Author's response

Wan and co-authors developed a multi-source water allocation model to evaluate the integration of alternative water supply sources under multiple drought scenarios. They developed and implemented this model for the Yellow River in the Hennan province of China. The topic is a good fit for NHESS but the manuscript needs considerable improvement before being suitable for publication. Key areas for improvement include description and citation of the data used, additional details on the model development and configuration, and clear concise writing throughout. In revising the paper it might be helpful to think of a student or early career researcher looking to apply similar methods to their project as the reader.

Comments

1.Little information is provided about the data used in this work. What soil variables were used? Are there any data gaps in the time series data for temperature and precipitation? If so, what percent of the data is missing and how were gaps filled? Additionally, please cite the sources for each variable in the data or set of variables used in this work. A table would be an efficient way to present this information. See for example Table 1 in Garcia and Islam (2021).

Re: The data used in this paper is the Palmer Drought Index (PDSI), which is used to characterize the evolution of drought in the Yellow River water supply area of Henan Province. The precipitation, temperature and soil data are used to calculate the Palmer Drought Index. In order to improve the integrity of the data, the data type and its source description are added in the "1.2 basic data" section of the text (Table 2). The literature corresponding to Garcia and Islam has been cited.

Table 2 Data Types and Data Sources Statistics

Data type	Data scale	Data sources	Data unit
Precipitation	Month by month	Institute of Geographical Sciences and Natural Resources Research, CAS; Geographical Information Monitoring Cloud Platform	mm

Temperature	Month by month	Institute of Geographical Sciences and Natural Resources Research, CAS; Geographical Information Monitoring Cloud Platform	℃
Soil humidity	Month by month	Institute of Geographical Sciences and Natural Resources Research, CAS; Geographical Information Monitoring Cloud Platform	%

2.Figure 2 is labeled a histogram but is not in fact a histogram. Histograms have the variable magnitude on the x axis and the frequency on the y axis. It is a diagram consisting of bars of even width whose height is proportional to the frequency of a variable. Figure 2 is a time series bar graph. Please see Hesel et al. (2020) for additional guidance on data visualization.

Re: Figure 2 is a histogram that reflects the overall PDSI sequence changes in the water supply area of the Yellow River in Henan Province. The x-axis represents the year, and the y-axis represents the PDSI value. This diagram has drawn on the histogram in the literature Hesel et al (2020). However, because the y value of the histogram of PDSI sequence changes is drawn according to the boundary of 0, greater than 0 and less than 0 represent wet and dry states respectively, which improves the degree of visualization and more clearly reflects the change state of dry and wet alternation.

3.The scenarios developed to augment water supplies during drought years include use of harvested rainwater, wastewater recovery, flood water recovery and groundwater. As described in Table 6, these scenarios assume that a specific amount of water will be available from these water sources will be available during those drought years. How has this been determined? For example, expanding the reservoir and changing the operating rules does increase the probability of carrying over water from high flow years to extreme drought years but it depends on the sequence of flows observed. What analysis was conducted to establish that this volume could be stored? With what probability will it be available? Similarly, precipitation will be lower during extreme drought conditions so how reliable will the harvested rainwater be? What storage capacity and use rules are needed to have this amount of water available from rainwater harvesting with high reliability?

Lastly, depending on the local hydro-geological conditions, groundwater levels and flow rates may decline during drought. Are all aquifers in this watershed unaffected by drought?

Re: First, the unconventional water, flood resources, and groundwater volume in Table 6 are calculated based on the potential water volume. The potential water volume has been explained in the section of the original “3.1 Multi-scenario Potential Water Source Analysis” (that is, the potential water volume of unconventional water in the Henan Yellow River water supply area in 2020 is 5.045 billion m^3, the potential water volume of flood resources is 10.223 billion m^3, and the potential water volume of groundwater elastic mining is 9.660 billion m^3. These potential water volumes are not used or rarely used in non-arid years)， at the same time, the potential water volume of different scenarios is calculated according to the percentage and the potential water volume of various water sources, and the percentage is based on the comprehensive setting of the supply capacity and scale of rainwater collection facilities, water storage projects, etc.

