Also, I suggest the authors add a graphical presentation of the research at the beginning of the paper showing inputs, methods and outputs with respective interrelations. That would help readers to follow the elaborate calculations.

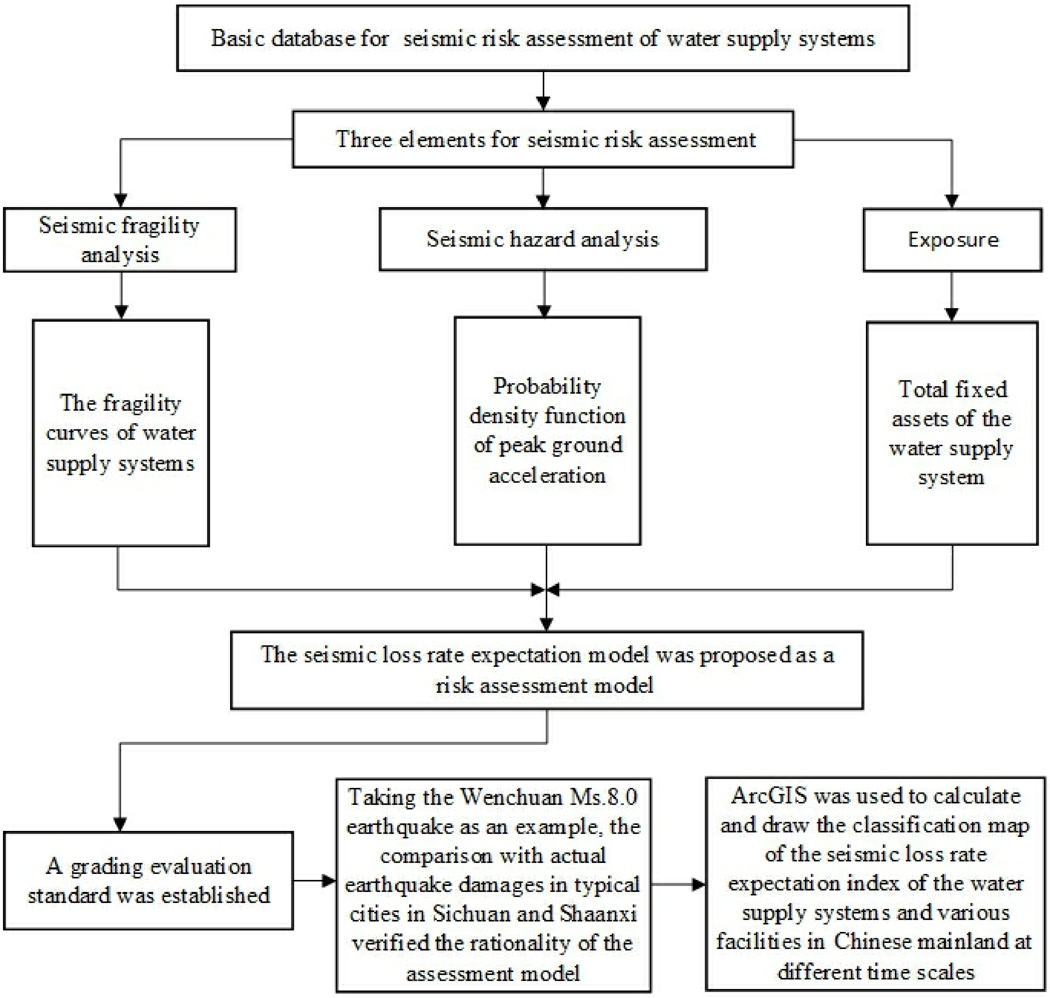

Figure 1 Flow Chart of Seismic Risk Assessment for Water Supply Systems

Adding a Discussion chapter can substantially improve the paper, especially in addressing the earthquake resilience of Chinese cities regarding water supply.

In terms of the research on the resilience of post-earthquake water supply networks, this article introduced the concept of recovery difficulty to evaluate the resilience of water supply networks after earthquakes. Recovery difficulty index could be calculated as follows:

$$R_d = \frac{Q_{La} - Q_{Lb}}{Q_{Lb}}$$

Q_{La} —Post-earthquake leakage rate（%）；

Q_{Lb}—Pre-earthquake leakage rate（%）.

