To Reviewer #2,

Zhang et al (2021) coupled the CCW and WaSSI models to study how vegetation greening impacted water yield of the Upper Han River Basin (UHRB). They first simulate water yield change from 2001-2018 to evaluate the model. Afterwards, they run two simulations to isolate the effect of vegetation on water yield and the effect on future potential water yield. Zhang et al (2021) show that vegetation greening significantly reduced water yield. The water yield reduction was stronger during warm or dry years. Furthermore, they show that greening could increase the number of droughts. They discuss their results in relation to the important role of the UHRB to provide water to other regions through a diversion project.

The study has an easy to understand set-up and addresses a relevant subject. The manuscript is clearly written. I listed some (major and minors) comments and suggestions below, both on the content and text.

Response: We appreciate the positive comments and summary of this study. Please find our specific responses to each of the comments below (in blue).

Comments:

The authors show that vegetation greening significantly reduced water yield and streamflow during the last decades. The authors discuss the implications for the SNWDP and other Water Diversion Projects and state that (future) vegetation greening could potentially reduce the annual water yield supply by 7.3 km^3. A few processes are missing in the manuscript that impact streamflow under changing vegetation. These processes could reduce the ‘negative’ effects of vegetation greening on water yield. First, the extra evaporated water will partly recycle back to the Earth’s surface and increase precipitation (P) (potentially within the UHRB catchment). This could have impacted your P during the studied years (therefore, the S2 and S3 scenarios are not entirely independent of vegetation status), and likely has an impact on future water yield. The study cannot separate this effect on increased P, but they could at least be included in the discussion of the manuscript.

Response: We appreciate the insightful comments here. First, we agree that effect of precipitation recycling feedback on WY was not captured in our modeling. The P used in this study (derived from a combination of model and ground data) was not generated by our model, but it was used as a driver to the model. If there is a such climatic feedback, it would already be implicitly included in the observed P data, but our model would not be able to disentangle this feedback.

We found that P did not have a significant increasing trend during the period, though ET increased significantly. We recognize that increasing ET may induce increasing P locally or downwind. However, the P in the UHRB is more greatly influenced by the Asia Monsoon, which comes from the Pacific Ocean from south-eastern China. The significant and widespread greening was also observed in south-eastern China (Chen et al., 2019) and transferred a larger amount of moisture which might be brought to the UHRB and potentially induce a P increase. However, these effects are difficult to quantify. Even if we know how much P in the UHRB was from the upwind area, it is beyond the capacity of our model to quantify the amount of P that comes from the extra ET from greening. We believe that the effects of greening in local and upwind area on P in the UHRB were limited. Roughly 67% of P in the Yangtze River Basin (where the UHRB located) comes from the Pacific Ocean (Tuinenburg et al., 2020), and a recent modelling study found that vegetation greening only induced a P increase of 1.5% per decade in the Yangtze River Basin from 1982 to 2011 (Li et al., 2018).

However, we agree with the reviewer that this is an important limitation, and we have therefore expanded discussion of this potentially important feedback in the Discussion section"4.4 Limitation".

Ref.:

Chen, C., Park, T., Wang, X., Piao, S., Xu, B., Chaturvedi, R. K., Fuchs, R., Brovkin, V., Ciais, P., Fensholt, R., Tømmervik, H., Bala, G., Zhu, Z., Nemani, R. R. and Myneni, R. B.: China and India lead in greening of the world through land-use management, Nature Sustainability, 2(2), 122–129, https://doi.org/10.1038/s41893-019-0220-7, 2019.

Tuinenburg, O. A., Theeuwen, J. J. E., and Staal, A.: High-resolution global atmospheric moisture connections from evaporation to precipitation, 12, 3177–3188, https://doi.org/10.5194/ESSD-12-3177-2020, 2020.

