Process-based three-layer synergistic optimal allocation model for complex water resource systems considering reclaimed water

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The authors deeply appreciate the editors and reviewers for providing constructive suggestions and valuable comments, as well as positive feedback. Your suggestions will be of great help to improve the quality of our manuscript. Changes made in the revised manuscript are marked with track changes. Responses are made to all the comments and suggestions raised by the associate editor and reviewers, and are briefly described as follows.

Response to Reviewer #1's comments:

1.Line 225-226: is there any other index can be used for comparison? How to evaluate the validity of this proposed index?.

Thanks for the comment! It is really beneficial for the improvement of our paper. As for the first sub-advice that "*is there any other index can be used for comparison",* the index for comparision has been supplemented in Lines 227-230 as follows: "System entropy (H(S)) can describe the evolution direction of a water resource system and was used to promote the coordination of water supply departments in a water resource allocation system(Li et al., 2022). So, it was used for comparison to evaluate the validity of this proposed index." More detail has been added in line 608 as follows:"This factor is also used to be compared with proposed index."

For the second sub-advice that *How to evaluate the validity of this proposed index"*, we have discussed and proved it in Lines 834-842 as follows : "In Fig.6, the value of TSI are significant diverse among different scenarios as well as different solutions. As a contrast, the value of H, which is used for comparison and construction of TSI, show slight difference among solutions and even are the same in some classes. Therefore, it is difficult for decision makers to select the best solution among all candidates if we only use H for evaluation and selection in the decision process. Compared to H, TSI

introduce SSI into evaluation and the difference of coordination relationship between different schemes is distinguished by SSI. But H only pay attention to the equity among the stakeholders. So, TSI is more effective and validity than H in some extent."

2. The titles of some sections need to be revised to make the structure of the manuscript much clearer: for example, there is "2.1.2 Constraints" and "2.2.2 Constraints". And some other sections also have this kind of issue.

Thanks for giving the useful suggestion. To clear the structure of the manuscript, the titles of some sections are revised. For example: "2.1.1 Objective functions of the first layer; 2.1.2 Constraints of the first layer; 2.2.1 Objective functions of the second layer; 2.2.2 Constraints of the second layer; 2.3.1 Objective function of the third layer; 2.3.2 Constraints of the third layer."

3.Fig 3. It seems that the river network is not well connected. What is the reason for that?

Thanks for the question. In the Fig.3, the light blue lines represent river network, and the white dash-dotted lines are boundaries of different sub-regions. We are not sure what you said is the blue lines or white lines. If what you said is the blue ones, we could see that most rivers ate connected in the Fig.3. Because Yiwu City have two river systems, one is Yiwu River system with Yiwu River as the main stream, and another is Pujiang River system with Pujiang as the main stream. However, only fewer tributaries of the later one flow through Yiwu City, so it seems that the river network is not well connected in the west frontier of the Yiwu City. If what you said is the white ones, it may be mainly because the legend of the Fig.3 is not clear enough. In case of unnecessary misunderstanding, the Fig.3 has been revised as the following:

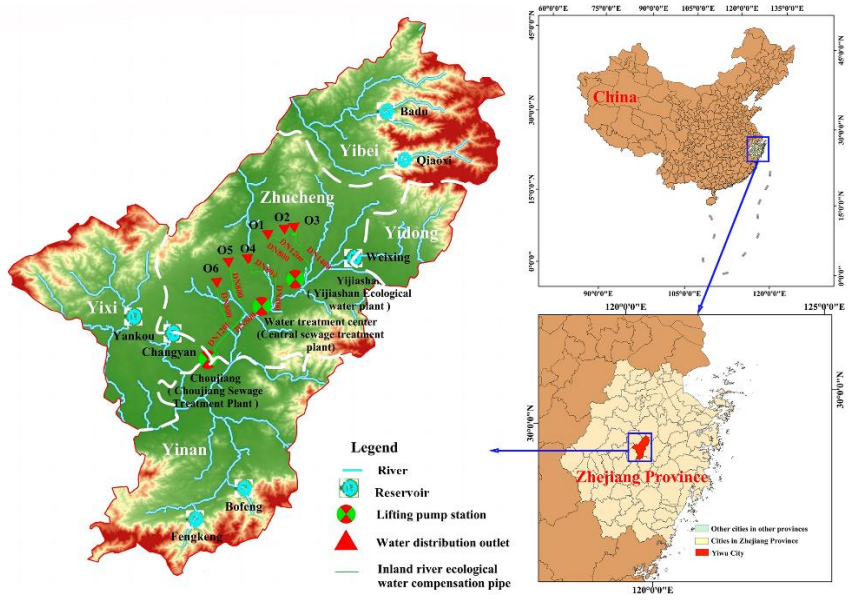

Fig. 3. Map of the study area

4. Some references need to be added to prove the choice or statement in the manuscript, such as 1) Line 699-700: agricultural irrigation water, which accounts for only a small portion of the total water demand in the area: is there any official report or reference to support this statement? 2) Line 760-761: why COD, TP and TN are selected?