This indicator has low requirements for the completeness of statistical data in practical operation, therefore it has practical engineering value. The changes in the leakage rate of water supply pipelines before and after an earthquake can reflect the damage situation of the pipeline network. The greater the leakage rate of the pipeline network after an earthquake, the more severe the damage to the pipeline network, and the greater the difficulty of recovery.

It can be seen from Table 1 that Mianzhu and Dujiangyan, where the seismic intensity was 9, the networks fortification intensity was 7, and the water supply networks damage level was destroyed, were the most difficult to recover. Secondly, Jiangyou, with an seismic intensity of 8, network fortification intensity of 7, and water supply network damage level of severe damage. The seismic intensity of Mianyang, Guangyuan, and Ningqiang was 7, and the seismic fortification intensity of the networks was 6. The difficulty of recovering the water supply networks after the earthquake was relatively low.

Table 1 Damage and Recovery Difficulty Index of Water Supply Networks in Wenchuan Earthquake

City	Pre-earthquake leakage rate（%）	Post-earthquake leakage rate（%）	Basic seismic ground motion (fortification intensity)	On site investigation seismic intensity	Seismic damage level	Recovery difficulty index
Mianzhu	17	85	VII	IX	Destroyed	4.00
Dujiangyan	27	60	VII	IX	Destroyed	1.22
Jiangyou	26	50	VII	VIII	Severe damage	0.92
Mianyang	12	17	VI	VII	Moderate damage	0.42
Guangyuan	21	24	VI	VII	Moderate damage	0.14
Ningqiang	20	25	VI	VII	Slight damage	0.25

1. The data set is not explained or shown in an overview table.

1. Basic database for risk assessment

The risk assessment data involved in this study includes regional basic data of the water supply system, including five categories. The first category is the material of the water supply pipeline network extracted from the "Water Supply Yearbook"(Statistical Yearbook of Urban Water Supply (2009-2018)). The second category is the urban basic fortification intensity extracted from the "Seismic Code"(GB50011-2010 Code for seismic design of buildings. (2010).). The third category is the urban population, GDP and other data extracted from the Census (National Bureau of Statistics of China. (2011).), which have been processed to provide urban classification. The fourth category is site classification. The fifth category is seismic hazard data extracted from the "Fifth Zonation Map"(GB18306-2015Seismic ground motion parameters zonation map of China. (2015).). The above basic data covers 720 cities in 31 provinces and autonomous regions except Taiwan, Hong Kong, and Macau.

（1）Regional basic data

1) Water supply system

This paper is mainly based on the pipeline material data in 2018 Water Supply Yearbook, and mainly collects the length data of five pipeline materials, namely, Ductile Cast iron pipe, steel pipe, Cast iron pipe, prestressed reinforced concrete pipe and plastic pipe. At present, data from a total of 720 cities has been compiled. Although the data covers 31 provinces and cities in mainland China, there are differences in data coverage for each province. The western region does not have complete data for the eastern region, such as Qinghai and Tibet, which only have data for one city each.

2) Fortification intensity data

This article extracts the seismic fortification intensities of 720 cities that have been organized in the "Seismic Code".

3) City category data (population and GDP)

Extract urban category data based on the urban population and GDP data from the 6th National Population Census released by the national statistical department. Determine the city categories of 720 cities through certain data processing methods.

4) Site Category Data

In the national site classification database established using the BP neural network site classification method (Allen, T. I., and Wald, D. J. (2007). Shi, D. C. (2009).), 720 site categories representing the city's water supply system were extracted.

5) Seismic hazard data

According to the determined potential source area division scheme, seismicity parameter scheme and ground motion parameter attenuation relationship, the peak acceleration a_{EI} under four different exceeding probability levels of basic ground motion, frequent ground motion, rare ground motion and extremely rare ground motion in I1 site category of grid averaged distribution sites nationwide was given by using the probabilistic seismic hazard analysis method and the basic database of the Fifth Generation Zonation Map. The grid density is $0.1^{\circ}\times 0.1^{\circ}$. This article extracted seismic hazard data for government residences in 720 cities from the database. Taking Heyuan city as an example, seismic hazard raw data could be seen in Table 2. The probability density function of the PGA of 720 cities was calculated by the piecewise fitting method of the seismic hazard curve.

