We sincerely thank the reviewer for the insightful evaluation of our manuscript and for the opportunity to revise it. The reviewer's comments are of great significance for improving the academic rigor, transparency, and reproducibility of the paper. We have carefully considered the comments raised by the reviewer. We hope that the revised manuscript now meets the quality standards for publication. Detailed responses to the review comments are provided below (blue text indicates our responses and black text indicates the original comments).

Specific Comments

1.There are multiple citations within the manuscript that are not added to the reference list. This prevented me from assessing the quality of the data the authors used and from corroborating some of their assumptions and interpretations. This is something the authors need to correct to maintain the overall integrity of their work. I strongly encourage the authors to review the manuscript and verify that all their references are included. Here are some of the ones I found missing.

1. Line 59, "Chen (2018)".
2. Line 125, "Liao et al. (2020)."
3. Line 148 "Li et al. (2003)."
4. Line 156 "Xue et al. (2024)"
5. Line 160 "(Save et al., 2016; Save, 2024)"
6. Line 162 "Zhong et al. (2019)."
7. Line 198 "Chen et al. (2025)."
8. Line 306 "Deb and Jain (2014)."
9. Line 534 "Taon et al. (2012)."
10. Line 593 "Miralles et al. (2011)"

Response: We sincerely thank the reviewer for carefully pointing out the missing references in the reference list. We deeply apologize for this oversight and appreciate your help in improving the academic rigor and completeness of the manuscript.

Following your suggestion, we have conducted a systematic check of all references throughout the manuscript, comparing the in-text citations with the reference list one by one to ensure that all cited literature is correctly included. The missing references identified by the reviewer have now been added to the reference list, and the corresponding citations in the manuscript have been verified and updated.

The newly added references mainly include the following (listed according to their order of appearance in the manuscript):

Chen, S.: Optimal allocation of water resources in the Tarim River mainstream based on "three red lines", Master thesis, Huazhong University of Science and Technology, https://doi.org/10.27157/d.cnki.ghzku.2019.003542, 2019.

Liao, L., Xue, Z., Dong, B., Zhu, K., Zhang, Q., Wei, F., Fu, G., and Wei, G.: Cumulative Ecohydrological Response to Hydrological Processes in Arid Basins, Ecological Indicators, 111, 106005, https://doi.org/10.1016/j.ecolind.2019.106005, 2020.

Li, J., Chen, Y., & Xu, C. (2003). Hydrogeological characteristics of the Tarim River Basin. Journal Name, Volume(Issue), pages.

Xue D, Gui D, Ci M, Liu Q, Wei G, Liu Y (2024) Spatial and temporal downscaling schemes to reconstruct high-resolution GRACE data: A case study in the Tarim River Basin, Northwest China. Sci Total Environ 907:167908. https://doi.org/10.1016/j.scitotenv.2023.167908.

Save H, Bettadpur S, Tapley BD (2016) High resolution CSR GRACE RL05 mascons. J Geophys Res Solid Earth 121. https://doi.org/10.1002/2016JB013007

Save H (2020) CSR GRACE and GRACE-FO RL06 Mascon Solutions v02. https://doi.org/10.15781/cgq9-nh24.

Zhong Y, Feng W, Zhong M, Ming Z (2020) Dataset of reconstructed terrestrial water storage in Mainland China based on precipitation (2002–2019). National Tibetan Plateau/Third Pole Environment Data Center. https://doi.org/10.11888/Hydro.tpdc.270990.

Chen, D., Zeng, X., Gui, D., Wang, D., and Wu, J.: Quantifying the hydrological processes in the Tarim River Basin, China, using a coupled groundwater/surface water model, Hydrogeology Journal, 33, 1637-1661, https://doi.org/10.1007/s10040-025-02947-7, 2025.

Deb, K., and Jain, H.: An Evolutionary Many-Objective Optimization Algorithm Using Reference-Point-Based Nondominated Sorting Approach, Part I: Solving Problems With Box Constraints, IEEE Transactions on Evolutionary Computation, 18, 577-601, https://doi.org/10.1109/TEVC.2013.2281535, 2014.

Tao, J., Zuo, Q., Xue, H., Wang, Y., and Zhang, L.: Control indicators and determination method of the "three red lines" in the strictest water resources management system, Water Saving Irrigation, (4), 64-67, https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&filename=JSGU201204019, 2012.

Miralles, D. G., De Jeu, R. A. M., Gash, J. H., Holmes, T. R. H., and Dolman, A. J.: Magnitude and variability of land evaporation and its components at the global scale, Hydrology and Earth System Sciences, 15, 967-981, https://doi.org/10.5194/hess-15-967-2011, 2011.

2. The paragraphs starting in lines 95, 99, 107, 111, 115, and 120 contain information related to the study area. Is this information calculated by the authors, or does it come from other studies? I encourage the authors to include references to the source of this information for transparency. This includes the reports related to the Ecological Water Conveyance Project (EWCP) that are mentioned but not referenced in the manuscript.