Li, Y., Piao, S., Li, L. Z. X., Chen, A., Wang, X., Ciais, P., Huang, L., Lian, X., Peng, S., Zeng, Z., Wang, K. and Zhou, L.: Divergent hydrological response to large-scale afforestation and vegetation greening in China, Science Advances, 4(5), eaar4182, https://doi.org/10.1126/sciadv.aar4182, 2018.

Second, the rising CO_2 concentrations are expected to increase the water use efficiency of vegetation, and this could reduce the 'negative' effects of future afforestation.

Response:

We thank the reviewer for the comments on the effects of CO_2 on water use, ET, and the water balance. There is no clear consensus in the literature on the extent to which increasing CO_2 concentrations will affect ET at the ecosystem level even with an increase in leaf level water use efficiency (see e.g., Frank et al., 2015; Ward et al., 2018), but it clearly has the potential to affect future forest productivity and water use. One of our model limitations is that we cannot directly evaluate the CO_2 effects on water use efficiency and thus ET and streamflow. However, we may have partially captured the effect because the underlying water use efficiency used in the model was calibrated based on global flux tower data, and over the short study period evaluated in this study (2001-

2018), CO_2 concentrations likely did not change enough to have a strong effect; Frank et al. (2015), for example, found that CO_2 fertilization led to only ~20% increases in evergreen forest WUE over the entire 20th century.

In response to this comment, we have provided further discussion about the potential CO_2 fertilization effect in section 4.4 ("Limitations"): "Future change in both temperature and precipitation will likely reduce the water supply in the UHRB, and increasing atmospheric $CO_2$is also likely to enhance vegetation greening due to the CO_2fertilization effects. Such greening effects could increase ecosystem productivity and water use efficiency, and thus alter the water cycle. However, the effects CO_2fertilization on total water use (ET) may not decrease as much as previously thought (Ward et al., 2018) and can be uncertain because CO_2fertilization may also cause an increase in total forest leaf area and a shift in plant species, both of which would also affect ET. While we the potential effects of CO_2fertilization on WY were not explicitly included in this study due to the structure of the light-use efficiency model, previous work has shown that forest water-use efficiency only increased by about 15-20% over the entire 20th century (Frank et al., 2015) and such effect weakened recently (Wang et al. 2021), so the effects of CO2 fertilization on WY over our comparatively short 2001-2018 study period were likely quite small.".

Frank, D. C. et al. (2015), Water-use efficiency and transpiration across European forests during the Anthropocene, Nature Climate Change, 5, 579-583.

Ward, E.J., Oren, R., Seok Kim, H., Kim, D., Tor-ngern, P., Ewers, B.E., McCarthy, H.R., Oishi, A.C., Pataki, D.E., Palmroth, S. and Phillips, N.G., 2018. Evapotranspiration and water yield of a pine-broadleaf forest are not altered by long-term atmospheric [CO2] enrichment under native or enhanced soil fertility. Global change biology, 24(10), pp.4841-4856.

Wang et al. 2021. Recent global decline of CO2 fertilization effects on vegetation photosynthesis, Science, 370: 1295-1300.

L31: For example … hydrological services: this sentence should be rewritten

Response: It was revised as "However, the sustainability of such projects depends on water supply from the donor watersheds, which is uncertain due to rapid vegetation greening and climate change."

L57: Consume instead of consumes

Response: Revised.

L61: are instead of is

Response: Revised.

Please adjust figure 1a (inset) to meet the HESS guidelines (remove the dashed line south of China to depoliticise the manuscript)

Response: Revised.

L136: please specify that is the light use efficiency.

Response: Revised.

L140: how are the values of the ‘environmental scalars’ determined? Are they independent of the vegetation data? And how is APAR determined? Is APAR also fixed under de S2 and S3 scenario?

