Response to Reviewer #2

General comments: This paper adopts three metrics to quantify the essential factors to drive water politics in the transboundary river basins of Centra Asia. The manuscript is organized logically and well written. The topic is relevant with the HESS audience and fall well within the scope of this special issue on transboundary river and socio-hydrology. However, the following comments should be addressed before its potential publication:

-Author response: We would like to thank reviewer #2 for the instructive suggestions and comments. These are very valuable to improve our manuscript, and the revised manuscript will follow the reviewer's recommendations. Our explanations and responses to all the comments are listed below.

1) The Gini coefficient is traditionally used in economical discipline, which is calculated based on a large population (e.g., tens of millions). In this study, the coefficient is calculated based on 5 countries. Does that make sense to indicate the inequality issue? Actually, we can just compare water resource amount per land area / capita / etc among 5 CA countries to indicate their difference (or the inequality as said by the authors). So what is the advantage of using Gini coefficient? Also, does that make sense to adopt the threshold value in Table 2 to evaluate inequality level of water issue? Similar concern is also applied to matching degree. As we have very limited country numbers in CA (i.e., 5), it is difficult to obtain a statistically meaningful coefficient. The authors need to demonstrate the rationality of adopted metrics and the threshold values.

-Author response: Thanks for the instructive comment. We will clarify the rationality of the adopted metrics and the threshold values with more details in the revised manuscript. Gini coefficient is an objective indicator usually used to describe the degree of income distribution inequality. The distribution of water resources is not balanced in the region, which directly affects the agricultural production and economic development, and it is similar to the income distribution inequality. Therefore, the Gini coefficient has been effectively used as an indicator in measuring the degree of imbalance of water resources in countries or regions (e.g., in South Africa, Cole et al., 2018; in India, Malakar et al., 2018; the Sanjiang Plain in China, Yan et al., 2016; the Lake Dianchi Basin in China, Dai et al., 2018).

The higher the value of the Gini coefficient, the worse the matching situation is, and the more likely the country will compete for water resources. The amount of water resources per land area can show the relative spatiotemporal ratio between water resources and land resources, but it does not take into account the different types of water utilization. Thus, based on previous studies (Gunasekara et al., 2014; Yan et al., 2016; Dai et al., 2018; Qin et al., 2020), we used the Gini coefficient to comprehensively reflect the overall matching situation of water and socio-economic elements in CA, and analyzed the spatial matching differences among countries combined with the matching coefficient of water and land resources.

For the selection of the threshold values, the thresholds were widely recognized as effective in classification of matching degree between water resources and socio-economic development in many regions, including the CA (Yan et al., 2016; Liu et al., 2018; Zhang et al., 2020). We will clarify this issue in the revised method section.

References

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8. Zhang, Y., Yan, Z. X., Song, J. X., and Wei, A. L.: Analysis for spatial-temporal matching pattern between water and land resources in Central Asia, Hydrol. Res., 51(5), 2020.

2) For the water political event dataset, the authors combine different sources for different periods. The authors need to explain the consistency between TFDD, WCC, and ICWCCA.

-Author response: Thank you for the helpful suggestion. We will explain about the consistency between TFDD, WCC, and ICWCCA in the revised manuscript. Since both the water conflictive and cooperative events of CA recorded in the TFDD database occurred between 1951-2008, we selected the WCC database as the complementary data for water conflictive events and the ICWCCA database for water cooperative events during 2009-2018, respectively. The WCC is a detailed interactive online database that contains global conflicts over freshwater resources, where readers can retrieve and filter water conflicts by time, location, and subject (Gleick and Heberger, 2014). The data on water conflicts in CA cover the period during 1990-2018. To verify the consistency of conflictive events between TFDD and WCC, we compared the conflictive events from these two databases in their common timespan (1990-2008), and found that the conflictive events registered in the two datasets matches well with each other (Fig. s1a). The results indicated that the conflictive events by combining the TFDD and WCC database is reliable.

