Response to Anonymous Referee #3

General comments:

The paper entitled "Can the combining of wetlands with reservoir operation largely reduce the risk of future flood and droughts?" is an interesting work that integrates wetlands as nature-based solution for mitigation of flood and droughts in modelling. This work helps improve the understanding of how to integrate wetlands into hydrological models as well as how wetlands can be used for hydrological assessments. I believe it deserves publishing but with major revisions.

This paper is a long and sometimes repetitive read in which it is easy to lose track of all the given information. Overall, the article could be more condensed and straightforward. Moreover, some clarification concerning the modeling approach, more explicit description of the methods as well as better connection to the aim and research questions is needed. For instance, the work of future projection of flood and droughts are given more space than could be understood in the aim and research questions and also compare to what the reader initially would think regarding the focus on wetlands with reservoir operations as mentioned in the title. It is not clear how this study comes to the conclusions regarding how wetland and reservoir operation reduces the risk of future floods and droughts. I believe this should be the main aspects of the results and discussion. In addition, the results and discussion should better reflect the fact that this work is based on a case study and that local conditions/mitigations from wetlands combined with reservoir operation could vary between river basins.

Response: Thank you very much for your careful assessment of our manuscript and for acknowledging the value of our work. We highly appreciate your constructive comments and have diligently revised the manuscript. Please find our responses to the detailed comments below.

Specific comments:

Introduction- very long and repetitive introduction that can be condensed to the most important and relevant aspects of the study.

Response: We thank your comment here. Mostly based on your constructive comments, and taking into account the suggestions of Referee #1 and Referee #2, we condensed the Introduction to preserve the most important and relevant aspects of the study.

Line 47: what do you mean by cascade up the flood risks to a great extent?

Response: We apologize for unclear representation here. We have changed 'cascade up' to 'mitigate' in the sentence as follows:

Concurrently, the disaster-related loss of ecosystems (e.g., wetlands, forest and grassland) and their services can mitigate the flood and drought risks to a great extent (Gulbin et al., 2019; Walz et al., 2021).

Line 53-68 if you are referring to wetlands as NBS, why not write it in a same unifying paragraph?

Response: We thank your comment here. We have carefully checked and revised the full text to make it in a same unifying paragraph.

Line 74-75 what do you mean by hydrologic equivalent wetland.

Response: We thank your comment here. Due to our drastic changes to Introduction, the hydrologic equivalent wetland has been removed here. But in the following text, we describe the hydrologic equivalent wetland in detail as follows:

It should be mentioned that the HEW concept developed by Wang et al (2008) served as the foundation for the integration of RWs and IWs into the modeling framework. This concept contends that the features of one HEW (also known as an isolated wetland or riparian wetland) are equivalent to the sum of the characteristics of each wetland inside a RHHU (which could either be hill slopes or elementary sub-watersheds related to one river segment). The following premises apply to this concept: (i) only one isolated and/or riparian HEW per RHHU; (ii) one HEW can be fully integrated within a RHHU; (iii) isolated HEW parameters must be numerically integrated; and (iv) riparian HEW parameters must be numerically integrated and spatially integrated (i.e., located in a specific location on the river segment). Therefore, IWs and RWs do not appear to have direct hydrological connection within a RHHU. However, IWs also have hydrological interactions with RWs through vertical water balance processes and fill-spill processes (Fossey et al., 2015).

Line 76-77: instead of typing all the references, you could shorten and simplify the reading to " multiple studies (e.g., references)"

Response: We agree with your opinion here and have rephrased the sentence as follows:

Since then, multiple studies (e.g., Evenson et al., 2016; Evenson et al., 2018; Zeng et al., 2020) successively modified wetland modules (isolated or riparian wetlands) and improved the applicability of SWAT model to discern hydrological services of basin wetlands.

Line 93-95: sentences that could be rewritten into previous sentence inline 91-93

Response: We agree with your comment here and have rephrased the two sentence as follows:

Such numerous reservoirs and their large storage capacity should not be neglected in water hazard assessment and hydrological projection because of their significant modification on flood and drought patterns (Boulange et al., 2021; Brunner et al., 2021).

Line 95-96: how is this information relevant to the study?

Response: We agree with you that this sentence is not relevant to the study and we have deleted the sentence.

Line 115: what is meant by the expression " 1+1=2" simulation effect?

