The standardization of water use statistics in China

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Abstract. This paper outlines the current situation concerning the standardisation of water use statistics in China. The water classification, statistical subjects, objects, methods and report templates are clarified in part regarding national total water use. Additionally, the standards of water use statistics for enterprises are introduced, which define statistical items, procedures, methods. Suggestions are proposed on issues such as insufficient statistical accuracy and imperfect statistical systems.

Keywords: Standardization, total water use statistics, water statistics in enterprises, water management.

1. Introduction

Water use statistics is the progress of collection, analysis, interpretation, and presentation of masses of water use numerical data of specific groups of enterprises and institutions. It is the foundation of planning and managing water use and which government bodies make decisions on as well.

Standardization of water use statistics is the process of implementing and developing water use technical standards like statistical objects and statistical methods based on the consensus of different parties that include firms, interest groups and governments. Standardization can help maximise compatibility, interoperability, repeatability, or quality. It can also facilitate the commoditisation of formerly custom processes. In social sciences, the idea of standardization is close to the solution for a coordination problem, a situation in which all parties can realise mutual gains, but only by making mutually consistent decisions. Therefore, without well-built standardization, it is impossible to run water-saving work well.

2. Current status of water use statistics

From the 1980s, China launched various programs like the assessment on the development and utilisation of national water resources, national long-term water supply and demand plan, comprehensive plan for national water resources, and conducted national surveys on supply and demand of water use in 1980, 1993 and 2000 respectively[1]. From 2010 to 2012, the first national water conservation census was conducted in China, taking counties as the basic unit, to investigate in details the economic and social water use in China (except Hong Kong and Macao special administrative regions and Taiwan province).
Since 1998, China has implemented the water resources bulletin system, in which the ministry of water resources announces the annual utilisation of water resources each year, including the statistical results of water use across the country. The water resources bulletin system is the main form of the current national total water consumption statistics system[2]. The water consumption in total and main categories of that from 1998 to 2018 are illustrated in the following charts. Agriculture contributes the most, covering 61.3% - 69.3% of the total water (chart 2), followed by industry, artificial ecological water supplement and residents living descendingly. The total amount of water use increased yearly from 2003, reaching its peak in 2013, and then gradually decreased to $6,015.5 \times 10^9 \text{ m}^3$ in 2018 (chart 1). The agriculture water use fluctuated the same trend given its dominated percentage (chart 2). The industry water use roughly flowed the trend except it peaked in 2011 (chart 3). However, the residents living and artificial ecological water supplement water use showed an upward trend in general (chart 4, chart 5). The latter two categories of water use trend might reflect the improvement of residents’ life quality. The reasons behind those different trends need to be investigated further, and the forecast of the structure need to be carried out, thereby enhancing the efficient water resources planning and using.

Source: China Water Resources Bulletin (1998-2018)

**Figure 1.** The trend of total water consumption in China from 1998 to 2018.

Source: China Water Resources Bulletin (1998-2018)

**Figure 2.** The trend of agricultural water consumption in China from 1998 to 2018.
Figure 3. The trend of industrial water consumption in China from 1998 to 2018.

Figure 4. The trend of domestic water consumption in China from 1998 to 2018.
Figure 5. The trend of ecological water consumption (artificial ecological water supplement) in China from 1998 to 2018.

For enterprises and public institutions and other general water users, through the measurement and statistics of water use, it is helpful to find out the amount and efficiency of water use of the unit as whole and its internal production processes, and afterwards identify the great water-saving potential, rationalise water management, and finally save water expenditure, and gradually build into a water-conserving enterprise.

With the rapid development of economy, the contradiction between supply and demand of water resources intensifies. In 2012, the state council issued the guidelines *Opinion on the implementation of the strictest water resources management system*, which defined the "three red lines" for water resources management and pointed out that China's total water consumption should be limited to no more than 700 billion cubic meters by 2030. In 2016, the ministry of water resources and the national development and reform commission jointly released the *action plan for controlling the total and intensity of water consumption during the 13th five-year plan period*, which set out more specific requirements. The implementation of these policies and action plans requires statistics on water consumption in various sectors of the institutions and society to provide technical support and data comparability.