Secondly, in the case of extreme drought, the spatial and temporal distribution of precipitation is uneven, and the scale of rainwater collection and storage can be expanded in the concentrated rainy season and strong precipitation areas. The construction of facilities needs to consider the local rainfall characteristics, topography and soil conditions, while minimizing the use of multi-functional storage facilities to ensure sufficient water storage capacity during drought periods; improve various rainwater collection systems, such as source interception measures, initial rainwater abandonment or diversion, which helps to reduce pollutants in rainwater and improve the quality of rainwater collection.

Third, during the drought period, the supply of rainfall and surface water will be reduced, resulting in a decrease in the supply of groundwater, which will affect the amount of water in the aquifer. The elastic mining of groundwater in this paper is based on extreme drought. Considering the groundwater enrichment and potential water volume of each partition, under the premise of ensuring the sustainable utilization of groundwater resources, scientific and reasonable mining is carried out. Or under extreme drought, there will be over-exploitation of groundwater, and groundwater will be recharged during the wet year.

4.It is not clear how the model developed addresses the spatial variation in water demands and supplies. Can these alternate water sources be developed to the same degree in all regions? Is sufficient water available in the correct locations to fully meet demands? If not, what infrastructure assumptions are made?

Re: The multi-water source model is based on the consideration of available water supply constraints, water demand levels and configuration principles, and proposes a fair, scientific and reasonable configuration plan for the county level to alleviate the drought situation in the Yellow River water supply area of Henan to the greatest extent. Due to the difference of groundwater enrichment and reservoir structure distribution, the development degree of each partition in Henan Yellow River water supply area is different. The potential tapping based on different water supply scenarios cannot fully meet the water demand of Henan Yellow River water supply area. This paper considers the multi-water source configuration in extreme drought years, which can alleviate the drought status of Henan Yellow River water supply area to the greatest extent. This paper has made potential tapping measures in different scenarios (Table 5), and has not proposed infrastructure assumptions from the perspective of implementation.

Table 5 Measures for increasing supply of different potential water sources under different supply scenarios

Additional supply scenario	Unconventional Water Tapping	Flood resource utilization	Elastic groundwater exploitation
Scenario 1	Increase the scale of rainwater harvesting facilities by 5%	Increase the scale of water storage project by 5%	Mining 15% of water source in strong water-rich area and extremely strong water-rich area
Scenario 2	Expand the scale of 5% rainwater harvesting facilities; reclaimed water and sewage utilization efficiency increased by 10%	Increase the scale of water storage project by 5%; reasonable setting to speed up the recovery scheduling rules	Mining 15% of the water source in the strong and extremely rich water area; mining and excavating 10% of the water source in the medium water-rich area
Scenario 3	Expand the scale of rainwater harvesting facilities by	Increase the scale of water storage project by 5%;	Mining 15% of the water source in the strong and extremely rich water

	5%;the utilization efficiency of reclaimed water and sewage is increased by 10%;increase the utilization ratio of mine water by 20%	reasonably set up the scheduling rules for accelerating the recovery of savings; dynamic adjustment of reservoir flood control level	area; mining and excavating 10% of the water source in the medium-rich water area; mining 5% water source in weak water-rich area

5.The methods description leave me with many questions about the model is set up and run. Have the authors used streamflow from only 2010 for the optimization? How were initial conditions such as reservoir levels determined where considering reservoir expansions and changing operating rules? Is demand assumed to be constant at 2010 levels? Is the model fully deterministic or are there stochastic elements? What software or programming language was used to implement the model? What algorithm was used for optimization?

Re: In this paper, 2010 is selected as the extreme drought year, and 2010 is used as the demand level of multi-water source allocation. The initial conditions are determined based on historical data, hydrological and meteorological conditions, reservoir design standards, etc. The multi-water source allocation model is not completely determined, and there may be uncertainties in parameters and solving process. The model in this paper is solved by genetic algorithm, and the population replacement and iterative optimization are optimized by cross-compilation. The individual gradually reaches the optimal until. In this paper, the “3.4 model solution” section is added, and the new contents are as follows:

Genetic algorithm is a kind of intergenerational evolution, survival of the fittest, from low to high level algorithm. This algorithm takes the optimization of the global as the goal, carries out random search in the feasible solution space, realizes the group replacement and iterative optimization through cross compilation, and makes each individual gradually reach the optimal until the evolution of each generation. The genetic algorithm has strong adaptability, can independently optimize and search the solvable space, has fast convergence speed and does not depend on the decoding process, and the large search space greatly improves the calculation accuracy.