Table 2 Seismic Hazard Data of Heyuan City (Raw Data of 4 Probability Control Points)

50 year exceeding probability	63%	10%	2%	0.5%
PGA（gal）	19.6	71.6	172.4	296.6

Among the 5 types of data in the above databases, the water supply networks data from the Water Supply Yearbook, the seismic fortification intensity of the Seismic Code, the population and GDP data from the Census do not require complex processing for this study. However, the site category data needs to be analyzed for accuracy and usability, and the seismic hazard data needs to be processed using seismic hazard analysis methods for this study. Taking the basic data of Heyuan City as an example, the database structure is shown in Table 2 and Table 3.

Table 3 Basic Data of Water Supply Network in Heyuan City

City code	Province Code	City	Province	Longitude	Latitude	Site category	City category	Fortification intensity
441600	440000	Heyuan	Guangdong	114.692	23.7367	II	3	7

Table 3(continuous) Basic Data of Water Supply Network in Heyuan City

Pipe category	Ductile cast iron pipe	Steel pipe	Plastic pipe	Prestressed reinforced concrete pipe	Cast iron pipe
Pipe length of water supply network (kilometers)	48.96	84.23	289.16	41.3	15

（2）Seismic damage data of water supply system

1）Water supply system data

This article collected seismic damage data from cities such as Haicheng, Tangshan, and Wenchuan (Institute of Engineering Mechanics, CEA.,1979. Institute of Engineering Mechanics, CEA.,2009.) and classified, organized and calculated the seismic damage matrices of water supply pipelines, water tanks, and pump houses according to the city classification and seismic damage data. A database of seismic damage data for water supply systems was established.

After sorting, the seismic damage rates of different materials of water supply pipelines in the Haicheng earthquake are shown in Table 4. The water supply pipeline materials are mainly cast iron pipes.

Table 4 Seismic damage rates of different pipeline materials in Haicheng earthquake (location/10 kilometers)

City	Steel pipe	Asbestos cement pipe	Cast iron pipe
Panshan（VII）	70.0	13.0	16.0
Yingkou city（VIII）	114.0	20.0	10.6
Yingkou town（IX）	21.0	70.0	12.3
Haicheng（IX）	157.0	90.0	212.0

The seismic damage rates of the water supply pipelines during the Tangshan earthquake was summarized in Table 5. Water supply pipelines include cast iron pipes, prestressed reinforced concrete pipes, steel pipes, and self stressing reinforced concrete pipes, with cast iron pipes accounting for the largest proportion.

Table 5 Seismic damage rates of water supply network in Tangshan earthquake (location/kilometer)

City	Pipe length（km）	Diameters（mm）	Average damage rate（location/km）
Tianjin（VII~VIII）	870	75~1000	0.18
Tanggu（VIII）	79.5	75~600	4.18
Hangu（IX）	-	-	10
Tangshan（IX~X）	111	75~600	4

After sorting, the seismic damage rates of various pipes in the water supply network during the Wenchuan earthquake are shown in Table 6.

Table 6 Seismic damage rates of water supply pipelines during the Wenchuan earthquake (location/10km)

Seismic intensity	Steel pipe	Cast iron pipe	Cement pipe	PE pipe	Ductile cast iron pipe	PVC pipe
VI	0	1.50	0	0	0	0
VII	0.60	12.90	8.30	3.00	0.34	6.14
VIII	22.30	40.00	20.36	8.00	1.20	25.00

2）Water reservoir（Clean water reservoir and water treatment reservoir）

We have compiled seismic damage data for 200 clean water reservoirs and 124 water treatment reservoirs in the Haicheng earthquake, Tangshan earthquake, Baotou West earthquake, Yutian-Cele earthquake in Xinjiang, Wenchuan earthquake, and Yushu earthquake (Gao Lin, 2012). The seismic damage statistics are shown in Tables 7 and 9; The seismic damage matrix of the clean water reservoir and water treatment reservoir is shown in Tables 8 and 10.

