clothing demand, health demand, accommodation demand, entertainment demand, safety demand, knowledge demand and so on. According to Maslow’s hierarchy of needs theory, the above water needs correspond to different levels (as table 1 shows).

| Functional classification | Hierarchical classification | Examples of water use activities |
|---------------------------|-----------------------------|----------------------------------|
| Class                     | Subclass                    |                                  |
| Drinking                  | Drinking                    | Physiological demand             | Daily drinking water |
|                           |                             | Safety demand                    |                      |
| Food                      | Food processing             | Physiological demand             | Water for food production and processing |
|                           |                             | Social demand                    | Cooking and washing water |
| Accommodation             | Room temperature            | Physiological demand             | Water for Construction Industry |
|                           |                             | Social demand                    | Water for air conditioning and heating |
|                           | Greenland                   | Physiological demand             | Greening water        |
|                           |                             | Social demand                    |                      |
| Security                  | Fire control                | Safety demand                    | Water for fire fighting |
|                           | Medical care                | Safety demand                    | Disinfection water   |
| Hygiene                   | Clean                       | Physiological demand             | Self-cleaning, washing, bathing |
|                           |                             | Social demand                    |                      |
|                           | Housekeeper                 | Physiological demand             | Cleaning of environment and equipment, towing and car washing |
|                           |                             | Safety demand                    |                      |
|                           |                             | Social demand                    |                      |
| Clothing                  | Clothes                     | Social demand                    | Water for Clothing Processing |
|                           | Shoes                       | Esteem demand                    | Water for washing clothes and shoes |
| Entertainment             | Sports activities           | Social demand                    | Water for product processing |
|                           | Party tourism               | Esteem demand                    | Water use for facilities and sites |
| Seek knowledge            | Seek knowledge              | Esteem demand                    | Water for product processing |
|                           |                             | Self-fulfilment demand           | Experimental water    |
|                           |                             | Self-transcending demand         |                      |

Drinking water demand is not only the basic need for human survival, but also the demand directly related to water.

Food demand is mainly related to the production and processing of food and water demand in the cooking process. The latter mainly includes the thawing, cleaning and processing of food materials, cleaning of cooking utensils and tableware. Food demand at the lower level of demand is only for the purpose of maintaining life consumption. Food demand at the higher level of demand is for shaping a certain social status: eating delicate food usually shows a certain social identity and gains the recognition of other social individuals, thus forming a sense of psychological satisfaction.
Similarly, the demand for accommodation also spans many levels of demand, which are embodied in the maintenance of residential environment temperature (cooling, heating) and landscape construction (greening).

Safety needs can be subdivided into fire safety needs and medical safety needs. Fire safety needs are mainly manifested in water for firefighting, while medical safety needs are mainly manifested in water for clinical treatment, water for operation and other water with obvious disinfection attributes.

Health needs include cleaning needs for individuals themselves and for the environment in which they live. Cleaning needs include washing, bathing, laundry, etc. Different levels of cleanliness correspond to different levels of demand. The cleanliness corresponding to the lowest level of demand only guarantees normal physiological activities. The cleanliness corresponding to the higher level of demand often stems from their own pursuit of comfort or social needs. The higher the level of demand, the greater the amount of water consumed. Cleaning demand is similar to cleaning demand, but the difference is that the degree of intimacy with individuals is reduced. Cleaning needs are mainly for the environment and equipment cleaning, including toilet flushing, floor mopping, car washing and so on.

Clothing demand and entertainment demand mainly include water used in the production and processing of products (clothes, shoes, entertainment products, etc.), as well as water used in the washing and use of products.

The demand for knowledge is a high-level demand with respect, self-realization and self-transcendence as its main body. The satisfaction of individual demand for knowledge can be recognized and respected by other individuals. The demand for knowledge can be met through learning and research (mainly corresponding to experimental water).

Generally speaking, human needs play a decisive role in water demand for economic and social development, which mainly includes two aspects: on the one hand, water is one of the physiological needs of human survival, and aggregated human (population) is one of the main determinants of water use for daily life, and population size directly affects the total amount of water used for daily life; on the other hand, because human beings have a direct impact on food, industrial products and ecological environment. The demand of environment indirectly determines the scale of water demand of agriculture, industry and artificial ecology in a region. At the same time, agricultural products and new industrial water-saving products in turn further affect domestic water use.