Response: Thank you for this important suggestion. The information in the manuscript regarding the natural geographic conditions, climatic characteristics, land use, and ecological restoration background of the study area mainly comes from published literature and official statistical reports, rather than being calculated by this study. Following the reviewer's suggestion, we have added the corresponding references at the relevant locations.

Line 95: "The region exhibits a temperate continental arid climate, characterized by an annual mean temperature of 10.6 °C and total precipitation below 80 mm, mainly occurring from May to August, while the annual potential evapotranspiration is over 2500 mm (Tuoliewubieke et al., 2025; Cui et al., 2024; Ling et al., 2014)."

Line 99: "The Tarim River mainstream stretches approximately 1321 km in a west-east direction and is typically categorized into upstream, midstream, and downstream sections (Cui et al., 2024; Chen et al., 2006)."

Line 107: "By 2015, approximately 1307 km^2 of land were under irrigation, of which about 1073 km^2 is cultivated land (Xinjiang Bureau of Statistics, 2016)."

Line 111: "The area contains several large irrigation districts, where water for irrigation is primarily drawn from the Tarim River mainstream, supplemented by groundwater (Hao et al., 2015)."

Line 115: "The downstream ecosystem is extremely fragile. Ecological degradation has intensified since the 1950s with the area of Populus euphratica forests decreasing by approximately 86% compared to historical conditions (Jiang et al., 2005)."

Line 120: "To mitigate ecological degradation in downstream reaches, China launched the Ecological Water Conveyance Project (EWCP) along the Tarim River mainstream in 2000, aiming to restore river connectivity, groundwater levels, and riparian vegetation in downstream areas (Gao et al., 2026; Wang et al., 2025; Jiao et al., 2022; Dou et al., 2022; Xu et al., 2007)."

References

Chen, Y., Takeuchi, K., Xu, C., Chen, Y., and Xu, Z.: Regional climate change and its effects on river runoff in the Tarim Basin, China, Hydrological Processes, 20(10), 2207-2216, https://doi.org/10.1002/hyp.6200, 2006.

Bureau of Statistics of Xinjiang Uygur Autonomous Region, 2016. Xinjiang Statistical Yearbook 2015. Xinjiang Bureau of Statistics Official Website. Available at: https://tjj.xinjiang.gov.cn/.

Cui, B., Wang, G., Wei, G., Gui, D., Abd-Elmabod, S. K., Goethals, P., and Ahmed, Z.: Proactive policies are the key to reversing desertification in the main stream of the Tarim River in the past 30 years, Journal of Environmental Management, 370, 122919, https://doi.org/10.1016/j.jenvman.2024.122919, 2024.

Dou, X., Ma, X., Huo, T., Zhu, J., and Zhao, C.: Assessment of the environmental effects of ecological water conveyance over 31 years for a terminal lake in Central Asia, CATENA, 208, 105725, https://doi.org/10.1016/j.catena.2021.105725, 2022.

Gao, B., Xu, J., Deng, M., and Ling, H.: Study on the synergistic effects of ecological water conveyance and climate change on ecological restoration in arid areas: A case study of the Tarim River Basin, Ecological Engineering, 222, 107793, https://doi.org/10.1016/j.ecoleng.2025.107793, 2026.

Hao, Z., Chen, S., Li, Z., Yu, Z., Shao, Q., Yuan, F., and Shi, F.: Quantitative assessment of the impacts of irrigation on surface water fluxes in the Tarim River, China, Hydrology Research, 46(6), 996–1007, https://doi.org/10.2166/nh.2015.215, 2015.

Ling, H., Guo, B., Xu, H., and Fu, J.: Configuration of water resources for a typical river basin in an arid region of China based on the ecological water requirements (EWRs) of desert riparian vegetation, Global and Planetary Change, 122, 292-304, https://doi.org/10.1016/j.gloplacha.2014.09.008, 2014.

Jiang, L., Chen, X., and Bao, A.: Analysis on the Changing Dynamics of Groundwater Level in the Lower Reaches of the Tarim River, Xinjiang, Arid Land Geography, 28(1), 33-37, https://doi.org/10.13826/j.cnki.cn65-1103/x.2005.01.007, 2005.

Jiao, A., Wang, W., Ling, H., Deng, X., Yan, J., and Chen, F.: Effect evaluation of ecological water conveyance in Tarim River Basin, China, Frontiers in Environmental Science, 10, 1019695, https://doi.org/10.3389/fenvs.2022.1019695, 2022.

Tuoliewubieke, D., Yao, J., Mao, W., Chen, P., Ma, L., Chen, J., and Li, S.: Dominant spring precipitation anomaly modes and circulation characteristics in the Tarim Basin, Central Asia, Atmospheric Research, 313, 107767, https://doi.org/10.1016/j.atmosres.2024.107767, 2025.

Wang, X., Xu, H., Liu, K., Zhao, X., Wei, G., Aili, A., and Zheng, G.: Ecological water conveyance-driven wetland hydrological connectivity and morphological changes in arid regions: An analysis of the Taitema Lake wetland, Journal of Environmental Management, 385, 125615, https://doi.org/10.1016/j.jenvman.2025.125615, 2025.