(1) The calculation steps of multi-water allocation algorithm are as follows:

The first step: Let the random scale value A, the initial population B_0, and B_0 as the parent population;

The second step: calculate the crowding distance and the order of the parent population, and optimize the selection, crossover and mutation to obtain the offspring population B_t;

The third step: merge B_0 and B_t to obtain a scale of $2A$, and the resulting offspring population is C_t.After sorting, the individual crowding degree is calculated, and the previous A individuals are selected to form the parent population B_{t+1};

Step 4: judge whether the result meets the conditions, if not, go back to the second step, and output the result if it meets.

(2) The decision variables are written as follows:

This paper considers five water sources (surface water, elastic groundwater exploitation, flood resources, unconventional water) and three water supply scenarios (Scenario 1, Scenario 2, Scenario 3), four water sectors (domestic, industrial, agricultural, and ecological water). According to the constraints of the multi-water allocation model, the decision variables are numbered as follows (Table 7), $x_{i,j}$ represents the water supply of different water supply sources to different water use sectors. Among them, i represents the type of water supply source, (i=1,2,3,4,5), j represents different water use sectors, (j=1,2,3,4), p represents different water supply scenarios, (p = 1,2,3).

Table 7 Numbering of decision variables

Water use sector	Life	Industry	Agriculture	Zoology
Surface water	$x_{11,\ p}$	$x_{12,\ p}$	$x_{13,\ p}$	$x_{14,\ p}$
Unconventional water	$x_{21,\ p}$	$x_{22,\ p}$	$x_{23,\ p}$	$x_{24,\ p}$
Groundwater	$x_{31,\ p}$	$x_{32,\ p}$	$x_{33,\ p}$	$x_{34,\ p}$
Flood resource utilization	$x_{41,\ p}$	$x_{42,\ p}$	$x_{43,\ p}$	$x_{44,\ p}$

(3) Function call and optimal solution selection:

The gamultiobj function needs to be called during the operation of the genetic algorithm. The function expression to be called is [x, fval] = gamultiobj (fitnessfcn, nvars, A, b, Aeq, beq, lb, ub, options), x is the pareto solution set obtained by the gamultiobj function, fval is the objective function, nvars is the total amount of variables, options is the genetic parameter, fitnessfcn is set as the handle of the objective function, which is regarded as the fitness function. A, Aeq, b and beq are the constraint conditions of the function, and ub and lb are the upper and lower limits of the constraint values. The genetic parameters of the genetic algorithm are set as follows : the individual coefficient is 0.3, the highest evolution generation is 3000, the end generation is 3000, and the fitness function error value is 0.0001.

The optimal solution is distributed in the pareto solution set, and the minimum water shortage of domestic water demand, industrial water demand, agricultural water demand and ecological water demand is comprehensively considered. Finally, the optimal solution is selected. Under the condition of satisfying the available water supply and related constraints, the priority of domestic water supply is considered, then the industrial water supply is considered, then the agricultural water supply is considered, and finally the ecological water supply is considered.

Minor Comments

1.The sentence starting on line 40 ("In recent years…") is not a complete sen

Re: "In recent years..." has been changed to "The Yellow River Water Supply Area in Henan with monsoon climate characteristics has been dry and wet imbalance in recent years".

2.The use of the word "staged" in describing drought occurrence (see line 43 for example) is not appropriate because to stage means to produce or arrange and it implies human control while drought is a (mostly) natural phenomena. You could use the verb occurred in place of staged.

Re: "staged" has been changed to "occurred".

3.What is meant by the "social economy" on line 44? Is this different that the economy?

Re: Social economy is a concrete and systematic concept, which refers to the overall system formed on the basis of social structure and economic structure, through the condensation of material resources and social relations, and focuses on the economic behavior of human beings in the process of social movement. Economy is a broader concept, which refers to the production, circulation, distribution and consumption of all material and spiritual materials. Its core is the creation, transformation and realization of value to meet the needs of human material and cultural life. For social and economic development, water resources are indispensable basic support conditions. Daily life, industrial production or agricultural production all need a lot of water resources to meet the demand.

4.What is the elastic exploitation of groundwater? In particular, what does elastic mean here? Please clarify for the reader.