Response: Thanks for your kind reminder here. This expression in unclear and we have rephrased the sentences as follows:

Furthermore, on a global scale, most river basins have wetlands and their river flow has or will experience reservoir regulation (Schneider et al., 2017; Muller, 2019), which elicits a thought-provoking concern: What will be the changes of future floods and droughts under the combined influence of wetlands and reservoirs?

Line: 137: I think it is worth mentioning and clarifying that you use the Nenjiang river basin as a case study to answer the aim of the effect of wetland and reservoir operations into hydrological modelling for mitigating future flood and drought.

Response: We thank your comment here and have added the description about this point as follows:

The Nejinang River Basin was selected as a case study here because it has abundant wetlands and a large reservoir, and has undergone intensive anthropogenic activities in the past half century, particularly in the increasing agricultural water consumption and conversion of wetlands to agricultural and other land uses.

Line141: the main research questions are not clear enough. My understanding is that you want to analyze how the combined wetland and reservoir operation can mitigate flood using modelling. So the (a) question should be written in that direction and the question (b) might be oriented towards the mitigation of wetlands and reservoir operations of future flood and drought.

Response: Thank you for highlighting the need to better describe the main research questions. We specified it in the introduction that:

We then applied it to a large river basin with abundant wetlands and a large reservoir, the Nenjiang River Basin in northeast China, to address a central question: Can the combining of wetlands with reservoir operation largely reduce the risk of future flood and droughts?

Methods-To many sections that are repetitive and could be deleted/incorporated into each other and with fewer sections.

Response: Thank you for indicating that this section needed improvement. We have largely adjusted the structure and revised text to make it more concise. Specifically in the following three aspects:

(1) Structurally, Section 2.2-2.3 of the original manuscript were reorganized into Section 2.3;

(2) Rewriting the text to detail how to couple wetlands and reservoir operation into hydrological modelling;

(3) Removal or merging of repetitive and irrelevant sentences/contents;

(4) Revise the text according to the constructive comments on Section 2.2-2.3.

Line 160: what is meant by “the wetlands and their contributing areas within the reaches”?

Response: We are sorry for unclear description of contributing drainage areas here. Since there is a detailed introduction to 'the wetlands and their contributing areas' later in the text, we have made a note here and a detailed introduction in subsequent text.

The sentence that contains the note is:

The wetlands and their contributing drainage areas (see Section 2.2.1 for specific definition) within the reaches monitored by the ten hydrological stations range from 14 to 23% and from 39 to 56% respectively, demonstrating the large wetland coverage of the NRB and its sub-basins (Table 1).

The detailed introduction in subsequent text: The contributing area of wetlands is defined as the sum of the area of all wetland RHHUs and upland RHHUs within their immediate catchment areas situated along active fill-spill pathways to the stream network (Evenson et al., 2016).

Line 164-165: you should delete that information. You already mention that the lower NRB is an important agricultural area.

Response: Deleted.

Line 166: what is meant by "ecological integrity"?

Response: We are sorry for unclear presentation here. We want to express the ecological integrity of wetlands. Based on your comments, it is modified as follows:

Therefore, understanding potential floods and hydrological droughts under future climate change is crucial for ensuring regional food security and wetland ecological integrity.

Line 168-171: these two sentences could be shortened into one.

Response: We thank your comment here and have condensed the two sentences into one as follows：

The area of wetlands in the NRB decreased by nearly 23% from 1978 to 2000 (Chen et al., 2021), with only 16.34% remaining today (Table 1), which largely degraded their services (Wu et al., 2021).

Line 177: Could you give a percentage of the total catchment instead? It would give more understanding of how important the area that drains into the reservoir if it was in percentage of the total catchment.

Response: We than your comment here and have detailed the drainage area of the reservoir as follows：

The drainage area of the reservoir accounts for 22.8% of the NRB.

Line 181: It would be easier to read the figure 1 if less background information was there. Also, the (b) and (c) part of the figure is missing.

Response: We apologize for the poor readability of Figure 1 and inconsistencies in the representation here. We have redrawn Figure 1 and changed its caption as follows:

[redacted]

Figure 1. Location of the Nenjiang River Basin and the distribution of wetlands, river networks, Nierji Reservoir, and hydrological and meteorological stations within the basin.