Response: We made it clearer in revised manuscript as shown belong:

APAR is the product of FPAR and PAR. PAR is taken as 45% of shortwave radiation (Running et al. 2000). FPAR, R_s, T_s, and W_s were calculated according to Sims et al. (2005), King et al., (2011), Raich et al., (1991), and Landsberg and Waring, (1997), respectively, as:

$$FPAR = 1.24 \times NDVI - 0.168, \tag{3}$$

$$R_s = 1 - K_1 \times R_a / R_{cs}, \tag{4}$$

$$T_s = \frac{(T - T_{min}) \times (T - T_{max})}{(T - T_{min}) \times (T - T_{max}) - (T - T_{opt})^2}, \tag{5}$$

$$W_s = exp\,(-K_2 \times (VPD - VPD_{min})), \tag{6}$$

Where R_a and R_{cs} are respectively actual and clear-sky radiation. The calculation of R_{cs} is based on Raes et al. (2009). T_{min}, T_{max}, and T_{opt} are respectively the minimum, maximum and optimal air temperatures for photosynthetic activity, varying by biome (derived from the land cover data). VPD_{min} is the minimum VPD exceeding which moisture stress starts to take effect, which also varies by biome, and K_1 and K_2 are biome-specific empirical parameters that scale the radiation and VPD effects, respectively. The parameters (ε_{pot}, T_{min}, T_{max}, T_{opt}, VPD_{min}, K_1 and K_2) are calibrated based on global FLUXNET data through a Monte Carlo simulation (Zhang et al., 2016, 2019).

Ref.:

Sims, D. A., Rahman, A. F., Cordova, V. D., Baldocchi, D. D., Flanagan, L. B., Goldstein, A. H., Hollinger, D. Y., Misson, L., Monson, R. K., Schmid, H. P., Wofsy, S. C., and Xu, L.: Midday values of gross CO2 flux and light use efficiency during satellite overpasses can be used to directly estimate eight-day mean flux, 131, 1–12, https://doi.org/10.1016/j.agrformet.2005.04.006, 2005.

King, D. A., Turner, D. P., and Ritts, W. D.: Parameterization of a diagnostic carbon cycle model for continental scale application, 115, 1653–1664, https://doi.org/10.1016/j.rse.2011.02.024, 2011.

Raich, J. W., Rastetter, E. B., Melillo, J. M., Kicklighter, D. W., Steudler, P. A., Peterson, B. J., Grace, A. L., Moore, B., and Vorosmarty, C. J.: Potential Net Primary Productivity in South America: Application of a Global Model, 1, 399–429, https://doi.org/10.2307/1941899, 1991.

Landsberg, J. J. and Waring, R. H.: A generalised model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance and partitioning, 95, 209–228, https://doi.org/10.1016/S0378-1127(97)00026-1, 1997.

Raes, D., Steduto, P., Hsiao, T. C., and Fereres, E.: Aquacrop-The FAO crop model to simulate yield response to water: II. main algorithms and software description, 101, 438–447, https://doi.org/10.2134/agronj2008.0140s, 2009.

Zhang, Y., Song, C., Sun, G., Band, L. E., McNulty, S., Noormets, A., Zhang, Q. and Zhang, Z.: Development of a coupled carbon and water model for estimating global gross primary productivity and evapotranspiration based on eddy flux and remote sensing data, Agricultural and Forest Meteorology, 223, 116–131, https://doi.org/10.1016/j.agrformet.2016.04.003, 2016.

Zhang, Y., Song, C., Band, L. E. and Sun, G.: No Proportional Increase of Terrestrial Gross Carbon Sequestration From the Greening Earth, Journal of Geophysical Research: Biogeosciences, 124(8), 2540–2553, https://doi.org/10.1029/2018jg004917, 2019.

L161: the streamflow records of the reservoir (/ the Danjiangkou Reservoir)

Response: Revised.

L173: dynamic greening effects instead of dynamics greening effects

Response: Revised.

L179: The Mann-Kendall test is used for trend and change point detection. Could the authors elaborate on the change points you found? Why did they decided to use change-point detection analyses instead of trend analyses only? What extra information do these change-points add to the discussion or results of the manuscript?