Xu, H., Ye, M., Song, Y., and Chen, Y.: The Natural Vegetation Responses to the Groundwater Change Resulting from Ecological Water Conveyances to the Lower Tarim River, Environmental Monitoring and Assessment, 131, 37-48, https://doi.org/10.1007/s10661-006-9455-7, 2007.

3. Clarifications are needed regarding the data and model construction.

3.1. The authors mentioned that the surface water and groundwater systems within the region are closely connected (lines 102-103). Is this a result of this study or of other studies? Please clarify and add proper references.

Response: Thank you for the reviewer's correction. This statement was not first proposed in this study but is based on the consensus from previous research. The interaction between surface water and groundwater in the Tarim River Basin has been systematically analyzed in multiple studies. We have added the relevant references in the revised manuscript and cited them at the appropriate locations to clarify the reliability of this statement.

References

Chen, D., Zeng, X., Gui, D., Wang, D., and Wu, J.: Quantifying the hydrological processes in the Tarim River Basin, China, using a coupled groundwater/surface water model, Hydrogeology Journal, 33, 1637-1661, https://doi.org/10.1007/s10040-025-02947-7, 2025

Li, Z., Wang, Y., Chang, J., Guo, A., Wang, L., Niu, C., Hu, R., and He, B.: Multi-objective double layer water optimal allocation and scheduling framework combing the integrated surface water - groundwater model, Water Research, 262, 122141, https://doi.org/10.1016/j.watres.2024.122141, 2024

Liu, Q., Hanati, G., Danierhan, S., Zhang, Y., and Zhang, Z.: Modeling of multiyear water-table fluctuations in response to intermittent artificial recharge, Hydrogeology Journal, 29, 2397–2410, https://doi.org/10.1007/s10040-021-02388-y, 2021.

Schilling, O. S., Doherty, J., Kinzelbach, W., Wang, H., Yang, P. N., and Brunner, P.: Using tree ring data as a proxy for transpiration to reduce predictive uncertainty of a model simulating groundwater-surface water vegetation interactions, Journal of Hydrology, 519 (Part B), 2258-2271, https://doi.org/10.1016/j.jhydrol.2014.08.063, 2014.

3.2. The authors derived their hydrogeologic conditions from borehole and regional hydrogeologic maps reported by Li et al. (2003) (citation not presented in the reference list). I have a few questions regarding this data,

3.2.1. Are the authors looking at confined and unconfined aquifers? Have these aquifers been reported in the area? Is there any groundwater pumping that might alter their model assumptions or the water allocation parameter? I encourage the authors to provide this additional information and add potential limitations.

3.2.2. According to the authors, the hydrogeologic parameters were constrained based on the primary lithology and parameter ranges reported in previous studies (lines 149-150). However, there is no citation for this statement. I encourage them to provide the necessary references and a table or map containing geologic units and the hydraulic conductivity values selected, as this will enhance the reproducibility of their work.

Response: We sincerely thank the reviewer for the careful review and for pointing out the omission in the reference list. We apologize for this oversight and have added the following references to the revised manuscript.

References

Chen, D., Zeng, X., Gui, D., Wang, D., and Wu, J.: Quantifying the hydrological processes in the Tarim River Basin, China, using a coupled groundwater/surface water model, Hydrogeology Journal, 33, 1637-1661, https://doi.org/10.1007/s10040-025-02947-7, 2025.

Li, W., Hao, A., Liu, Z., & Wan, L. (2003). Research on Prospective Areas for Groundwater Exploration in the Tarim Basin. Science Press, Beijing. (In Chinese)

Regarding the specific questions raised by the reviewer, our responses are as follows.

Response to Comment 3.2.1

In the groundwater model developed in this study, the aquifer system is explicitly represented as a multi-layer structure, consisting of one unconfined aquifer (Layer 1) and five underlying confined aquifers (Layers 2-6). This hydrogeological structure and the hydraulic connections between these aquifer layers were defined based on regional hydrogeological cross-sections and borehole data (Li et al., 2003). Existing hydrogeological surveys indicate that the study area is widely underlain by Quaternary unconsolidated sediments forming a multi-layer aquifer system, with an upper unconfined aquifer and several confined aquifers beneath it.

In addition, human activities, especially groundwater pumping caused by agricultural irrigation, are important factors affecting the regional water cycle. In this study, groundwater extraction has been explicitly incorporated into the model as an external stress. The relevant data were obtained from the Xinjiang Water Resources Bulletin published annually by the Xinjiang water resources management department (XJDWR, 2002–2021), and were input as a pumping time series to reflect the impact of agricultural abstraction on the groundwater system.

To reasonably represent the influence of agricultural activities under changing conditions, we used historical pumping data as a baseline in our scenario simulations. When simulating different cropping patterns or planting areas, the pumping amount was proportionally adjusted according to changes in planting area. This approach is intended to maintain a logical correspondence between agricultural water demand and groundwater withdrawal, enabling the model to better capture the potential impacts of land-use changes. Following the reviewer's suggestion, we have added a discussion of limitations in Section 5.2 of the revised manuscript.

