We deeply appreciate the additional comments provided by the two anonymous reviewers. Following their suggestions and comments, we have 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.

Report 2

Thank you for the revised manuscript and sufficiently addressing my comments. The manuscript is now much stronger and makes the model description more transparent. I have a few remaining minor suggestions for the authors to consider:

1. In the Supporting Information Section S2.3, I suggest that the revised text where you have justified piecewise linear regression, you elaborate what you mean by socioeconomic shifts:
e.g. "Notably, these parameters were estimated using a piecewise linear regression with distinct coefficients for the pre- and post-2010 periods to capture the structural changes in China's socio-economic development and energy policies starting around 2010 (e.g., improved energy efficiency and industrial restructuring)."

Response: We are extremely grateful for this constructive suggestion and have incorporated the suggested text changes into Section S2.3 of the revised Supporting Information.

2. On circularity in per capita meat demand, I would like to point out that the circular dependency is due to the lack of a stock variable. Feedback loops in SD are closed by at least one stock, otherwise we end up with unsolvable simultaneous equations. In this case, I would have made 'per capita meat demand' a smth (where you define the initial value) that adjust to changes in GDP per capita with a short adjustment time. This would've solved the issue without resorting to the IF THEN ELSE function.

Response: We sincerely thank the reviewer for this highly insightful and rigorous

methodological suggestion. The reviewer is absolutely correct that feedback loops should theoretically be closed by a stock variable to introduce a time delay and avoid simultaneous equations. We are now aware of this technique, it is an elegant and conceptually sound way which can be used in our further model development.

3. On out of sample test: Perhaps including sample points beyond 2020 in the historical simulation (as was done in Figure 1 in the response letter to reviewer 2) would really benefit building confidence in the calibration of the model.

Response: We sincerely appreciate the reviewer's suggestion for the out-of-sample test using post-2020 data to build confidence in the model's calibration. We completely agree with this rationale.

Wherever recent data is available, we have extended the historical comparison, as noted in our response to Reviewer 2. The validation for the energy sector in the current manuscript is extended to 2022/2024. These near-term comparisons confirm that the model's recent trajectories align well with observed trends.

However, for the vast majority of variables in our comprehensive CHANS framework (particularly agricultural, hydrological, and specific socio-economic indicators), official statistical yearbooks have not yet released stable, long-term data beyond 2020 or 2021. Therefore, while we have incorporated the limited post-2020 data points into our visual validation to build confidence, a more comprehensive out-of-sample evaluation across all coupled sectors could be done when more recent statistical data become available.

4. L521-524: The sentence still guides the reader to assume there is a red line in the graph – it's not clear that red line is a specific policy terminology. For clarity, I suggest rephrasing the sentence as such:

" Under the future baseline scenario, land use patterns remain relatively stable based on historical trends (Fig. 14(a)), as no new land use policies are introduced and cropland area in each province has to stay above a mandatory minimum

threshold for food security (China's Cropland Red Line policy)."

Response: We are extremely grateful for this suggestion and have incorporated the suggested text into the revised manuscript.

5. L646-650: The authors could consider the recent article from Wells et al. published in GMD (https://doi.org/10.5194/gmd-19-1229-2026) on the representation of climate impacts as part of human-climate feedback loops, consistent with the system dynamics framework, that can be adapted to future versions of the model.

Response: We sincerely thank the reviewer for directing our attention to this highly relevant and recent publication. We have carefully read Wells et al. (2026) and completely agree that their work provides an excellent and highly compatible approach for representing climate impacts within human-climate feedback loops.

Because their framework aligns perfectly with the system dynamics architecture of our CHANS-SD-YRB model, we recognize it as a crucial theoretical foundation for our future work. Accordingly, we have updated the Discussion section to explicitly cite this article and highlight how its insights will be adapted to model endogenous human-climate feedbacks in the next major version of our model.

The revised texts are shown below:

In particular, recent modeling work by Wells et al. (2026) demonstrated that a more comprehensive representation of climate-to-society feedbacks is possible within the system dynamics framework.

6. On CMIP data: Thank you for your response and clarification of the bias correction. In the response you mentioned that "Exploring the sensitivity to other pathways (SSP1-2.6 and SSP5-8.5) is a valuable direction for future scenario comparisons." The authors should also consider including this notion in the discussion section as part of future research.