Re: Elastic exploitation of groundwater is a strategy for groundwater exploitation and management. It allows the dynamic adjustment and exploitation of groundwater resources within a certain range according to the recharge capacity and hydrogeological conditions of the groundwater system under appropriate conditions. The meaning of the word "elasticity" refers to the ability of the groundwater system to maintain self-regulation and recovery within a certain range in the face of mining pressure. This ability allows the groundwater system to make corresponding water level and water volume adjustments according to changes in the amount of exploitation within a certain time scale, without causing system collapse or irreversible damage.

5.The sentence starting on line 58 continues until line 74. It's hard to follow. Please consider breaking this up into multiple sentences.

Re: This part has been modified. "Wang Yu et al. (2021) scientifically set the water diversion index in the river according to the incoming water situation, and at the same time consider fairness and efficiency, and increase the saved water supply to the provinces along the Yellow River; Yang Mingzhi et al. (2022) regarded social water use and natural hydrology as the research object, studied the feedback between the two processes, and developed a distributed allocation model based on the water cycle; Tan et al. (2018) took the unilateral water benefit as the objective function, considered the fractional programming and robust optimization at the same time, and established the water resources optimization model, which improved the utilization efficiency of agricultural water; Ren et al. (2017) gave full play to the advantages of multi-objective fuzzy programming, constructed a multi-objective model of multiple benefits, rationally planned land use and irrigation water, and obtained an effective and fair irrigation plan; Aiming at the prediction of water supply and demand and its comprehensive value, Zhang et al. (2023) used the WRA model to study the coordination and stable development of each system, used the emergy analysis method to carry out quantitative analysis, reasonably calculated the base year and the planning year, and proposed a sustainable water distribution plan; Sperotto A et al. (2019) discussed the application of multi-scenario analysis method based on Bayesian network in water quality sustainability assessment under uncertain conditions." has been changed to"Wang Yu et al. (2021) set the water diversion index in the river according to the science of the water situation, and consider the fairness and efficiency at the same time, and increase the saved water supply to the provinces and regions along the Yellow River; Yang Mingzhi et al. (2022) took social water use and natural hydrology as the research object, studied the feedback between social water use and natural hydrology, and developed a distributed allocation model based on water cycle; Tan et al. (2018) taking the single water benefit as the objective function, considering the fractional programming and robust optimization, the water resources optimization model is established to improve the utilization efficiency of agricultural water; Ren et al. (2017) giving full play to the advantages of multi-objective fuzzy programming, a multi-objective model of multiple benefits is constructed to rationally plan land use and irrigation water, and an effective and fair irrigation scheme is obtained; Zhang et al. (2023) aiming at the prediction of water supply and demand and its comprehensive value, the WRA model is used to study its coordinated and stable development, and the emergy analysis method is used for quantitative analysis. The base year and the planning year are reasonably calculated, and the sustainable water distribution scheme is proposed; Under uncertain conditions, Sperotto A et al. (2019) discussed the application of multi-scenario analysis method based on Bayesian network in water quality sustainability assessment"

6.Many acronyms are introduced in the introduction and not later used such as MS-MPC, UDN, etc. Please only introduce an acronym if it will be repeatedly used.

Re: MS-MPC, UDN, IPCC, ROs, GA, NSGA-II, MPC (MS-MPC) appeared only once in the text, and did not appear again. In order to facilitate readers understanding, the above abbreviations have been changed to "Genetic Algorithm (GA), Non-dominated Sorting Genetic Algorithm II (NSGA-II), Model Predictive Control (MPC), Multi-scenario MPC (MS-MPC), Urban Drainage Networks (UDN), Real Options (ROs)".

7.What is the definition of “tapping potential”? I am not familiar with this term and do not think it is commonly used in water resource engineering.

Re: “tapping potential of water resources” is a new vocabulary in the discipline of water resources. “tapping potential” refers to the excavation, development and exploration of potential capabilities or resources. Therefore, “tapping potential” refers to the excavation and utilization of certain potential capabilities or resources through certain methods and measures. Specifically, “tapping potential of water resources” refers to excavating and utilizing the unutilized or potential parts of water resources (such as unconventional water and flood resources) through scientific planning, technological innovation and management improvement, so as to increase the effective supply and rational utilization of water resources and alleviate the contradiction of water shortage.

8.What does mu refer to on line 106 and 107? It looks like a unit, but I am not familiar with this unit or its abbreviation.

Re: “mu” refers to the unit of land area, one mu is equal to 666.7 square meters, and the unit in English is “mu”.