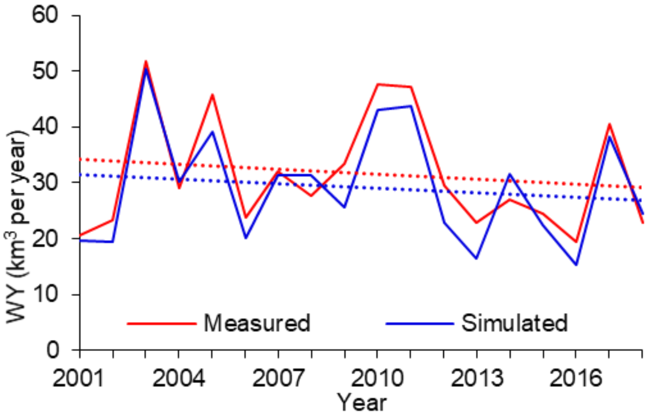
Response: We used the change-point detection because we found the WY did not have a statistically significant trend, then want to get another method to detect the WY change. As reviewer #1 suggested, the change point detection related content was removed since the 18-year study period is quite short for the change point method, and its results are sensitive to outliers.

Fig 4a+b legend: km^3 per year / mm per year.

Response: Revised.

Fig 4a: the simulated WY seems to show a higher decreasing trend than the measured WY. Was there a negative trend in the measured WY?

Response: They have almost identical trends (see the following fig). The trend lines are added in the Figure 4a.



She et al, 2017 (fig 2a) (https://doi.org/10.1002/2016JD025702) fitted an increasing trend through WY at the Danjiangkou Reservoir between 2000 and 2010 (same data). How does this compare to your results?

Response: Indeed, the measured data also showed an increasing trend in WY during 2000-2011 with a slope of 1.45 km^3 per year (see the following Figure), which is consistent with She et al's (2017) data. However, this appears to be largely an effect of having abnormally low values early in the record and anomalously high WY values in

2009 and 2010. The longer time series in our study shows a decrease in WY since 2010 leading to overall negative trends in WY from 2001-2018.

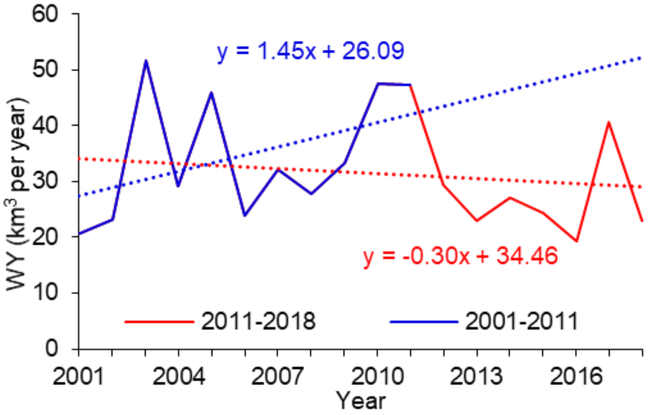
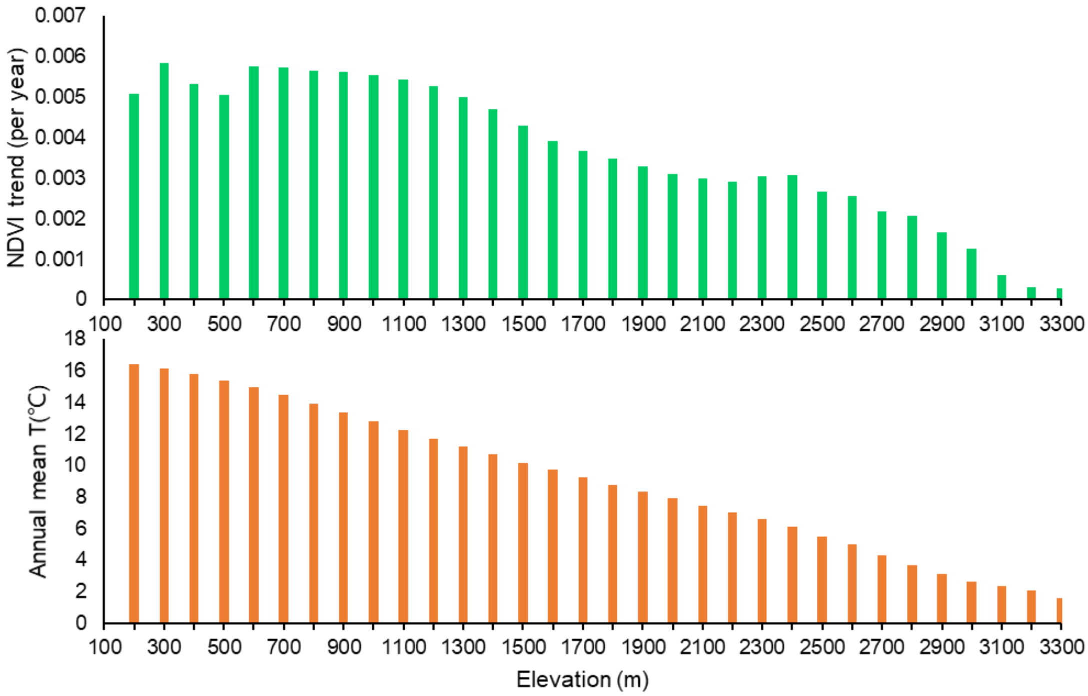