3. **Standardization status**

3.1. **National statistical standardization of total water use**

In 2009, at the request of the ministry of water resources, China academy of water resources and hydropower drafted *The guidelines of water resources bulletin system* (GB/T 23598-2009), clarifying the substance and form on water consumption statistics[3]. In the establishment process of the national, regional and provincial levels bulletins. In 2014, in order to improve the quality of water resources bulletins and enhance the strictest assessment system on water resources management, the ministry of water resources drafted *The statistical solution of total water use (Trial version)*. It provided technical solutions for provincial administrative units to conduct agricultural, industrial, social and ecological water use statistical work, clarify the index system, statistical categories, statistics subjects and objects,
statistical method, report forms. It has reached a somewhat scientific and practical level. Several local governments have also drafted statistical solutions for local water use, such as *The statistical solution of total water use in Gansu Province (Trial version).*

3.1.1. **Statistical classification.** The water use classification is the progress of classifying water use according to the source, form, purpose, requirement [4]. Proper classification of water use could eliminate multiple duplications and omissions and improve efficiency by making data easier to locate and retrieve hereby demonstrating more accurate and objective results.

Since the implementation of the water resources bulletin system, China has made annual statistics on agricultural, industrial and domestic water use. In 2003, the river, lake and wetland artificial makeup water and urban ecological water, i.e. ecological water in total, are added into the bulletin system[5]. According to *The statistical solution of total water use (Trial version)*, the total water use is divided into four categories, namely, agricultural water, industrial water, domestic water and ecological water, with provinces (autonomous regions and municipalities directly under the central government) as regional units. The major categories and statistic items are shown in Table 1.

**Table 1.** The main categories and items of total water use statistic for provinces or other regional units

| Categories          | Statistic Scope                                                                 |
|---------------------|---------------------------------------------------------------------------------|
| Agricultural water  | Water used for irrigation (for cultivated fields, woodland, orchard land and grassland), water for replenishment in fishing ponds, water for livestock and poultry |
| Industrial water*   | Water used for such purposes as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. |
| Domestic water      | Urban domestic water (including residential water and public water), rural domestic water** |
| Ecological water    | Urban environmental water (including green space irrigation water and sanitation water), replenishment water into rivers and lakes*** |

*The quantities of recycled water within the enterprise and the river water used for hydropower are excluded. Furthermore, desalination seawater and reclaimed water intaken by industrial enterprises are counted as unconventional water sources. The seawater and other saltwater directly used by industrial enterprises excluded in the scope, but the amount needs to be listed separately.

**Water used for family-run hotels, restaurants, planting, livestock and poultry farming are not counted as domestic water if the water consumption is less than 20% of total household water use.

***Replenishment water into rivers and lakes refers to water replenished by artificial measures, excluding water naturally satisfied by precipitation and surface runoff.

The agricultural water includes irrigation water, fish pond water and water for livestock and poultry. The irrigation water includes the water needed for cultivated land, woodland, orchard land and grassland.

The industrial water use is calculated according to two categories: fire and nuclear power industry and non-fire and nuclear power industry, and mainly consists of water used for such purposes as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility.

The domestic water includes urban and rural domestic water. The urban domestic water includes water for urban residents and public use (including water for the construction and tertiary industry); the rural domestic water mainly includes water for rural residents and scattered livestock and poultry breeding.

The ecological water includes urban greening irrigation water, urban sanitation water, and river and lake replenishment water.
3.1.2. Statistical subjects. China's government is the main body of the national total water use statistics. The statistical solution of total water use (Trial version) defines the responsibility and accountability of water administrative departments at all levels in the process of water use statistics.

The provincial water administrative departments at the provincial level shall, as required, submit a list of survey objects within their respective jurisdictions, collect and verify the data reported by the administrative regions at different levels within their respective jurisdictions, and conduct statistics on the total water use. River basin agencies shall be responsible for checking and sampling the water use data and relevant information of the survey objects reported by provincial administrative regions, and reviewing the reported annual total water use, water use by different industries and other relevant statistical information. The ministry of water resources shall be responsible for the unifying of statistics nationwide and shall release the statistical results to the public.