3.2. Construction of water resource demand hierarchy theory

According to the above analysis, in the process of economic and social development, water users' demand for water resources is also hierarchical. Therefore, this paper proposes a three-level and three-grade theory of water resources demand, including three-level and three-grade water demand, as shown in figure 2.

![Figure 2. Conceptual framework of hierarchical demand for water resources [28.]](image-url)
• Rigid demand: the first level demand is the lower level demand, which corresponds to the physiological and safety demand in Maslow's hierarchical theory of demand (X theory) [29]. Rigid demand refers to the basic amount of water needed to meet the basic needs of biological survival, start-up production of enterprises and basic health of rivers and lakes, mainly reflected in the demand for water. At this level, water resources become a limiting factor and are not satisfied. Water demand is facing a threat to survival; without the restriction of resources and engineering conditions, water demand at this level should be fully met; water demand at this level is also known as basic water demand.

• Elastic demand: the second level of demand, which is beyond the water resources limitation, corresponds to the social, respect and self-realization needs of Maslow's hierarchy of demand theory (Y theory) [30]. Water demand at this level is to meet the rapid economic and social development, of course, this development should be sustainable development. At this level, water use efficiency is high. Water resources, as a constraint factor of sustainable development, develop rapidly to meet water demand, while water shortage restricts its development. There is a large space for demand elasticity at this level. In the process of guaranteeing sustainable economic, social and ecological environment security, water demand at this level should be dynamically regulated and controlled so as to keep water demand within a relatively reasonable range. The sum of rigid and elastic demands of water resources is called reasonable demand.

• Luxury demand: it belongs to the third level of demand and is also the highest level of demand, which corresponds to the self-transcendence demand (Z theory) in Maslow's hierarchy of demand theory. Luxury demand has a certain stage. At this stage, water demand beyond the scope of reasonable demand can be called luxury water demand, such as wasteful water demand caused by inefficient water use and technical level system. Technical water demand and conceptual water demand caused by backward water use habits should be gradually reduced through different control measures. For the future stage, people and nature live in harmony and achieve human-water harmony [31], coordinated development of economy, society, ecology and environment, fair and just water use; At this stage, the project conditions play an extreme role, the whole society has achieved comprehensive water saving, water use efficiency is very high, water demand tends to be stable, at this time luxury demand into a reasonable demand, should be met. The above three levels of water demand are called representational water demand.

4. Discussion
At present, the commonly used water demand forecasting methods at home and abroad mainly include index forecasting method, quota forecasting method, trend forecasting method and so on. Each method has its advantages and disadvantages. Generally speaking, the long-term water demand forecasted is on the high side. The water demand forecasting method is based on Maslow's hierarchical theory of demand should be based on the internal water demand mechanism of the main body of water demand (hereinafter referred to as the water demand mechanism forecasting method). Focusing on the study of its water consumption law, the method establishes the relevant water balance relationship, mainly from the perspective of the main body of water demand, through the study of the water consumption and replenishment mechanism of the main body of water demand. Only in this way can we fully consider all aspects of water demand, but this method requires a thorough understanding of water use, water demand mechanism and future evolution trend of each water demand body. The water demand mechanism of the main body of water demand is usually difficult to be quantitatively described by scientific methods. Even if empirical formulas are proposed based on experiments, there are certain assumptions [32]. If the assumption is unreasonable, the error may be larger than the result of traditional methods such as "quota method". There are many driving factors for water demand, and the impact is complex [33]. Therefore, the prediction method of water demand mechanism needs further study and practice.
5. Conclusions
Based on Maslow’s hierarchical theory of demand and the analysis of individual water demand behavior at micro level, this paper considers that human demand for water resources is hierarchical. Different demand behavior corresponds to different levels of water demand; different levels of water demand characteristics, driving mechanism and evolution law are different; then constructs a hierarchical theory of water demand, which divides water demand into rigid demand and elasticity. There are three levels of demand and luxury demand, which are basic water demand, reasonable water demand and representational water demand. The research results enrich the theory and method of water demand prediction, and lay a theoretical foundation for scientific prediction of future water demand.

Acknowledgments
This research was financially supported by the [National Natural Science Foundation of China] grant number [51625904, 51509267 and 51779271] and the [IWHR Research & Development Support Program] grant number [WR0145B522017 and WR0145B622017].

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