We deeply appreciate the detailed and constructive comments provided by the three anonymous reviewers. Following their suggestions and comments, we have extensively revised the manuscript and provided a point-to-point response to each comment. The original comments are in **bold** font, our response is in regular font, and the changes in the text are in blue.

Comment 3

This manuscript develops a regional coupled human–natural systems model for the Yellow River basin (CHANS SD-YRB) using a System Dynamics framework that integrates 10 interacting sectors at annual, provincial, and sub-basin scales while explicitly conserving hydrological connectivity among sub-basins. The model reproduces historical dynamics with strong reported agreement and is then used for baseline projections under continued policies and SSP245. The key novelty is the basin-specific, multi-sector CHANS platform that couples socio-economic dynamics with water, sediment, land, carbon, and climate processes in a single connected sub-basin framework, enabling diagnosis of cross-sector feedbacks and trade-offs relevant for long-term sustainability planning. However, some revisions are required before the manuscript can be considered for publication.

Response: Thank you for taking your time to review our study and provide feedback and comments. Following the suggestions and comments, we have extensively revised the manuscript and provided a point-to-point response to each comment.

1. **Could the authors clarify the key advantages of this study (and the CHANS SD-YRB model) compared with Sang et al. (2025)?**

Response： We thank the reviewer for giving us the opportunity to clarify the relationship and distinct contributions of this study compared to Sang et al. (2025).

The conceptual modeling framework for the Yellow River Basin CHANS proposed by

Sang et al. (2025) is a theoretical architecture with identified key feedback loops to guide system model integration. This study implements the theoretical modeling framework into a fully operational and open-source System Dynamics model CHANS-SD-YRB 1.0, including the detailed mathematical equations, parameter values, and internal structures for all coupled sectors. With rigorous historical calibration and validation, we demonstrate the feasibility and accuracy of the model to project future CHANS dynamics, providing specific quantitative evidence to support the practical suggestions outlined in the conceptual framework.

We have added the clarification to the last paragraph in the manuscript. The revised texts are shown below:

Drawing on the conceptual framework of Sang et al. (2025), this study implements it into a fully functional, validated System Dynamics model tool, CHANS-SD-YRB 1.0.

2. **Figure 4: The model appears not to include a price response to market changes. Under scenarios with carbon pricing, this assumption may miss some impacts of the carbon price. Could the authors discuss this limitation?**

Response: Thank you for pointing out this issue.

The current CHANS SD-YRB model does not include an endogenous price-clearing mechanism but uses exogenous prices. Following the reviewer's suggestion, we have added a dedicated paragraph in the Discussion section to articulate this limitation. We clarify that while the model captures the physical results of climate policies, it cannot evaluate the economic efficiency of specific pricing mechanisms. The revised texts are shown below:

Moreover, there are still important feedbacks absent from the current coupling framework. Notable examples include the effects of land use change on climate, the effects of climate change on economic growth, and the effects of pricing on energy use and carbon emissions. These missing feedbacks could be incorporated based on recent studies, including the land use feedback on precipitation through moisture recycling (Sang et al., 2025), socioeconomic losses from climate change impacts (Waidelich et

al., 2024), and integration with Computable General Equilibrium (CGE) models (Fujimori et al., 2014).

3. **Lines 284: Electricity generation shares are treated as exogenous and sourced from the yearbook. Do these shares account for future changes? If not, given that the SSP2 baseline is above 6.0 W/m² while this study uses SSP245 (which still implies future climate policy), would assuming fixed shares remain reasonable?**

Response： Thank you for the comments.

We apologize for the ambiguity. The electricity shares are not fixed but time-varying for both historical and future projection. While historical shares are sourced from statistical yearbooks, the future shares in the Baseline Scenario are sourced from the projections by Li et al. (2024) including year-by-year projections (2021-2060) of the generation mix (Coal, Hydro, Wind, Solar, Nuclear) for each province to meet China's national Carbon Peaking and Carbon Neutrality goals.