The ICWCCA is a joint committee established and authorized by the heads of the five Central Asian countries, which is responsible for making binding decisions on issues related to water distribution and utilization in the transboundary river basins of CA (Rahaman, 2012). It contains comprehensive water cooperative events such as conferences and agreements on transboundary rivers in CA since 2000. We also show that the two different datasets (TFDD and ICWCCA) produce similar trends of water cooperative events during 2000-2008 (Fig. s1b). This showed that the cooperative data obtained by merging the ICWCCA database and the TFDD is also reliable. Finally, we classified the levels of the complementary conflictive/cooperative events according to the classification criteria of water political events in TFDD.

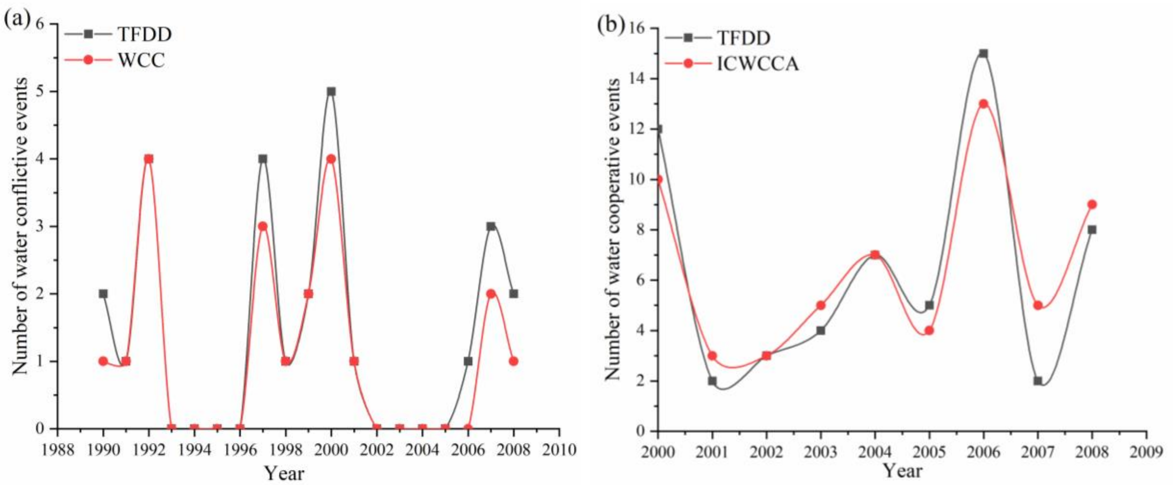

Figure 1: Comparison of the number of water conflictive events in the TFDD and WCC datasets (a) and the number of water cooperative events in the TFDD and ICWCCA datasets (b)

References

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3) The authors are suggested to be careful with some conclusions, which should be drawn logically based on the supporting evidence. For example, in Sect 3.1.2, the authors conclude that "the quantity of water resources was not the causation of water contradictions in CA. Rather, the issues stemmed from the uneven allocation and utilization of water resources

among these five countries". In the previous paragraphs, they discussed the mismatch between water and socio-economic elements including population, GDP, and cropland, but they did not discuss why water quantity is not an issue. Besides, at the end of discussion section, the authors discuss the approaches to eliminate conflicts and strength cooperation, which are useful but not logical in the context of research results. In discussion part, the readers may expect some logical deductions from the results, not just slogan.

-Author response: Thank you for the insightful comment. We will strengthen the analysis to make all conclusions more clear and logically consistent. We will also explain why water quantity is not an issue in the revised manuscript. Water quantity refers to the total amount of water resources in CA, which equals to 3688.80 m^3 per capita and is in fact more than many regions of the world (e.g.,1148.00 m^3 per capita in India, 1989.33 m^3 per capita in China, and 3355.33 m^3 per capita in Japan). But the distribution of water resources among countries is extremely uneven. Kazakhstan has the largest amount of water resources (643.50×10^8 m^3), followed by the upstream countries Tajikistan and Kyrgyzstan, which has 634.60×10^8 m^3 and 489.30×10^8 m^3, respectively. While the downstream countries Uzbekistan and Turkmenistan both have very few water resources, with 163.40×10^8 m^3 and 14.05×10^8 m^3, respectively (Wang et al., 2020). Therefore, the water contradictions in CA are not due to the shortage of total water quantity. Rather, the issues stemmed from the uneven allocation water resources and the mismatch between water and land resources among countries. We will add these analyses in the results section.