"Specifically, we note that the proportional adjustment method used for groundwater abstraction represents a simplified treatment. When the intensity or spatial distribution of groundwater abstraction changes significantly, the model should be updated and recalibrated using the latest statistical data to ensure the reliability of simulation and prediction results."

Response to Comment 3.2.2

The values of key hydrogeological parameters in the model (such as horizontal and vertical hydraulic conductivity, specific yield, and specific storage) are based on our previous study (Chen et al., 2025), where these parameters were systematically described. Based on the regional lithological information provided by Li et al. (2003), the study area was divided into hydrogeological zones, and corresponding initial parameter ranges were assigned to different lithological units. We have added a geological cross-section map of the model area in the Supplementary Materials. This figure was constructed based on regional borehole data and clearly shows the spatial distribution of aquifers and lithological variations in the study area, providing direct geological evidence for the conceptualization of the aquifer structure in the model. The complete input files of the coupled groundwater–surface water model used in this study (including parameter settings) have been uploaded to a public data repository: https://doi.org/10.5281/zenodo.18924068

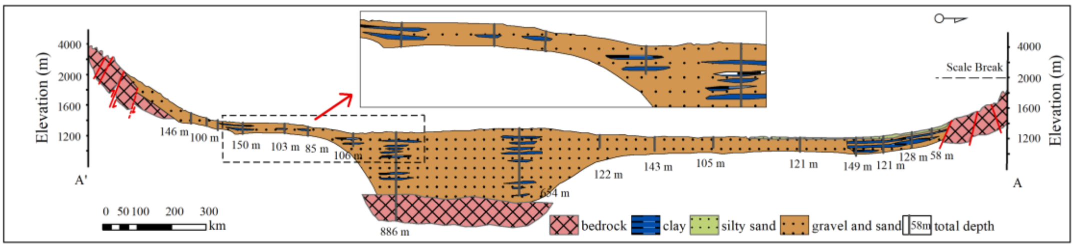

Figure R1. Geological section map of model area

3.3. They mentioned that their coupled surface water-groundwater model was developed based on the GSFLOW framework proposed by Chen et al. (2025), which is not in the reference list. The authors should add this reference and provide additional clarifications to their modeling approach. Mainly,

3.3.1. The current groundwater model is discretized into 6 layers. Is the depth between the layers coming from the geologic data? What is the hydraulic conductivity of these layers? How was the depth of the aquifer (i.e., depth to a confining unit) determined for this area?

3.3.2. I also encourage the authors to provide a figure that shows the boundary conditions they used for their model.

3.3.3. The authors calibrated their model using 139 monitoring wells from Xue et al. (2024), which is another work not in the reference list. Is this information looking at unconfined aquifers in the area, or is it also looking at confined aquifers? This can have important implications for the model's calibration that depends on the conceptualization of the subsurface structure.

3.3.4. They also mention that other key parameters, such as infiltration coefficients and aquifer hydraulic conductivity, were calibrated using a Bayesian uncertainty framework (lines 209-210). However, they do not provide the specifics of their calibration scheme or the distribution of values used for calibration. I encourage the authors to provide this additional information.

3.3.5. They used evapotranspiration data from the GLEAM dataset. However, different crop compositions will increase or decrease evapotranspiration. Did the authors consider this in their optimization process?

3.3.6. This reviewer understands the limitations behind their complex modeling approach. However, there is not much information in the modeling section about nitrogen loads. Are the authors also including a transport model to move nitrogen through the system? Or do they assume this is a point-source contamination that stays in crop areas? The authors should to clarify how they are handling nitrogen loads in their optimization scheme.

Response: Thank you for the reviewer's valuable suggestions. We have added the relevant reference to Chen et al. (2025) in the revised manuscript. That study systematically introduced the basic structure, parameter zoning method, and coupling mechanism of the GSFLOW model in the Tarim River Basin. Based on that modeling framework, this study recalibrated the model using new observational data from the Tarim River mainstream region.

The responses to the reviewer's specific questions are provided below.

Response to Comment 3.3.1

The six-layer structure of the groundwater model and the thickness of each aquifer layer were mainly determined based on regional hydrogeological maps and borehole data, which were obtained from Li et al. (2003) and related reports from the Xinjiang Geological Survey. The elevations of the top and bottom of each layer were obtained through interpolation of borehole data, based on which a three-dimensional aquifer structure was constructed. Hydraulic conductivity values for each layer were assigned according to the dominant lithology (e.g., clay, silt, fine sand, medium-coarse sand, and gravel). The prior parameter ranges were determined based on regional hydrogeological data and previous studies, and the posterior distributions of these parameters were identified using the Markov Chain Monte Carlo method during model calibration. In addition, according to the collected borehole data, the thickness of Quaternary unconsolidated sediments in the study area is approximately 200-400 m, underlain by a relatively stable basement confining layer. This depth range was used as the bottom boundary of the model.

Response to Comment 3.3.2

Thank you for the reviewer's suggestion. To more clearly present the model structure, we have added a schematic diagram of the model boundary conditions in the

Supplementary Materials.