Table 7 Statistical table of seismic damage of clean water reservoir

Damage level	Basically intact	Slight damage	Moderate damage	Severe damage	Destroyed
Total(seats)	156	15	12	14	3

Table 8 Seismic damage matrix of clean water reservoir（%）

Seismic intensity	Basically intact	Slight damage	Moderate damage	Severe damage	Destroyed
VI	85	15	0	0	0
VII	76	19	5	0	0
VIII	19	29	33	15	4
IX	8	12	43	28	9
X	0	0	25	45	30

Table 9 Statistical table of seismic damage of water treatment reservoir

Damage level	Basically intact	Slight damage	Moderate damage	Severe damage	Destroyed
Total(seats)	97	8	10	8	1

Table 10 Seismic damage matrix of water treatment reservoir（%）

Seismic intensity	Basically intact	Slight damage	Moderate damage	Severe damage	Destroyed
VI	92	7	1	0	0
VII	64	21	12	3	0
VIII	33	26	22	13	6
IX	0	0	35	45	20

3) Pump station building

This article uses the seismic damage matrix of pump station buildings obtained through actual seismic damage statistical analysis as the basic seismic damage data for the fragility curves. The seismic damage matrix of pump buildings can be found in the literature "Research on New Techniques for Evaluating the Loss of Large Earthquake Disasters in Water Supply Systems" (Institute of Engineering Mechanics, China Earthquake Administration, 2013).

The above basic data constitute the basic database for seismic risk assessment of water supply system.

2. The authors should explain the procedure of monetizing loss in more detail.

For example, let's assume that the probability of a specific damage level occurring at the peak ground acceleration a of Class S water supply facilities is $P_{ms}\left(D|a\right)$, and this specific damage level is assumed to be m (a total of five damage levels, with a sum of 1 at the same peak acceleration). The economic loss when a specific damage level m occurs is the product of the total asset cost W_s and the loss ratio r_{ms}. Due to the fact that under a specific peak ground acceleration a, the probability of m damage level occurring is not 1, but $P_{ms}\left(D|a\right)$. Therefore, under a peak acceleration a, the loss of a water supply facility with m damage level occurring is $W_s r_{ms} P_{ms}\left(D|a\right)$ (equation 1). According to seismic hazard analysis, the exceeding probability of peak ground acceleration a at a certain time scale can be converted into the cumulative distribution probability of peak acceleration a. The probability density function $f_t\left(a\right)$ of peak acceleration a can be obtained by calculating the first derivative of the cumulative distribution probability function. Due to the fact that the probability density function is a continuous function rather than a step function, the probability of the occurrence of peak acceleration a can be considered as $f_t\left(a\right)da$. For a complete seismic risk assessment, the possibility of the earthquake itself should be considered. The loss caused by the damage level m of s type water supply facilities should be multiplied by the probability of the occurrence of peak acceleration a based on equation 1, that is, $W_s r_{ms} P_{ms}\left(D|a\right) f_t\left(a\right)da$ (equation 2). Due to the uncertainty of earthquake occurrence, each peak acceleration a has a certain probability of occurrence. Therefore, equation 2 is summed in the direction of acceleration a, $\int W_s r_{ms} P_{ms}\left(D|a\right) f_t\left(a\right)da = \left(W_s r_{ms}\right)\int P_{ms}\left(D|a\right) f_t\left(a\right)da$. The total expected loss caused by various damage levels and types of water supply facilities is: $E\left[L_t\right] = \sum_s \sum_m (W_s r_{ms}) PDf_{ms}$.

3.The authors should better justify showing PE pipes results only.

The seismic risk assessment model for water supply systems proposed in this article involves at least five types of pipeline materials, namely ductile iron pipes, cast iron pipes, steel pipes, PE pipes, and prestressed reinforced concrete pipes. The pipeline fragility curve of each material will be divided into 5 categories according to the seismic capacity zones of cities in Chinese Mainland, because the seismic capacity of

Chinese Mainland is divided into 5 zones in this paper. As shown in the example of the PE pipe fragility curves in the article, each pipeline material involved in the model in this article will have data similar to the parameters of the PE pipe fragility curve. Due to space limitations, only the fragility curves of PE pipe will be placed in the manuscript.