Meanwhile, we will revise the discussion section and propose the approaches to eliminate conflicts and strength cooperation based on our research results. The newly added discussion content may include the followings. Firstly, based on the Gini coefficient and the matching coefficient of water and land resources, we have found that the matching degree of water and socio-economic elements (especially water and land resources) in CA is pretty poor. This is an important factor that increases the potential for water conflicts, and the main concern of the water conflictive events in CA is also the competitive utilization of water resources. Therefore, improving the water and land allocation systems and strengthening the water cooperative networks among countries will help reduce water conflicts and promote transboundary river management. Secondly, although there are more water cooperative events than conflictive events in CA, the cooperation mainly belong to weak levels based on our findings, and verbal supports (less effective) accounted for a large proportion (Level 1-2) in the current situation. There should be more high-level cooperation between the five countries, such as the military, economic or strategic supports, and freshwater treaties. The successful management of transboundary rivers in CA depends on deepening the countries' cooperation and trust. In addition, the CA should strengthen cooperation with its neighboring countries (such as Russia and China) in the water cooperative network, and make full use of the assistance of international and regional organizations, because neighboring countries are the key trading partner and play an important role in the water policy reform of CA.

Reference

1. Wang, X. X., Chen, Y. N., Li, Z., Fang, G. H., and Wang, Y.: Development and utilization of water resources and assessment of water security in Central Asia, Agr. Water Manage., 240, 106297, 2020.

Minor comments:

Ln32, use the latest number for transboundary rivers and other facts. The authors can refer to the papers in the same special issue.

-Author response: Thank you for the instructive comment. We will revise and update it by referring to the papers in the same special issue.

Ln61, cite the original literature for the TFDD dataset.

-Author response: Thank you for the instructive comment. We will cite the original literature in the revised manuscript.

Ln94, no rainfall feeds the river?

-Author response: Thank you for the instructive comment. We will revise this sentence. There is little rainfall in CA, and the glaciers and snowmelt in high mountains account for a large share of the river's replenishment.

Ln122, what's *n*?

-Author response: Thank you for the insightful comment. The "*n*" represents the number of countries, and the value of "*n*" in this study is 5. We will explain it with more details in the revised manuscript.

Ln169, release of water exceeds inflow, this confuses me. Especially when the authors say "since the Fergana Valley is an important agricultural region". Should not the agriculture consume a lot of water and cause release much lower than inflow?

-Author response: Thank you for the insightful comment. To avoid any confusion, the sentence will be adjusted in the revised manuscript. In fact, the Andijan reservoir is located in mountainous areas and has no irrigation task of its own. Water entering the Andijan reservoir is mainly from the mountain rivers, and water released from the reservoir is most used for irrigation of agricultural areas in the Fergana Valley, downstream of the reservoir. Therefore, this may cause the release of water exceeds inflow in the Andijan reservoir.

Ln275, why include Tarim? Traditionally we do not consider Tarim as transboundary rivers. Maybe more specific to discuss Aksu?

-Author response: Thank you the instructive comment. We will add the explanation in the revised manuscript. Traditionally we regard the Tarim River as an inland river in China, and the Aksu River, one of its sources, is a transboundary river. According to the latest version of TFDD in 2018 (McCracken and Wolf, 2019), Tarim as a transboundary river flows in China (area: 1048700 km^2, accounting for 95.5%), Kyrgyzstan (23900 km^2, 2.2%), Tajikistan (920 km^2, 0.1%), disputed area between India and China and administered by China (22200 km^2, 2.0%), disputed area between India and China and administered by India (2000 km^2, 0.2%), Kazakhstan (110 km^2, <0.1%). In addition, some scholars also regarded the Tarim as transboundary river in their studies (De Stefano et al., 2017; Yan et al., 2019). Therefore, we think it is appropriate to discuss the Tarim River.

References

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Ln640, figure 9. The size of line is hard to differentiate as the number of water conflictive events.

-Author response: Thank you for the kind comment. We will revise and update the figure to make it clear.

Ln647, figure 10(b), the title of y-axis should be Number of water conflictive events? Check it.

-Author response: Thank you the instructive comment. We will check it. A total of 53 water conflictive events were recorded in CA, of which the most occurred in January (9 conflictive events). We want to show the monthly distribution of water conflictive events, so the title of y-axis is the number of water conflictive events, and the title of x-axis is month.