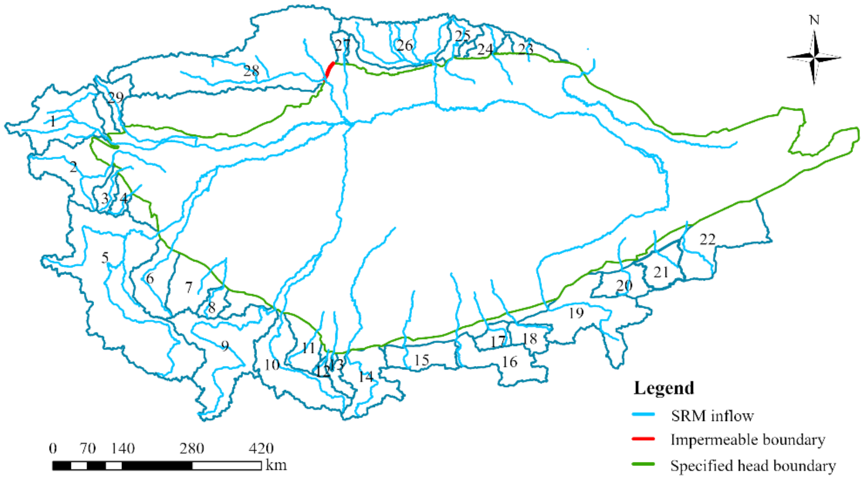

Figure R2. Schematic diagram of model boundaries.

Response to Comment 3.3.3

We thank the reviewer for pointing out the missing reference, and we have added the following reference in the revised manuscript:

Xue, D., Gui, D., Ci, M., Liu, Q., Wei, G., and Liu, Y. (2024). Spatial and temporal downscaling schemes to reconstruct high-resolution GRACE data: A case study in the Tarim River Basin, Northwest China. Science of the Total Environment, 907, 167908.

The 139 monitoring wells used for model parameter identification include both shallow monitoring wells and deep monitoring wells. Water level data from both shallow and deep wells were used in the parameter identification process to ensure that the model can reasonably represent groundwater dynamics in the multilayer aquifer system.

Response to Comment 3.3.4

Thank you for the reviewer's suggestion. In this study, the $DREAM_{ZS}$ (Differential Evolution Adaptive Metropolis with sampling from past states) algorithm was used to perform Bayesian parameter uncertainty analysis. This algorithm can effectively explore high-dimensional parameter spaces and estimate the posterior distributions of parameters. We set up three parallel Markov chains, each running 20,000 iterations, including a burn-in period of 5,000 iterations. The likelihood function was defined using a Gaussian distribution. The parameters to be identified and their prior ranges are listed in Table S1 of the Supplementary Materials. The prior ranges of these parameters were mainly determined based on regional hydrogeological survey reports (e.g., data from the Xinjiang Geological Survey) and related literature (e.g., Li et al., 2003), ensuring that the parameters remain physically reasonable.

Table S1 The unknown model parameters in GSFLOW

Parameters	Unit	Prior Range
Soil maximum available capillary water-holding capacity	cm	12.0 - 42.0
Linear coefficient of gravity drainage	cm/d	0.00015 - 2.5
Hydraulic conductivity	m/d	0.01 - 65
Specific yield	-	0.02 - 0.30
Specific storage	10^{-6} m^{-1}	1 - 36
Maximum evapotranspiration depth	m/d	0.5 - 8
Streambed hydraulic conductivity	m/d	0.02 - 60

Response to Comment 3.3.5

In this study, GLEAM evapotranspiration dataset was used only for the validate of the hydrological model results, not as model input or driving data. The GSFLOW model dynamically calculates actual evapotranspiration based on energy balance and water balance processes, taking into account vegetation type and soil moisture conditions. For agricultural areas, GSFLOW sets parameters such as crop coefficients according to crop type. Therefore, when the optimization model changes the crop planting area A_{ij}, the evapotranspiration simulated by GSFLOW will automatically respond to the new crop structure, thereby reflecting the impact of agricultural structure changes on the water consumption process.

Response to Comment 3.3.6

This study mainly focuses on the water quantity processes within the coupled system and does not construct a complete nitrogen transport and transformation model. The total agricultural nitrogen load (f_{TN}) is estimated using an empirical approach based on crop fertilization intensity:

$$f_{TN} = \Sigma\, (N_{ij} \times A_{ij})$$

where N_{ij} is the annual nitrogen load per unit area for crop j in irrigation district i, and A_{ij} is the corresponding planting area. This method has been widely used in multi-objective agricultural water management studies to characterize the potential environmental pressure caused by agricultural intensification, rather than to simulate the actual transport and transformation of nitrogen in the soil-groundwater system (e.g., Tang et al., 2024; Song et al., 2022). This simplified approach is suitable for strategic analyses of large-scale watershed water resource management and ecological security assessment. It enables rapid characterization of regional agricultural non-point source pollution risk while maintaining computational efficiency, making it suitable for multi-objective coupled optimization decision-making at large watershed scales. Following the reviewer's suggestion, we have further clarified this simplifying assumption in Section 5.2 (Limitations) of the revised manuscript and noted that future studies will consider incorporating a complete solute transport model.