4. **Line 92: Could the authors please double-check the citation format here?**

Response： Thank you for the comments.

The variation in the citation format (including the initial "X.") was automatically generated by our citation management software (Zotero) to disambiguate two different first authors with the surname "Li" published in the same year.

To ensure consistency with the journal's citation style, we have manually corrected this in the revised manuscript. We now use the standard suffix format (e.g., Li et al., 2018a; Li et al., 2018b) to distinguish these references without including the first initial.

5. **Line 178: Could the authors clarify how these variables are used as proxies for disaggregation?**

Response： Thank you for the comments.

The gridded data serves as the basis for calculating spatial weighting factors to

downscale the model's provincial-level outputs to the sub-basin scale (up-, mid-, and downstream). We utilized high-resolution population grid data to calculate the proportion of each province's population located within the boundaries of the up-, mid-, and downstream. These calculated weights were then used to convert provincial-level demographic variables (e.g., total population, labor force) into sub-basin scale. Similarly, we employed GDP grid data to determine the spatial distribution of economic activity. The derived weights (the share of a province's GDP falling into each sub-basin) were used to disaggregate economic and emission-related variables, specifically GDP and human carbon emissions from the provincial scale to the basin scale.

In the revised manuscript and Supporting Information, we have clarified. The revised texts are shown below:

For manuscript: Given the availability of gridded data for human processes and the strong correlations among relevant variables, gridded population and GDP data were used as proxies to disaggregate demographic variables and economic and human carbon emissions, respectively, from provincial-level to the sub-basin scale (Table S3).

For Supporting Information: Using high-resolution gridded data, we calculated the spatial weights of each province within the up-, mid-, and downstream to convert provincial to sub-basin values.

The spatial weights derived from gridded population were used as proxies to disaggregate demographic outputs (e.g., total population and food demand), while weights derived from gridded GDP were applied to disaggregate economic and environmental outputs (e.g., GDP and anthropogenic carbon emissions) from the provincial level to the sub-basin scale.

6. **Equations (5) and (6): Could the authors explain why the functions are specified in this form?**

Response： Thank you for the comments.

The functional forms were chosen based on the distinct physical mechanisms and socio-economic development rules governing different water use sectors.

For Equation (5), it specifies a process-based physical coupling mechanism between the *Land* and *Water Demand* sectors.

For Equation (6), it employs a non-linear saturation function rather than a simple linear regression. Empirical studies (Flörke et al., 2013) suggest that per capita water use rises rapidly during early stages of economic development (due to improved sanitation and appliance usage) but eventually stabilizes or saturates at high income levels.

We have added these explanations in the revised manuscript. The revised texts are shown below:

Irrigation water withdrawal (WW_{irr}) is estimated through a physically-based function of exogenous irrigation water use intensity (WWI_{irr}), cropland irrigation ratios (IR) from the China Agricultural Yearbook (MAARA, 2020), and cropland area ($Area_{Cropland}$) provided by the *Land* sector (Equation 5).

Residential water withdrawal (WW_{res}) is derived from a non-linear empirical function of economic development and population growth with an upper limit of per capita domestic water use (Flörke et al., 2013) because water demand per person cannot increase indefinitely (Equation 6).

7. Lines 467: Could the authors elaborate on why SSP245 aligns more closely with the climate trends in the YRB?

Response： Thank you for the comments.

For the future baseline scenario presented, we selected SSP2-4.5 because it represents a "middle-of-the-road" trajectory that align with the ongoing real-world climate change. This trajectory aligns closely with China's current national strategy, specifically the goal to peak carbon emissions before 2030 and achieve deep reductions thereafter. In contrast, SSP5-8.5 assumes fossil-fueled development which contradicts current policies, while SSP1-2.6 assumes an immediate and drastic sustainability transition that may be overly optimistic for the developing western regions of the YRB. So we consider SSP2-4.5 to be the most representative baseline for the Yellow River Basin.

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