Thanks for giving the comment. It's helpful for improvement of the paper.

1) The official report to support the statement of agriculture irrigation water has been added as the reference in the line 709-710 as the following: "Since there are no data available for agricultural irrigation water, which accounts for only a small portion of the total water demand in the area,and most agricultural irrigation water is supplied from surface water stored in hundreds of small reservoirs and mountain ponds (2020 Yiwu Ecological Environment Status Bulletin)".

2) It is necessary to explain why these three factors are selected. In the line 770-772, the reason has been explained as follows: "COD, TP and TN are major pollutants in Yiwu City (Yiwu Ecological City Construction Plan), and they are also major controlled pollutants of all the monitoring sections. So, these there were selected as representative pollutants in the tributaries to guarantee the water environmental quality of inland rivers."

5. Line 745-746: How is the reduction coefficient k identified? What is the value?

Thanks for your comment. The reduction coefficient k is identified by expert experience, and the value is 0.88. The related statement has been supplemented in the line 755-758: "the difference of this coefficient is quite slight within a small watershed (Zhao, 2014). Thus, *k* is simplified to the same value 0.88 is the same for every reservoir and varies throughout the year according to expert experience"

6. Probably you can delete the "Results of the" in the title of section 4.1 and some other sections.

Thanks for your comment!

All the "Results of the" have been deleted in the manuscript.

7. Please revise the "yuan" as "Chinese Yuan" or "Renminbi"

Thanks for the comment! It is important to use standardized unit expressions. All the "yuan" have been revised as Chinese Yuan. There are 32 substitutions in total.

8. There are some typo errors in the manuscript, for example Line 765 "-~". Please check the manuscript carefully to avoid this kind of issue.

Thanks very much for giving this helpful comment. These kind of type errors have been checked cross the paper, and all the expression of the number interval is unified as the symbol "~". There are 11 substitutions in total.

9. The descriptions of the Application and Results and Discussion section are too tedious, so it is suggested to simplify the expression appropriately.

Thanks very much for giving this helpful comment. The Application and Results and Discussion section have been revised and the tedious sentences have been delated or simplified. For example: sentences in line 706-708 "Additionally, excluding water from reservoirs, most agricultural irrigation water is supplied from surface water stored in hundreds of small reservoirs and mountain ponds."; sentence in line 785-788

“According to the “Yiwu Water Resources Bulletin 2020”, the urban comprehensive domestic sewage quota is set to 90%, and the sewage treatment rate is set to 100%. The benefits per unit water supply for different users in different subregions are determined from the Yiwu Water Price Adjustment Plan 2020.”; sentence in line 801-803 “The optimization using the Pareto concept allows the operator to choose an appropriate solution depending on the prevailing circumstances and analyse the trade-off among the conflicting objectives.”; sentence in line 914-917 “In other words, the balancing of the two objectives is beneficial for managers to determine an equilibrium solution that satisfies the relevant demand and successfully avoids surplus conventional or unconventional water supply in terms of sustainable development.”; sentence in line 926-928 “After selecting the three scenarios that yield the best synergy and the two best objective functions for characterizing all Pareto fronts of the second layer in each scenario, these 3×3 solutions are input to the third layer for further optimization.”; sentence in 950-954 “However, the various subregions obtain the greatest benefits when maximizing the unconventional water supply in dry and extreme scenarios. This result indicates that increasing the use of unconventional water in dry and extremely dry years would significantly increase the potential benefits.” and some other sentences haven been delated or simplified.

10. In the discussion, I noticed that there are some descriptions about the complex network analysis, but these discussions are somewhat superficial. So, please highlight the role of complex network analysis in this model.

Thanks for the comment!

The role of complex network analysis have been highlighted in line 983-985 “Complex network analysis help reveal the interactions among different objectives, we determine the level of synergy in complicated water systems, identify the challenges and opportunities for sustainable development of water systems in cities with various subregions, and provide valuable insights and specific action priorities for these regions.”