3.1.3. Statistical method. There are two primary forms of total water use statistics in China, that is, measurement by metering facilities and calculation by typical analysis methods [6,7]. In The statistical solution of total water use (Trial version), water use is measured with different methods according to the water consumption scale. The divisions by water use scale for different statistic categories and their corresponding statistic forms are illustrated in Table 2.

| statistic categories and water-use scales | statistic methods |
|-----------------------------------------|-------------------|
| **agricultural water**                  |                   |
| irrigation                              | The irrigation area is more than 300,000 mu. * measured one by one |
|                                        | The irrigation area is between 1 mu and 30 mu. measured one by one if the water users are fully equipped with measuring instrument approaching the total amount of water use through typical analysis if the water users are not equipped with measuring instrument |
|                                        | The irrigation area is less than 1 mu. approaching the total amount of water use through typical analysis |
|                                        | water for replenishment in fishing ponds approaching the total amount of water use through typical analysis |
|                                        | water for livestock and poultry approaching the total amount of water use through typical analysis |
|                                        | public waterworks measured one by one |
| **industrial water**                    |                   |
|                                        | water users with annual withdrawal from self-supplied underground water reaching certain quantities ** measured one by one |
|                                        | water users with annual withdrawal from self-supplied underground water less than certain quantities approaching the total amount of water use through typical analysis |
| **domestic water**                      |                   |
|                                        | areas well covered by the public water supply network mainly obtaining from the water supply institutions |
|                                        | Others approaching the total amount of water use through typical analysis like sampling |
| **ecological water**                    |                   |
|                                        | urban environmental water approaching the total amount of water use through typical analysis |
|                                        | replenishment water in rivers and lakes obtaining from the water institutions based on actual replenishment |

* 1 mu is about 666.666 m²;
** The certain quantities scale differs according to the water resources status of each province.
The water consumption of water users whose agricultural irrigation area is more than 300,000 mu shall be measured one by one; the rest of them shall be measured with the method of sampling, whereby approaching the total amount of water use through typical analysis.

Public water supply users and industrial users whose annual water consumption reaches certain quantities are classified as key water users, water use of which shall be measured by each — however, industrial users whose annual water consumption below a particular scale shall be sampled.

Domestic water is primarily measured by typical sampling method to determine the water use for residents, construction and tertiary industry (for the areas well covered by the public water supply network, domestic water data can be obtained from the water supply institutions).

In term of ecological water, river, lake and wetland makeup water is measured one by one, and, urban ecological water is obtained by sampling.

3.1.4. Statistical report template. The water supply and water use template tables are given in The guidelines of water resources bulletin system. Moreover, The statistical solution of total water use (Trial version) systematically presents template tables in all aspects of the statistical process, including the table of the number of objects of different industries, the table of water use and related information for all categories and considerable detailed supporting tables. These tables are supplemented with the calculation methods for the convenience of the statisticians.

3.2. Statistical standardization of water use in industrial enterprises
For a long time, there have been notable differences in the water use statistical projects and statistical statements of enterprises in various industries in China, in lack of standardization management [8]. In 2011, the Chinese Institute of standardization and the national office of water conservation drafted The general rules on statistics of water use in enterprises (GB/T 26719-2011), which classify water use into three procedures, namely, intaking, using and draining water, and other water users can refer to this standard.

3.2.1. Statistical items for industrial enterprises. According to The general rules on statistics of water use in enterprises (GB/T 26719-2011), there are lots of individual water use processes for water intaking(including conventional and unconventional water withdrawals), using(including primary production water, affiliated production water, auxiliary production water, non-production water) and draining [9]. Meanwhile, the standard makes specific requirements on the form of statistical statements and management methods are illustrated. The calculation formulas of essential water use statistic items for industrial enterprises are displayed in Table 3.
After decades of exploration and practice in water use statistics, China had made significant progress in term of organisation and technology. However, there are still problems such as imperfect water use. Water balance test method for cement production enterprises (GB/T 12452-2008). This standard specifies the method, procedure, result evaluation and report templates of water balance test [10]. For specific industries, more elaborate water balance test standards have been formulated, such as Water balance test and calculation method for oil and gas field production system (GB/T 31457-2015) and Water balance test method for cement production enterprises (GB/T 36536-2018). These standards further enhanced the rational and accuracy of water use statistics.