4.The verification of the proposed model is not convincing. The accuracy is verified using only one earthquake (damage losses in Deyang City). The loss rate model was verified by showing “the key earthquake prevention areas in Chinese Mainland” but not explained how?

The seismic disaster risk assessment model for water supply systems proposed in this article is an assessment of the uncertainty of the occurrence of seismic disasters in water supply systems, and model validation should adopt a qualitative approach. This model covers the levels of ground motion at the probability levels of frequent, basic, rare, and extremely rare occurrences. Therefore, taking the Wenchuan 8.0 earthquake that occurred on May 12, 2008 as an example, this article used the model to calculate the seismic loss rate expectation and risk levels of water supply systems in 5 cities in Sichuan Province and 1 city in Shaanxi Province before the earthquake, as shown in Table 11. For the convenience of verifying the rationality of the model, Table 11 listed the leakage rates of the water supply systems before and after the earthquake, the basic seismic ground motion (pre-earthquake fortification intensity), the on-site investigation seismic intensity, and the evaluated earthquake damage degree (Institute of Engineering Mechanics, China Earthquake Administration, 2009). It can be seen from Table 4-3 that the post-earthquake on-site investigation intensities of the listed cities are to varying degrees greater than the pre-earthquake fortification intensities. Among them, the post-earthquake intensity of Mianzhu and Dujiangyan exceeded the pre-earthquake intensity by 2 degrees, and the pre-earthquake predicted seismic risk level are the highest (Grade A). The post-earthquake intensity of Jiangyou, Mianyang, Guangyuan and Ningqiang exceeded the pre-earthquake intensity by 1 degree. The pre-earthquake predicted seismic risk levels are Grade B and Grade C, although it is lower than that of the first two cities, However, they are still at high and medium risk levels, respectively. In addition, cities with a predicted seismic risk level A of water supply systems before the earthquake correspond to the earthquake intensity of "IX" and the earthquake damage level of "destruction" surveyed on site after the earthquake; Cities with seismic disaster risk level B correspond to the seismic intensity of "VIII" and seismic damage level of "severe damage" in the post-earthquake on-site investigation; Cities with a seismic disaster risk level of C correspond to the seismic intensity of "VII" and the seismic damage level of "moderate damage" or "slight damage" according to the on-site investigation after the earthquake. The validation results indicate that the proposed water supply systems risk model can accurately predict the level of seismic risk faced by urban water supply systems in China.

Table 11 Comparison between the Wenchuan 8.0 earthquake damage and predicted seismic risk levels

City	Pre-earthquake leakage rate（%）	Post-earthquake leakage rate（%）	Basic seismic ground motion (fortification intensity)	On site investigation seismic intensity	Seismic damage level	Pre-earthquake loss rate expectation index	Pre-earthquake risk level description
Mianzhu	17	85	VII	IX	Destroyed	0.111	Very high（A）
Dujiangyan	27	60	VII	IX	Destroyed	0.087	Very high（A）
Jiangyou	26	50	VII	VIII	Severe damage	0.032	High（B）
Mianyang	12	17	VI	VII	Moderate damage	0.019	Medium（C）
Guangyuan	21	24	VI	VII	Moderate damage	0.018	Medium（C）
Ningqiang	20	25	VI	VII	Slight damage	0.018	Medium（C）

In order to illustrate the rationality of the classification of the seismic loss rate expectation index of the water supply systems in Chinese Mainland, the research results of China's seismic hazard and key monitoring and defense areas from 2006 to 2020 (Wang Xiaoqing, 2006) are introduced. The key hazard areas and seismic damage prediction results are the main basis for determining the key monitoring and defense areas in China from 2006 to 2020. The key monitoring and defense areas are determined based on comprehensive consideration of the earthquake situation, disaster situation, and social development. Among them, the prediction results of earthquake life and economic losses are the most important basis for determining the key monitoring and defense areas.

As shown in Figure 2, the country is divided into four seismic hazard areas and key monitoring and defense areas (areas surrounded by the blue line in the figure). 1 represents North China (Beijing, Tianjin, Hebei, Shanxi, and southern Liaoning), 2 represents the north-south belt region (Gansu, Qinghai, Ningxia, Shaanxi, Sichuan, Yunnan), 3 represents the northwest region of Xinjiang, and 4 represents the southeast coastal region (Fujian Guangdong border area, Taiwan Strait, Haikou City, Hainan Province).