11. Some conclusions should be more organized and distinct..

Thanks for the comment! The main section of conclusions have been reorganized as follows: “The proposed model was applied to a representative city in Southeast China with scarce water resources and a developed industry. Achieving the optimal allocation of water resources in this kind of water-scarce city offers a valuable reference for other counties in China. Key advantages of PTSOA can be concluded from these results, as follows. Firstly, the results demonstrated that the PTSOA model achieved synergistic allocation among hierarchical decision-makers across various time scales and in different regions, yielding the highest TSI (-1.66 to -0.89) among the contrast models evaluated. Secondly, with a synergistic approach, a reasonable amount of conventional water is retained for future use in cases with potentially high risk, with volumes of 3.95×107 m^3, 3.12×107 m^3, and 2.43×107 m^3 retained in normal, dry and extremely dry scenarios, respectively. Moreover, 7.35×107 m^3, 7.56×107 m^3, and 7.37×107 m^3 of conventional water is saved in the three scenarios. Thirdly, considering both reclaimed water and conventional water in the optimization process efficiently improves the quality of municipal water, and more than 1272.21 t/year and 48.81 t/year of COD and ammonia nitrogen emissions are mitigated compared to those in the current situation. Lastly, distinct from previous models, the proposed optimal model was implemented with the consideration of spatial dimensions, which are important but often neglected. The results show that spatial allocation yields an improvement of 4-~95% for the comprehensive benefits in different subregions compared to the benefits achieved with traditional models, and the total comprehensive benefit increases by 1.76×109-~15.67×109 Chinese Yuan compared to that in the current situation.”

12. In the conclusion, attention should be paid to the results derived in this study. For example, Line 1069-1073: “the total amount of conventional water is saved, which is 7.35×107 m^3, 7.56×107 m^3, 7.37×107 m^3 in the scenarios, respectively. Thirdly, engaging both reclaimed water and conventional water in the process of optimization efficiently improves the municipal water environmental quality, and more than 1272.21t/year and 48.81t/year emissions of COD and ammonia nitrogen are reduced

compared to current situation." However, I didn't find other supporting material in the manuscript, so please clarify it.

Thanks for the comment!

For the first part "the total amount of conventional water is saved, which is 7.35×107 m^3, 7.56×107 m^3, 7.37×107 m^3 in the scenarios, respectively." The supporting explanation has been added in line 709-713 as follows "Moreover, by selecting the solution with highest TSI, 7.35×107 m^3, 7.56×107 m^3, and 7.37×107 m^3 of unconventional water would be supplied as an effective supplement to conventional water. In the other word, conventional water would be saved by our proposed model and index in the three scenarios."

For the second part "Thirdly, engaging both reclaimed water and conventional water in the process of optimization efficiently improves the municipal water environmental quality, and more than 1272.21t/year and 48.81t/year emissions of COD and ammonia nitrogen are reduced compared to current situation." The supporting explanation is in line 709-713 as follows "Additionally, based on the constraints regarding the contaminants allowed to be discharged, more than 1272.21 t and 48.81 t of COD and ammonia nitrogen emissions are avoided per year."

13. What are the main influencing factors of the proposed model? Although this manuscript gives many indices of the model, it is difficult to know the main influential factors of the PTSOA model. Please clarify it in the manuscript.

Thanks very much for giving this helpful comment.

The proposed PTSOA model is influenced by many factors. The main factors are listed in the manuscript. However, it seems also hard to identify which one is more important. So, the statement of main influential factors has been added in line 785-787 "There are plenty of influencing factors in the model, the most important ones among them are the value of water demand, the value of available water and some key hyper-parameter."

14. What is the specific meaning of the "complex water resources system" in the title? In case of misunderstanding, please define it clearly in the manuscript.

Thanks very much for giving this helpful comment. It is necessary to define the key words in the title across the manuscript. The specific meaning of the complex water resources system has been added in line 38-41 “Nowadays, the water resources system become more and more complex, and is consisted with multiple sources and users as well as water reused infrastructure. This kind of water resources system is called complex water resources system in the following.” Also, some other expression about complex water resources system have also been unified in the manuscript.

15. Some abbreviations are repeatedly explained in the manuscript. For example, Line 235: “a new reasonable evaluation index named synergy index of the system (TSI)”, and Line 611 says “synergy index of the system (TSI) is used for…”. Please check all repeats through the manuscript.