Line 190: In relation to Table 1, could you use the ID of the hydrological stations in figure 1 as well? It could be good to have a link between figure 1 and table 1.

Response: We thank the reviewer for pointing this out. Corresponding to the ID of hydrological stations in Table 1, we redraw Figure 1. Please refer to our previous reply.

Line 193. Section 2.2 might be superfluous in the paper and not really relevant as the study approach should be clear from the beginning. You should consider integrating this information in coming sections.

Response: We agree that Section 2.2 (original manuscript) can be clear here and we have deleted irrelevant contents and integrated the key information into the Section 2.2 and 2.3.

Line 213: Section 2.3 is too short for the reader to understand how the hydrological modeling coupled the wetlands and reservoir operation.

Response: Thank you for highlighting the need to further detail how the hydrological modeling coupled the wetlands and reservoir operation. We agree with your constructive suggestion and have substantially modified this section, describing in detailed steps how to achieve the coupling of them. The revised contents are as follows:

We developed a spatially-explicit hydrological modeling framework that considers wetland hydrological processes and reservoir operations based on HYDROTEL model and reservoir simulation algorithms (Fig.2). Such a modeling framework was based on a distributed coupling implementation at watershed scale from upstream to downstream. Observed streamflow from seven hydrological stations (see hydrological stations 1-7 in Fig.1) located upstream of the Nierji Reservoir and three hydrological stations (see hydrological stations 8-10 in Fig.1) installed at downstream of the reservoir, respectively, were used to calibrate the HYDROTEL model. For the upstream Nierji Reservoir, we calibrated the HYDROTEL model against observed streamflow of seven hydrological stations with consideration of wetlands (i.e., hydrologic-wetlands model). Among the seven hydrological stations, the Nenjiang Station is located at the end of the upstream, where the simulated streamflow was taken as the inflow of the reservoir. We then computed the reservoir outflow using the simulated inflow, estimated lateral inflow and reservoir simulation algorithms (see Section 2.2.2), thereby integrating reservoir operation into the hydrologic-wetlands model to build a hydrologic-wetlands-reservoir model. Based on the calibrated hydrologic-wetlands-reservoir model, we simulated the outflow of the reservoir (Sect. 2.2.2), which was used as the input streamflow for downstream model calibration. For the downstream reservoir, we calibrated the hydrologic-wetlands-reservoir model against observed streamflow of Tongmeng, Fulaerji and Dalai Stations Based on this framework, the simulation of basin hydrological processes coupled with basin scale wetlands and reservoir operations were realized.

Line 220-221: please clarify "The simulated runoff simulated by hydrologic- wetland model at the reservoir outlet was replaced with the estimated reservoir outflow, thus integrating reservoir operation into the hydrological modeling (i.e. hydrologic-wetland-reservoir model)"

Response: We are sorry for unclear presentation here. We have revised this sentence to make it understandable as follows:

We then computed the reservoir outflow using the simulated inflow, estimated lateral inflow and reservoir simulation algorithms (see Section 2.3.2), thereby integrating reservoir operation into the hydrologic-wetland model to build a hydrologic-wetland-reservoir model.

Line 226: section 2.3.1 could be integrated to the overall section of 2.3.

Response: We agree with your suggestion and have integrated Section 2.3.1 into the overall Section 2.2.

Line 229-231: this sentences could be integrated and refereed to above sentence in line 227-229.

Response: We integrated the sentence into the above sentence as follows:

The PHYSITEL/HYDROTEL modeling platform coupled with two wetland modules (isolated and riparian wetlands) (Fossey et al., 2015a), which had been used to quantitatively evaluate the hydrological function of wetlands (Fossey and Rousseau, 2016, Fossey and Rousseau et al., 2016, Blanchette et al., 2019, Wu et al., 2020a; 2020b; 2021; 2022, Blanchette et al., 2022), was used to simulate hydrological processes, assess model performance and project future flood and drought conditions.

Line 243: Please clarify the concept of a "hydrologically equivalent wetland"?

Response: We thank your comments here and have clarified the concept of hydrologically equivalent wetland. Please refer to our previous reply.

Line 255 & 257: You quite some abbreviations in the text, could you delete some and use the full word instead? For instance RW and IW could just be fully written out in order to facilitate the reading.