References

Song, J., Yang, Y., Yin, Z., Wu, J., Sun, X., Lin, J., Wu, J., 2022. Satellite data-driven multi-objective simulation-optimization modeling for water-environment-agriculture nexus in an arid endorheic lake basin. Journal of Hydrology, 612, 128207.

Tang, X., Huang, Y., Pan, X., Liu, T., Ling, Y., and Peng, J.: Managing the water-agriculture-environment-energy nexus: trade-offs and synergies in an arid area of Northwest China, Agric. Water Manag., 295, 108776, https://doi.org/10.1016/j.agwat.2024.108776, 2024.

3.4. In the multi-objective optimization model section, the authors provide decision variables, their constraints, and the objective functions. Although there are equations for all of them, I don't seem to find where the monthly ecological water allocation coefficient is presented within the modeling scheme. Is this an extraction within the hydrological model? Where is it drawn from? It would be helpful to have a schematic of the optimization process.

Response: Thank you for the reviewer's careful review and valuable suggestion. We agree that the explanation of the relationship between the monthly ecological water allocation coefficient θ_k and the hydrological model was not sufficiently clear in the original manuscript, which may affect readers' understanding of the model coupling process. Following your suggestion, we have systematically supplemented and clarified this part in the revised manuscript.

In the multi-objective optimization model constructed in this study, the monthly ecological water allocation coefficient θ_k(k = 5, 6, …, 9) is defined as a key decision variable used to control the distribution of the annual ecological water volume among the key ecological water conveyance months (May-September). The optimization model first determines the annual ecological water conveyance amount Q_e and then θ_k determines the ecological water volume for each month:

$$Q_{e,k} = \theta_k \cdot Q_{e,}, \quad \sum_{k=5}^{9} \theta_k = 1$$

where $Q_{e,k}$ represents the ecological water conveyance amount in month k.

In the coupled hydrological model, these monthly ecological water volumes are not directly converted into surface infiltration recharge but are instead introduced as additional stream diversion inputs into the river system. Within the GSFLOW framework, this process is simulated through the MODFLOW SFR (Streamflow Routing) module. After ecological water enters the river channel, it first alters streamflow and river stage, and then influences groundwater recharge through stream-aquifer exchange processes. Specifically, increased streamflow raises the river stage, which enhances riverbed leakage and consequently increases groundwater recharge to the riparian aquifer. This ultimately affects the simulated groundwater level changes (objective function f_{GL}) and the terminal lake area (objective function f_{LA}).

To further improve the readability and reproducibility of the model description, we have made the following additions in the revised manuscript:

"During the hydrological model coupling process, the monthly ecological water conveyance is introduced into the GSFLOW model as an additional river diversion boundary condition and simulated through the SFR module in MODFLOW. After entering the river system, the ecological water first changes river discharge and river stage, and then affects groundwater recharge through riverbed leakage mechanisms. When the river stage is higher than the groundwater level, the river recharges the aquifer; otherwise, groundwater may discharge to the river. Therefore, the monthly ecological allocation coefficient θ_k becomes an important variable linking the multi-objective optimization decisions with hydrological process simulations."

In addition, to clearly illustrate the theoretical framework of this study, we have added a schematic diagram of the multi-objective optimization-hydrological simulation coupling framework in the main text.

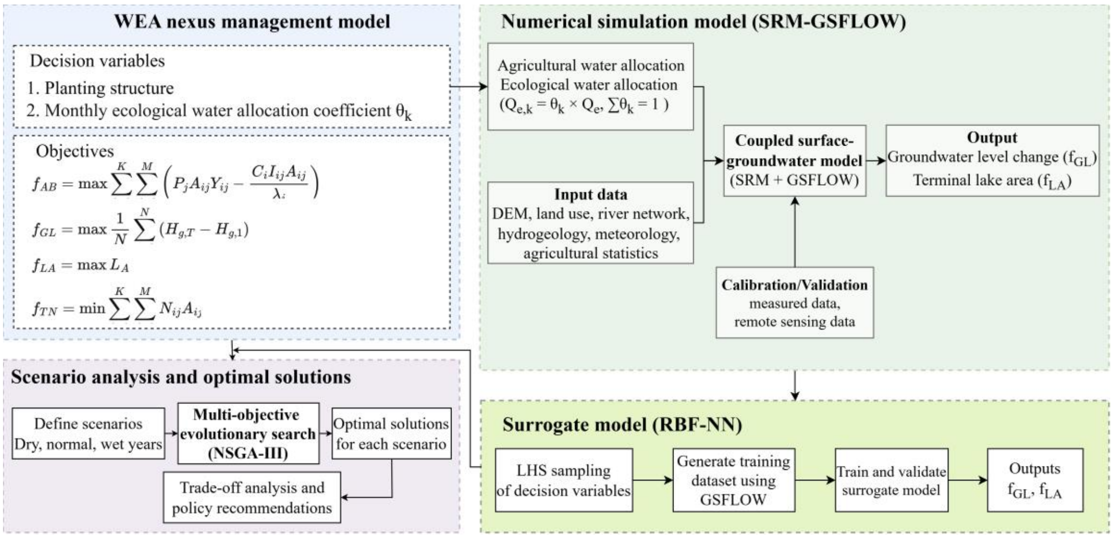

Figure R3. Framework of the multi-objective simulation–optimization for the WEA nexus management.