4. Challenges and suggestions

While water use may be measured and determined by water balance test, the unconventional water intake of each category of unconventional water industrial enterprise or the unconventional water intake per unit product can be calculated for every product, or calculated by a set of comprehensive indicators of typical products.

### Table 3 The calculation formulas of statistic items for industrial enterprises

| Statistic items                              | Calculation formulas                                                                 | Notes |
|----------------------------------------------|--------------------------------------------------------------------------------------|-------|
| quantity of water intaking                   | \( V_i = \sum_{j=1}^{n} V_{ij} \)                                                  |       |
| quantity of unconventional water intaking\(^*\) | \( V'^i = \sum_{i=1}^{n} V_{di} \)                                                 |       |
| quantity of recycled water                   | \( V_c = V_{ci} + V_{ai} \)                                                        |       |
| quantity of water use                        | \( V_{uai} = V_i + V'^i + V_r \)                                                   |       |
| quantity of water intake per unit of products\(^*\) | \( V_{ui} = \frac{V_i}{Q} \)                                                      |       |
| quantity of unconventional water intake per unit of products\(^*\) | \( V'^{ui} = \frac{V'^i}{Q} \)                                          |       |
| quantity of total water intake per unit of products\(^*\) | \( V_{ui} = \frac{V_i + V'_i + V_r}{Q} \)                         |       |
| recycle ratio                                | \( R = \frac{V_i}{V_i + V_r} \times 100\% \)                                    |       |
| reused ratio of wastewater                   | \( K_w = \frac{V_w}{V_{wd} + V_{wr}} \times 100\% \)                             |       |
| equipping ratio of water measuring instrument| \( R_e = \frac{N_e}{N_i} \times 100\% \)                                          |       |
| water measuring ratio                        | \( K_m = \frac{V_{mai}}{V_i} \times 100\% \)                                    |       |

\(^*\) The amount of unconventional water is measured by the supply quantity after purification or desalination.

\(^*\) If the enterprise produced more than one kind of product, water intake quantity per unit product, the unconventional water intake quantity per unit product and water use quantity per unit product can be calculated for every product, or calculated by a set of comprehensive indicators of typical products.

3.2.2. Statistical subjects and methods. Water use may be measured and determined by water balance test. In 2008, China institute of standardization, Sinopec engineering construction company and other organisations drafted The general rules for water balance test in enterprises (GB/T 12452-2008). This standard specifies the method, procedure, result evaluation and report templates of water balance test [10]. For specific industries, more elaborate water balance test standards have been formulated, such as Water balance test and calculation method for oil and gas field production system (GB/T 31457-2015) and Water balance test method for cement production enterprises (GB/T 36536-2018). These standards further enhanced the rational and accuracy of water use statistics.

4. Challenges and suggestions

After decades of exploration and practice in water use statistics, China had made significant progress in term of organisation and technology. However, there are still problems such as imperfect water
measurement facilities, weak-skilled professional statisticians, poor-quality filling of statistical
templates, insufficient statistical accuracy, and imperfect statistical system [11,12]. There is much room
for improvement.

Well-built water measurement facilities are the premise of water use statistics, which should cover
the statistical objects well. As a result, China might strictly check the quality of facilities, and standardise
the management and monitoring in more details. Meanwhile it is necessary to conduct professional
training for relevant staff, to strengthen the sense of responsibility and professional skills.

With the implementation of the general rules for water balance test in enterprises and the general
rules for water balance test in enterprises, the standardization of industrial enterprise water use statistics
has reached a reasonable level. However, agricultural, residential and ecological water use account for
78.9% of China's total water use [13], and relevant technical guidelines are still lacking. Therefore, it is
necessary to establish statistical standards or guidelines for water use in agriculture, residential life and
ecological environment.

The statistical solution of total water use (Trial version) is a periodic guideline mainly aiming at the
statistical work from 2014 to 2020, mentioning expanding the scope of direct measurement in order to
improve the accuracy of the statistic. China might establish a set of long term and comprehensive
standards, which would be evaluated based on effects and updated through the revision process on
statistics projects and technical methods, to improve the precision and accuracy of water statistics, as
the decision-making basis for controlling consumption and the intensity targets of water resources.

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