The loss rate expectation index and seismic risk levels of the water supply systems are relatively high in the four seismic hazard and key monitoring and defense areas mentioned above.

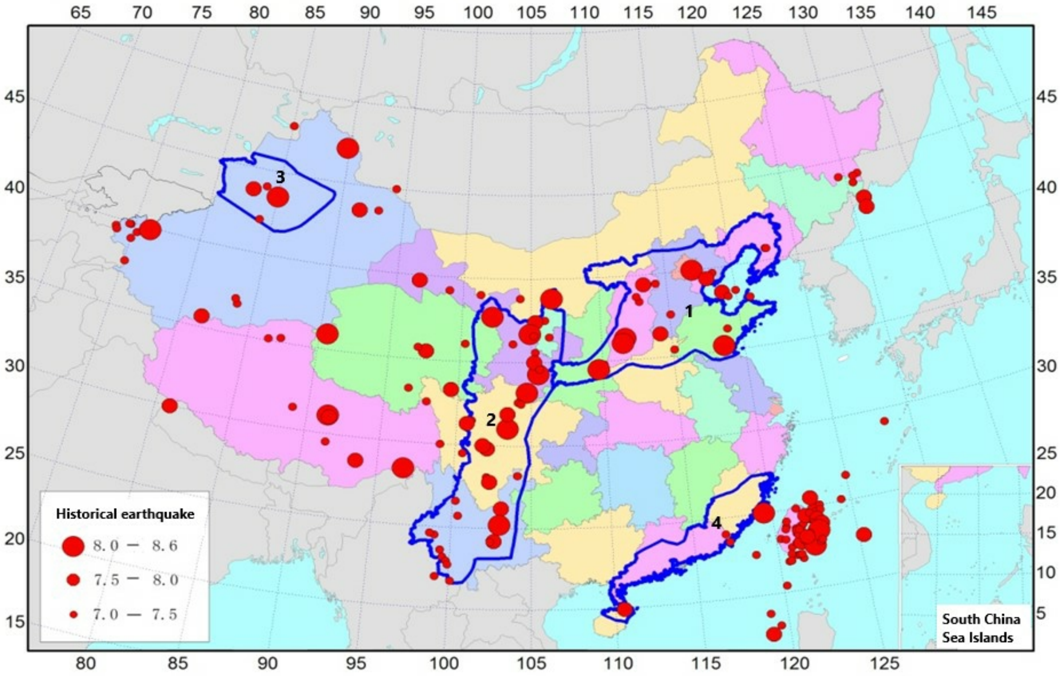

Figure 2 Seismic hazard and key monitoring and defense areas in China from 2006 to 2020

Newly added references

1. Wang Xiaoqing, Zhang Guomin, Fu Zhengxiang and Liu Guiping. Introduction of the Program 'Studies for the Seismic Prone Regions and Prediction of Seismic Losses in These Regions During 2006-2020'. Recent Developments in World Seismology, 2006, 9: 88-93.
2. Institute of Engineering Mechanics, China Earthquake Administration. Technical Report on Earthquake Damage Investigation of Wenchuan Earthquake. Harbin, 2009.
3. Gao Lin, Guo Endong, Wang Xiangjian, etc. Earthquake damage analysis of pools in water supply system. Journal of Natural Disasters, 2012, 10 (5): 120-126.
4. Institute of Engineering Mechanics, China Earthquake Administration. Research on New Techniques for Evaluating the Loss of Large Earthquake Disasters in Water Supply Systems. Harbin,2013.

1. **Technical corrections**

There is a need for technical corrections. The page numeration should be continuous. There seems to be missing text at the end of page 4. The authors should carefully check the paper for unnecessary long sentences and word choices. A more detailed technical review will follow at a later stage.

The initial letter of word 'parameters' was incorrectly capitalized. So it seemed to be two sentences. In fact, "Where a is peak ground acceleration, t is Time (year), k_b and k_H is parameters of seismic hazard curve.' is one sentence. I will carefully check the paper.