9.What does it mean for precipitation to be unbalanced spatially and temporally? (As on lines 108-109)? Do you mean that there is high spatial and temporal variability?

Re: The imbalance of precipitation in time and space means that the distribution of precipitation is uneven in time and space. For example, in the monsoon climate zone, summer precipitation is concentrated, while winter precipitation is scarce. This seasonal uneven precipitation may lead to serious floods and drought disasters. At the same time, the uneven distribution of precipitation in space may lead to floods in some areas due to excessive precipitation, while other areas face drought and water shortage due to too little precipitation. The uneven spatial and temporal distribution of precipitation means that there are different degrees of spatial and temporal variability. The variability of time and space makes the supply of water resources in different regions at different times may also change significantly. This variability has an important impact on agricultural production, water resources management, disaster prevention and control.

10.There are a number of instances where spaces between words are missing. For example, after the word "areas" on line 112.

Re: "areas (Sun, 2021)." has been changed to "areas (Sun, 2021)."; "Index(PDSI)" has been changed to "Index (PDSI)"; "zoning(Zhao and Zhao, 2014)." has been changed to "zoning (Zhao and Zhao, 2014)."; "Ministry of Water Resources(under construction)(2023-SYSJJ-05)" has been changed to "Ministry of Water Resources (under construction) (2023-SYSJJ-05)"; "Resources(KYFB202307260036)" has been changed to "Resources (KYFB202307260036)".

11.I am curious about the increase in ecological water use mentioned on line 113. What has driven the increase in ecological water use? Is this a legal or regulatory requirement?

Re: There are many reasons for the increase in ecological water use, including the improvement of environmental awareness, the need for ecological system maintenance, the decline in the proportion of industrial and agricultural water use, engineering construction and planning, and the implementation of ecological restoration projects. These factors work together to promote the increase of ecological water consumption. With the improvement of environmental awareness and the popularization of the concept of sustainable development, many countries and regions have formulated relevant laws and policies to protect and restore ecosystems. These laws and policies may require the consideration of ecological water demand in water resources management and distribution, thus indirectly promoting the increase of ecological water use.

12.Table 1 is not needed as knowledge of these subdivisions is not needed by the reader to interpret the results.

Re: Table 1 details the scope of the Yellow River water supply area in Henan.At the same time, not all districts and counties in the municipal area are in the Yellow River water supply area in Henan.Some districts and counties in the municipal area are not in the Yellow River water supply area in Henan.Therefore, table 1 is to more accurately explain the scope of the study area.

13.Line 139 refers to mild and normal drought years. These terms are not the ones defined in Table 2. For clarity, please use the terms defined.

Re: "Mild drought" has been changed to "Moderate and slight drought".

14.In Figure 3, outline each of the geographic areas. In the current figure some colors (drought levels) are outlined while others are not.

Re: Figure 3 has been modified, and the contours of each region have been added, as shown in the following figure.