Thanks very much for giving this helpful comment. All repeats through the manuscript about “synergy index of the system (TSI)” have been checked and revised. There are a total of six amendments

16. Some units have no brackets, but some do. For example, in Table 2, all units don’t have brackets, but the units in Table 3 have. Please adjust them to journal format requirements.

Thanks very much for giving this helpful comment. According to journal format requirements, all the units in the tables haven been added brackets. Table 1-3 are unified for standard.

17. The fonts in Fig.4 are not vary clear. Maybe it is because of the color and size of the fonts. Please adjust them for easier reading.

Thanks very much for giving this helpful comment. For easier reading of readers, Fig.4 has been repainted as following:

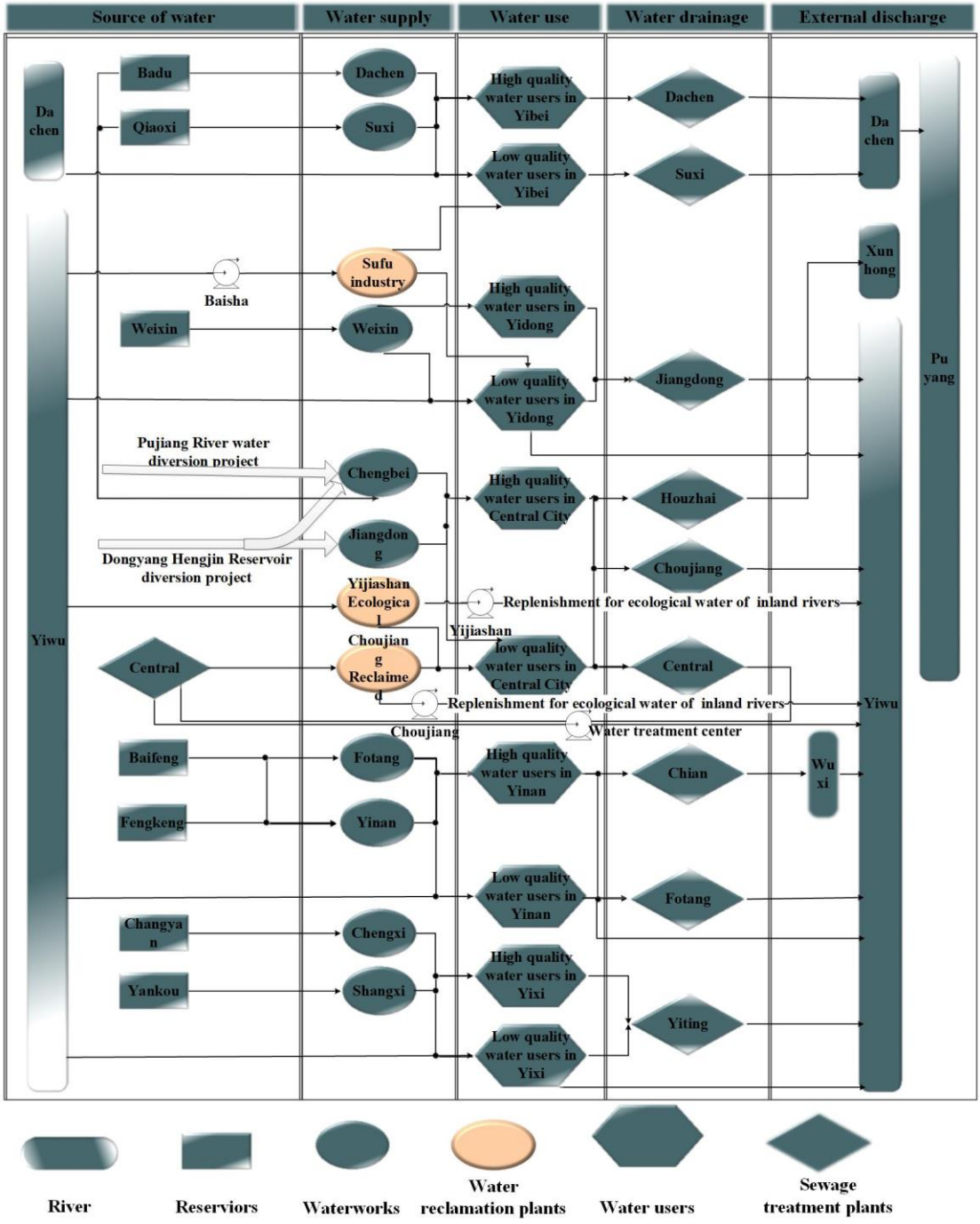

Fig. 4. Schematic diagram of Yiwu city