Figure: Temporal variation of observed inflow of the Danjiangkou Reservoir. The blue and red dashed lines are the trend line of 2001-2011 and 2001-2018.

L237: Why did WY increase due to vegetation greening in high elevation areas? Could it also be a climate-related effect in these high-elevation regions?

Response:

Here, “high elevation” refers to 3000 m and above, which only occupied a small proportion of the study area. There may be several reasons for the increase in WY here. First, the greening trend in high elevation was not as strong as in the low elevation (see the Figure below). Therefore, the decrease in WY in the high elevation was small (less than 15 mm in 18 years). Second, the annual mean temperature at the high elevation area is only around 3 °C (see the following Figure). The low temperature may greatly limit vegetation activity, even if vegetation is greening. Therefore, greening had limited effects on ET in the high elevation, but can increase soil water capacity, thus increasing WY.



Line 239-240: Did you mean to refer to fig. 5c instead of 5b?

Response: It is Figure 5c. Revised.

8: How is the relative change calculated? Relative to the year 2010, or the S2 scenario? Why is the sign of the absolute WY change opposite of that of the relative WY change. What does this say about the effects of greening versus climate?

Response: The relative changes refer to the proportion of WY (ET) changes to those in the scenario without greening (S2). We have made this clearer in the revised manuscript.

In the dry period, the greening effects on WY were lower in magnitude than those of the wet period because of the soil moisture limitation. Consequently, the WY change from greening in magnitude had positive correlation with P. However, the WY has resilience to short term drought thanks to soil water storage. Therefore, the WY change in proportion was less than that of P change. Moreover, as conditions get wetter, the negative effects of greening on water yield will increase before reaching the limitation of vegetation activity and energy supply. Thus, more P will not induce a comparable magnitude of WY increase. As a result, the magnitude of WY relative change from greening will decrease with increasing P within the range of climate variation we encountered.

L261: 2001-2018 instead of 2001~2018

Response: Revised.

L307: ‘Unlike the Loess Plateau … but climate did’ seems to contradict with your results. How should this sentence be interpreted?

Response: We meant to state that climate masked the effects of greening. From the following Figure (Figure 5c in the manuscript), vegetation greening in the UHRB significantly reduced WY, but WY did not decrease significantly as a result of climate variability. To make it explicit, this sentence was revised as “Unlike the previous two examples, vegetation greening in the UHRB induced a substantial decrease in WY (scenario S2), but WY under the combined effects (scenario S1) did not have a statistically significant trend as a result of the large interannual variation of climate in UHRB.” The sentence was also moved to the end of the paragraph as a lead to the following paragraph.