Response: Thank you for your suggestion. We have reduced the number of abbreviations and only kept which full names are longer. Particularly, isolated and riparian wetlands and their contributing areas has revised be fully written out. Also, the full text has been adjusted accordingly.

Line 263: To better understand how you set the model, could you consider to more explicitly describe how you integrate the reservoir operation into one common section, ex: 2.3 together with the coupling of wetlands? Your section 2.3 is very long and could be more condensed into one section about the set up of the model.

Response: Thank you for highlighting the need to detail how to integrate the reservoir operation into hydrological model. We improved the current description in two aspects: (1) in section 2.2.2, we refined the simulation of the Nirvana reservoir operation; and (2) in section 2.2.3, we refined how the reservoir operation was coupled in the hydrological model.

Line 266: What are the three algorithms?

Response: We have added this point in the text. The three algorithms are as follows:

The first algorithm considers a case when we want to always release a constant amount over the simulation period. This constant amount is the target release that would cover all downstream demand for water, for instance for domestic use and/or irrigation. The second consider a case when we still want to release the target demand but we would also like to (1) apply some hedging (that is, an intentional reduction of the release - even if it would still be feasible to release the target demand - aimed at saving more water and thus facing smaller deficits at later time); and (2) attenuate downstream peak flows for flood control purpose. The third algorithm, which was used in this study, dynamizes the operation rules.

Line 291-294: as the water level limit is always 216 m, could this sentence be rewritten in order to better understand the thresholds?

Response: Thank you for this suggestion. We have rewritten the sentence as follows:

The pre- and post-flood periods are June 1-20 and September 6-30, respectively, with a flood limited water level of 216.0 m; The main flood period is from June 21 to August 25, and the reasonable flood limited water level ranges from 213.4 m to 216.0 m and can be gradually increased.

Line 294-295: I sis not clear what the 25.3 % of the daily streamflow? Is it the average daily streamflow of the year or of the dry season?

Response: We are sorry for unclear presentation here. We consulted with the management of Nierji Reservoir and confirmed that it is the average streamflow during the dry season over the years. We have revised this sentence to make it clearly as follows:

During the dry season, the environmental flow was defined as 25.3% of the daily streamflow during the dry season over the years based on the designed operating curves of the reservoir operation chart.

Section 2.3.3 could be better integrated into the overall section of the model set up together with the other above sections.

Response: We agree with your suggestion and made several revisions in the following aspects: (1) Move 'description of driving datasets' to Section 2.1; (2) The rest of the content has been substantially revised to provide a clearer presentation of the model setup, calibration and validation process. The revised text is as follow:

2.2.3. Model calibration, validation and performance assessment

For all above scenarios, we calibrated the HYDROTEL model against observed streamflow at a daily time step over 8 years, including a 1-year warm-up (2010.10.01-2011.09.30) and a 7-year calibration (2011.10.01-2018.09.30) periods. The same model settings (i.e., key parameters, simulation periods, fitting algorithm, and objective function, etc.) were used for the calibration processes under the both presence and absence scenarios. Following Arsenault et al.(2018), the model was calibrated using full-time observations without additional validation, as the former allows for more reliable parameters and maximizes the accuracy of the model. The dynamically dimensioned search algorithm (DDS) developed by Tolson and Shoemaker(2007) was used to calibrate the 13 most sensitive parameters of the model as proposed by Foulon et al.(2018). Based on the maximizing of Kling-Gupta efficiency (KGE) (Gupta et al., 2009), automatic calibrations using DDS were carried out utilizing 10 optimization trials (250 sets of parameters per trial). Then, the best set of parameter values out the 10 trials were selected following Foulon et al.(2018). The KGE was chosen as the objective function because previous research has shown that it can improve flow variability estimates when compared to the NSE (Garcia et al., 2017; Fowler et al., 2018).

It should be noted that we calibrated the HYDROTEL model against observed streamflow under with and without wetland scenarios. For the without wetland scenarios are defined as follows: When the wetland modules are turned off in HYDROTEL, wetland areas are not removed, but they are treated as the land cover of saturated soils. Such a saturated soil is fixed and does not participate in hydrological processes such as water yielding and runoff routing, and thus their explicit storage properties are not accounted for in the modeling. This is a basic assumption that has been used in several studies using models such as SWAT (Liu et al., 2008; Wang et al., 2008; Evenson et al., 2015), Mike 11 (Ahmed, 2014) and HYDROTEL (Fossey et al., 2016; Fossey and Rousseau, 2016a, b; Wu et al., 2019, 2020a, 2021), to quantify the hydrologic services provided by wetlands (flood mitigation, flow regulation and baseflow support etc.).