3.5. Due to the complexity of their hydrological model, the authors opted to train an RBF-NN as a surrogate model. However, it is unclear what the model's input and output variables are, as well as its structure. I encourage the authors to include this information to improve reproducibility.

Response: Thank you very much for your valuable suggestion. In Section 3.3 "Surrogate Model Construction and Validation," we have supplemented a detailed description of the surrogate model construction.

"The input variables of the surrogate model are the decision variables to be optimized. Specifically, they include the planting areas of six major crops (cotton, maize, oil crops, vegetables, melons, and fruits) across seven irrigation zones, as well as the allocation coefficients of ecological water use during key months (May–September), resulting in a total of 47 decision variables. The output variables of the surrogate model consist of two hydrological variables simulated by the coupled hydrological model (GSFLOW), namely the change in the average groundwater depth in the study area and the area of the terminal lake. To construct the surrogate model, Latin hypercube sampling was first applied to generate samples within the input variable space. Each sample set was then used as input to the GSFLOW model to obtain the corresponding outputs, thereby forming an input–output dataset. The dataset was subsequently randomly divided into a training set (70%) and a test set (30%). The training set was used to train the radial basis function neural network (RBF-NN), while the testing set was used to evaluate the predictive accuracy and generalization capability of the

surrogate model."

3.6. Also, the authors show that the model performs better by giving additional training points, which is expected. However, doing this might also lead the model to overfit. I encourage them to consider using a cross-validation scheme for their surrogate model.

Response: Thank you for this important suggestion. To further evaluate the generalization capability of the surrogate model and reduce the risk of overfitting, we adopted a five-fold cross-validation approach to systematically assess the predictive performance of the surrogate model. The training dataset was generated using the Latin Hypercube Sampling method. During model validation, the training dataset was randomly divided into five non-overlapping subsets. In each iteration, four subsets were used as training data and the remaining subset was used as validation data. This process was repeated so that each subset served once as an independent validation dataset. The cross-validation results show that the surrogate model maintains relatively stable prediction errors under different data partition conditions, with small RMSE variations among the folds, and no obvious overfitting phenomenon was observed.

Table S2. Results of the 5-fold cross-validation for the surrogate models

Target	Fold 1 RMSE	Fold 2 RMSE	Fold 3 RMSE	Fold 4 RMSE	Fold 5 RMSE	Mean RMSE	Std RMSE
Groundwater level	0.031	0.035	0.032	0.036	0.033	0.033	0.002
Lake area	1.012	1.124	1.036	1.146	1.058	1.075	0.057

Technical Corrections

1. The text within Figure 1 is difficult to read; consider increasing the font size.

Response: The font size has been increased.