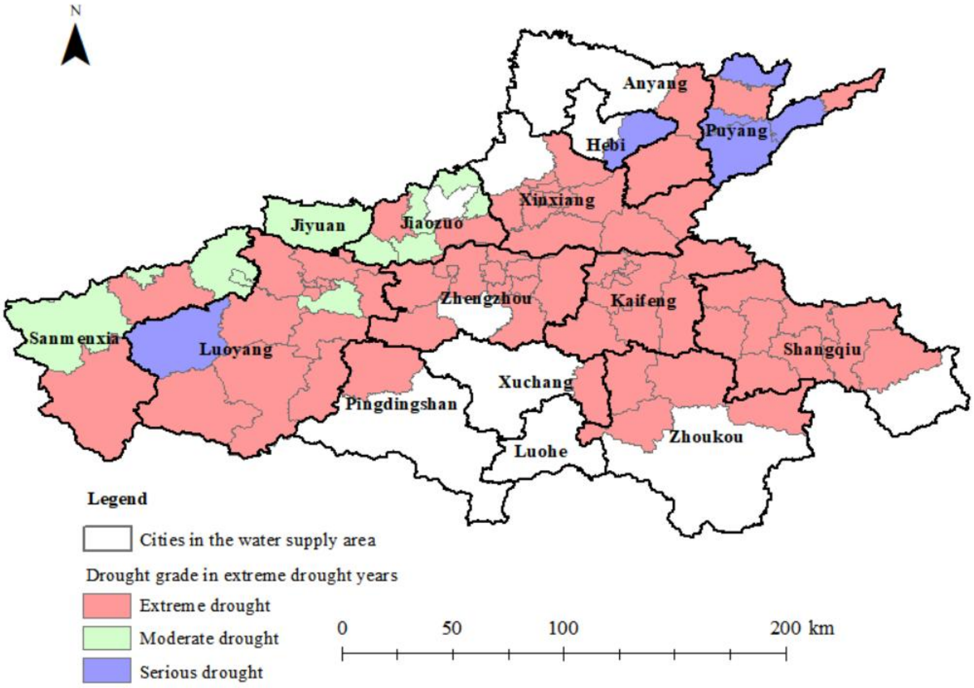

Figure 3 Distribution of drought grade in the Yellow River Water Supply Area in Henan in 2010

15.What does water-rich zoning refer to on line 183? This is not a common term so please explain to the reader.

Re: water-rich zoning refers to the water yield capacity of aquifer, which is a sign to measure the water yield of aquifer during groundwater exploitation. In this paper, the water-rich grade of groundwater in each zone is judged according to the unit water output of the water source well and the spring water flow. The specific quantitative division standard is referred to Table 4.

Table 4 Division table of groundwater water abundance in the Yellow River Water Supply Area in Henan

Regionalization basis	Partition			
	Weak water-rich area	Medium water-rich area	Strong water-rich area	Extremely strong water-rich area

Unit output of water source well($m^3/h \cdot m$)	$q<1$	$1 \leq q<5$	$5 \leq q<10$	$q>10$
Flow capacity of spring (L/s)	$Q<1$	$1 \leq Q<10$	$10 \leq Q<50$	$Q<50$

16.Do both criteria in Table 4 need to be satisfied for the classification? How are cases where the two criteria are not aligned dealt with?

Re: The classification of water abundance needs to meet the two standards of unit water yield of water source well and spring water flow at the same time. Any index does not meet the corresponding numerical range, it will not be divided into corresponding partitions.

17.In Table 6, what does "digging potential" mean? Is this the baseline scenario? Also in Table 6, all scenarios are labeled Scenario 1.

Re: "potential tapping" generally refers to excavating and utilizing certain potential capabilities or resources through various technical and engineering means to meet the needs of human production, life and ecology. Specifically, "tapping the potential of water resources" refers to excavating and utilizing the unutilized or potential parts of water resources (such as rainwater harvesting, flood recycling, seawater desalination, etc.) through scientific planning, technological innovation and management improvement, so as to increase the effective supply and rational utilization of water resources and alleviate the contradiction of water shortage. About the definition of the scenario, before the repair, in the "2.2 potential scenario setting" part has been described, the specific definition is as follows : According to the strength of water richness, different scenarios are tapped. Scenarios 1 to 3, the potential of increasing supply increases in turn, and different scenarios correspond to different measures of increasing supply.

18.In the Zp definition on line 264, who or what is the enemy?

Re: Z_p is the total water deficit of scenario p, " Z_p is the total water deficit in the scenario of enemy p „ has been replaced by " Z_p is the total water shortage of scenario p „.

19.There is no i in equation 1. What does variable i on line 265 refer to?

Re: There is an error in spelling, "$W_{c,p}$ is the water supply of type i user in scenario p" has been changed to "$W_{c,p}$ is the water supply of type c user in scenario p".

20.Can the variables introduced in equations 2 through 5 be labeled in a more intuitive way? For example, W_G is total water while W_B is groundwater and W_T is ecological water. If W_G were groundwater, W_T total water and so forth, the variable definitions would be easier to remember.

Re: "W_B" has been changed to "W_S", which indicates the available water supply of surface water ; "W_D" has been changed to "W_G", which indicates the amount of groundwater available; "W_S" has been changed to "W_L", which indicates the water demand for living ; "W_Y" has been changed to "W_I", indicating industrial water demand ; "W_N" has been changed to "W_A", indicating agricultural water demand ; "W_T" has been changed to "W_E", indicating ecological water demand.

21.On line 300, should D_0 read D_e?

Re: "D_0" has been changed to "D_e".

References

Garcia, M., & Islam, S. (2021). Water stress & water salience: implications for water supply planning. Hydrological Sciences Journal, 66(6), 919-934.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., (2020). Chapter 2: Graphical Analysis. Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chap. A3, 458 p., https://doi.org/10.3133/tm4a3.