To determine whether coupling the wetland module and the reservoir can improve the model performance, we compared (1) the efficiency of the model in simulating daily flow processes; and (2) the capability of the model to simulate floods and hydrological droughts in the presence or absence of the wetlands and the combination of wetlands and reservoir. Following the recommendations of N. Moriasi et al.(2007) and Moriasi et al.(2015), four performance criteria were selected to assess model performance with regards to simulated daily flows with and without the presence of the wetland modules and reservoir operation, namely the Nash-Sutcliffe efficiency (NSE) (Nash and Sutcliffe, 1970), Correlation Coefficient (CC), the root-mean square error (RMSE) and the percent bias (Pbias). We used multiple performance criteria because it may be unreliable to rely on a single objective function to determine whether the model performs well (Pool et al., 2018; Fowler et al., 2018; Seibert et al., 2018). It should be noted that although NSE as an objective function has shortcomings in model calibration, it can still provide an important reference for the evaluation of simulation results as a performance criterion as suggested by Moriasi et al. (2007, 2015). In addition, we compared model performance considering daily hydrograph changes. Furthermore, flood and drought features were extracted (see Sect. 2.4.2 and 2.4.3) and used to discern whether, and to what extent, the coupled wetland modules and reservoir simulations could improve the model's ability to simulate droughts and floods.

Section 2.4 and its subsection could also be better streamlined into one section describing the projection of future flood and drought.

Response: We agree with your constructive comments here and have streamlined Section 2.4 and its subsection into one section. Please refer to our previously revised text for details.

Line 383-389: Information that might be to detailed and should be mentioned rather swiftly than given too much attention.

Response: We acknowledge your suggestion to remove this section and move key information to other sections. In addition, we have moved the description of the datasets to Section 2.1 to make it easier for the reader to understand.

Line 433-434: repetitive sentence

Response: We thank your comments here and have rewritten the sentence as follows:

A threshold method was used to define hydrological drought events because it can determine the start and end of a hydrological drought event, which allows further assessment of drought characteristics, such as frequency, duration, and intensity of a drought event (Cammalleri et al., 2017).

Line 457-459: repetitive sentence of information already given before.

Response: Deleted.

Results-Your result should better reflect the modelling work. Instead of referring to the result figures in the supplementary materials, you should integrate them into the main text. In that way you should give more credit to how the model perform with couple wetland and reservoir operation that focusing on the projection of future flood and droughts.

Response: We would like to express our gratitude to you for the insightful comment. We have moved the key figures to the main text.

I would also recommend to use figure 5 &8 in text and leave figure 4 &7 in supplementary.

Response: We fully agree with your suggestion and have moved Figures 4 and 7 to the supplemental.

Figure 6 should be better explained and the explanation of the different plots (a-f) is missing.

Response: We thank your valuable comments here and have labeled the SSPs in Figure 5 (i.e., the Figure 6 in the original manuscript):