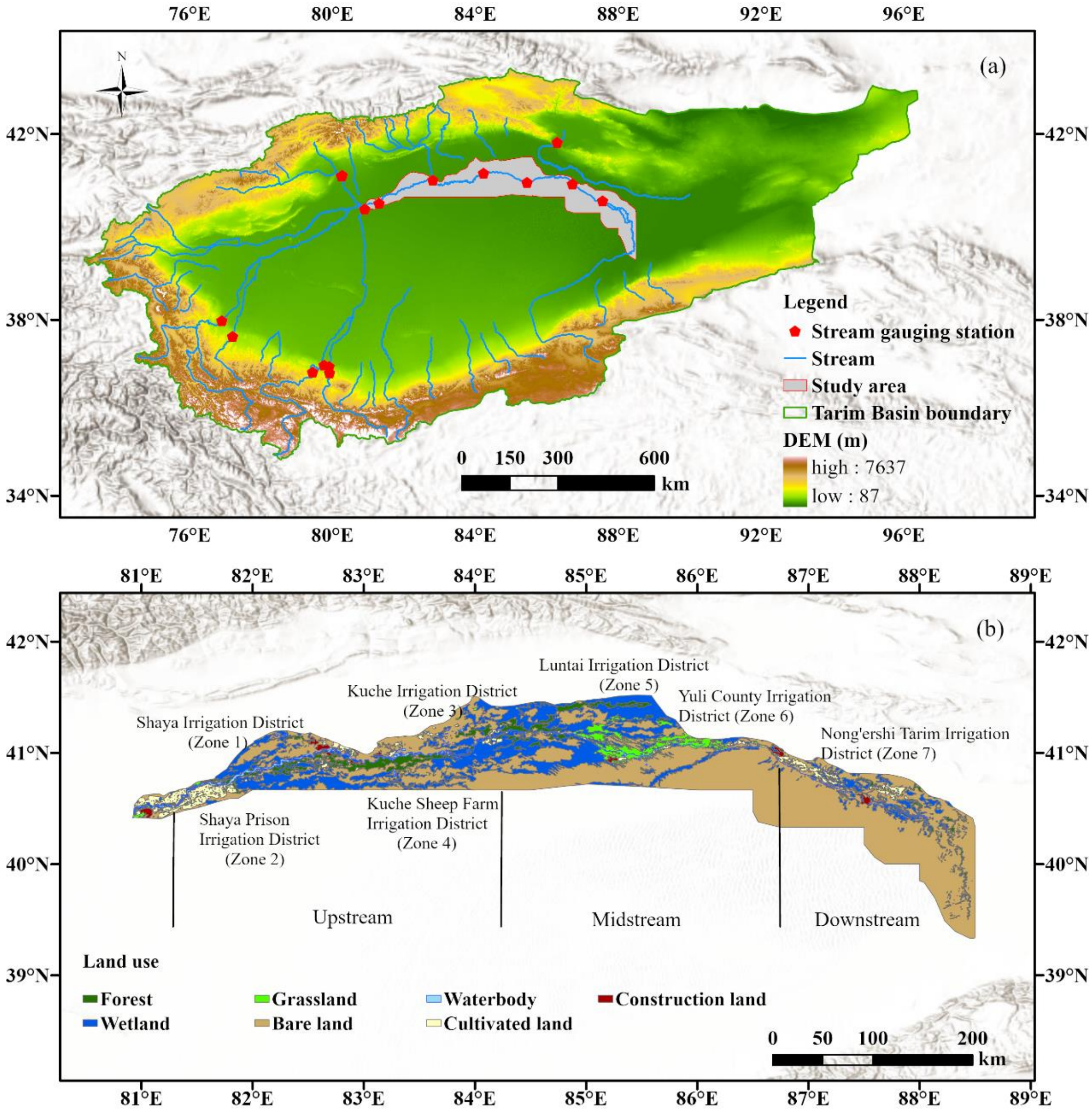

Figure 1. (a) The location of the Tarim River mainstream region. (b) Land use types across the Tarim River mainstream region. Sources: Esri; Powered by Esri; Basemap: Esri World 286 Hillshade (Esri).

2. In line 96, the authors state “and a total precipitation below 80 mm.” Is this total “annual” precipitation? Please clarify.

Response: Thank you for the question. The annual precipitation in the Tarim River mainstream region is indeed below 80 mm, and the original statement was correct. To avoid ambiguity, we will explicitly revise it to “annual total precipitation below 80 mm.”

3. Correct comma placement in “This dataset” (line 137).

Response: The punctuation error has been corrected.

4. Labels in Figure 2 are difficult to read. I recommend increasing the font size and

removing the x-labels from figures (a) through (d), as they are the same; this can give you more space in the figure.

Response: The font size has been increased and the repeated x-axis labels have been removed.

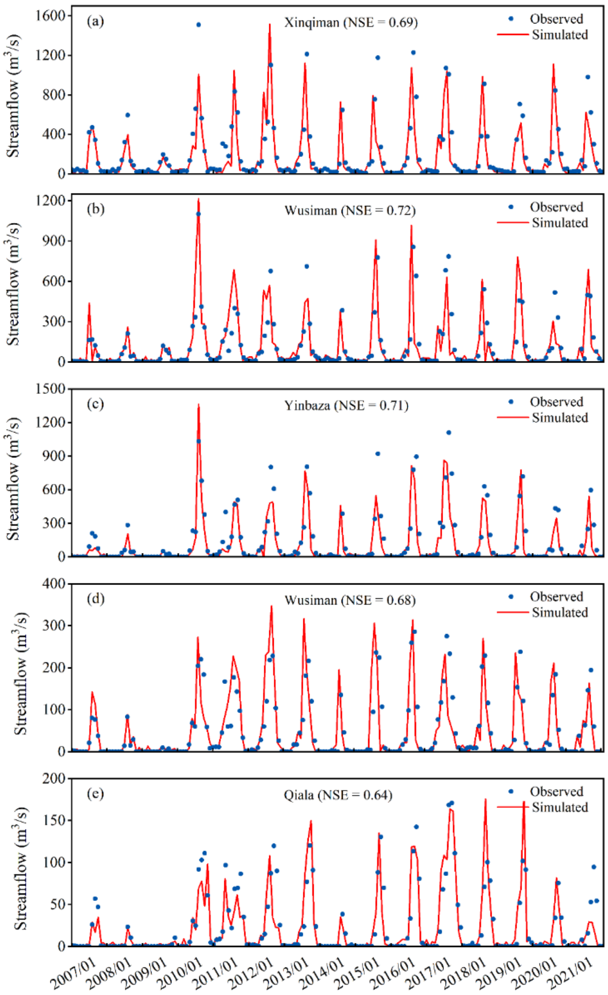

Figure 2. (a) - (e) present the evaluation of monthly streamflow simulations against observations at Alar and Xinqiman, Yingbaza, Wusiman, and Qiala gauging stations, respectively.

5. Table 5 is referenced before Figures 5-7. I recommend changing the order of their presentation in the manuscript.

Response: The order of the figures and tables has been adjusted to improve the logical presentation of the manuscript.