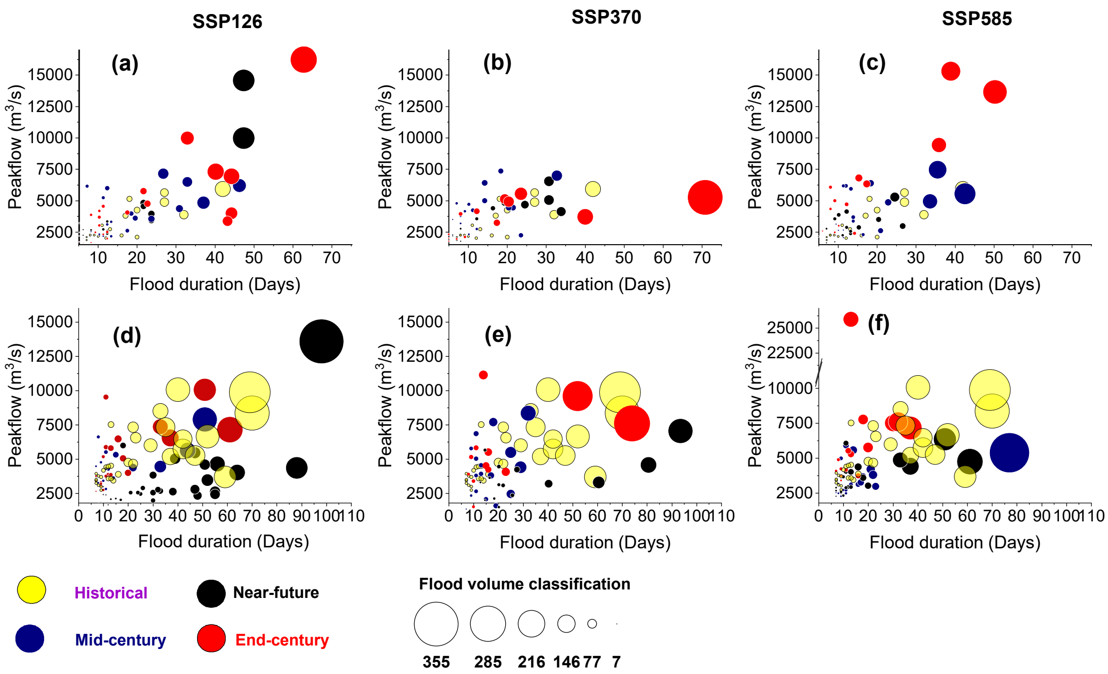

Figure 5. Historical and projected flood duration-peak flow-volume relationships at the Nenjiang (the first row) and Dalai (the second row) Station. The historical period refers to 1971-2020 and the near-future, mid-century and end-century refer to the 2026-2050, 2051-2075 and 2076-2100 under the Socioeconomic Pathways (SSP) 126 (the first column), SSP370 (the second column) and SSP585 (the third column) scenarios.

Line 619: please clarify the statement "droughts will equivalent to the historical period"

Here, it means that the number of droughts has no significant trend of increasing or decreasing.

Response: We are sorry for unclear state here. We intent to express that the number of droughts has no obvious increasing or decreasing trend. To better describe it, we revised the sentence as follows:

The number of droughts show no increasing or decreasing trend in the mid-century and end-century for the SSP126 scenario and in the mid-century for the SSP585 scenario compared to the historical period.

Discussion- Overall, your discussion section is less focused on the results of the work. You give statements that reflect the results but you tend to use that as reference to other research work. Sometimes, the discussion is too general and should be better connected to the aim and research questions and notably to the case study.

Response: Thank you for highlighting the need to improve discussion. This section has undergone extensive revision to better reflect our findings and tie them to the aim and research questions of this study. The specific changes are as follows.

(1) deleted section 4.5 from the original manuscript and moved the most relevant content to section 4.1; (2) substantially deleted section 4.2 from the original manuscript, retaining key

contents and moving them to the following sections; (3) carefully checked all the contents in the discussion and removed inappropriate case studies.

Line 714: you state that " such model performance improvement can minimize uncertainties" but is this the case for this analysis?

Response: We are sorry for unclear state here and have revised the sentence as follows:

Such model performance improvement can provide important information for developing downstream water resources management.

Line 736-744: It is not clear how this is related to the results of this work.

Response: We agree with your suggestion and have deleted these contents.

Section 4.5 could be deleted and integrated in the overall discussion of the results.

Response: Thank you for pointing this. We fully agree with you and have removed content that is not relevant to the purpose and results of the study, while keeping the most relevant content in other sections.

Line 831: "1 km resolution DEM" is information that should be mentioned earlier in the method part.

Response: We mentioned it in data description part (Section 2.1 Study area and datasets) as follows:

The land-use/land-cover types for 2015 (including wetland types), digital elevation models and digital elevation models with 1 km resolution were obtained from Resource and Environment Science and Data Center (https://www.resdc.cn/).

Technical corrections: typing errors, etc.

Line 219: delete "simulated"

Response: Deleted.

Line 432: delete "characteristics"

Response: Deleted.

Line 454: delete "The cumulative number of days during a drought event" as you repeat it just after the "i.e.," .

Response: Deleted.

Line 759: "needs an extensive assessment"

Response: Thanks for your kind reminder here. We have changed the sentence as follows:

Therefore, from perspective of NBS, it is important to further assess and understand their role in improving basin resilience to water risks.