Response: We sincerely thank the reviewer for this constructive recommendation. We

completely agree that exploring the system's sensitivity to alternative climate and socio-economic forcing pathways is a critical next step. As suggested, we have now explicitly incorporated this notion into the Discussion section:

Given the uncertainty in future climate change, the sensitivity of the system's future projections to alternative climate change scenarios (SSP1-2.6, SSP3-7.0, or SSP5-8.5) warrants exploration.

References:

Wells, C. D., Blanz, B., Ramme, L., Breier, J., Callegari, B., Muralidhar, A., Rajah, J. K., Lindqvist, A. N., Eriksson, A. E., Schoenberg, W. A., Köberle, A. C., Wang-Erlandsson, L., Mauritzen, C., Grimeland, M. B., and Smith, C.: The representation of climate impacts in the FRIDAv2.1 Integrated Assessment Model, Geoscientific Model Development, 19, 1229–1260, https://doi.org/10.5194/gmd-19-1229-2026, 2026.

We deeply appreciate the additional comments provided by the two anonymous reviewers. Following their suggestions and comments, we have 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.

Report 3

I thank the authors for their careful and thorough responses to the previous review comments, as well as for the substantial revisions made to the manuscript. The paper has improved considerably as a result. I have two follow-up points that would benefit from further clarification before the manuscript can be accepted for publication

Re: "Could the authors clarify the key advantages of this study (and the CHANS SD-YRB model) relative to Sang et al. (2025)?"
I appreciate the authors' explanation that Sang et al. (2025) proposed the overall framework and that the present study implements it. However, in Sang et al. (2025), Section 3 ("Implementation of the modeling framework with a system dynamics approach",
https://www.sciencedirect.com/science/article/pii/S2666683925000331#sec0003:~:text=the%20external%20factors.-,3.%20Implementation%20of%20modeling%20framework%20with%20system%20dynamics%20approach,-Inspired%20by%20existing), the authors state that they implemented the framework shown in their Figure 3 and present historical and future simulations using a YRB system-dynamics model spanning 1981–2100.
Given this apparent overlap in both framework implementation and temporal coverage, I encourage the authors to more explicitly articulate the key methodological or analytical or … advances of the present study relative to Sang et al. (2025), and to clearly state what new insights this study provides beyond that

earlier work.

Response: We sincerely thank the reviewer for their meticulous reading of Sang et al. (2025) and for raising this excellent point. We apologize that our previous explanation was oversimplified.

We acknowledge that Sang et al. (2025) did present an initial system dynamics simulation spanning 1981–2100. However, that simulation served purely as a macroscopic proof-of-concept to demonstrate the mathematical feasibility of the proposed theoretical framework.

In contrast, this study represents the detailed description and methodological documentation of the fully operational CHANS-SD-YRB 1.0 model. This study transitions from a conceptual demonstration to a robust modeling tool. It explicitly documents how the complex internal mathematical formulations, sector-specific parameterizations, and structural mechanics are modeled that were absent in the perspective article.

Unlike the illustrative simulation in Sang et al. (2025), CHANS-SD-YRB 1.0 includes meticulous data calibration, and extensive sensitivity analysis.

We revised the text to clarify the aim of this study and its differences with Sang et al. (2025):

This study presents a detailed description and methodological documentation of the model, offering both theoretical and practical insights to advance regional CHANS modeling and promote sustainable development in the YRB.

Re: " Line 467: Could the authors elaborate on why SSP2-4.5 aligns more closely with the observed and projected climate trends in the YRB?"

I appreciate the detailed explanation for selecting SSP2-4.5. However, I would like to raise a related question regarding its consistency with the stated policy framing. The response notes that "this trajectory aligns closely with China's current national strategy, specifically the goal to peak carbon emissions before 2030 and achieve deep reductions thereafter."

This description seems more consistent with a lower forcing pathway (e.g., RCP2.6), which features earlier emissions peaking and sustained, deep post-peak reductions. In contrast, RCP4.5 is generally characterized as a stabilization pathway, with later peaking and more gradual declines, rather than deep reductions.

While I do not question the rationale for adopting SSP2 as the socioeconomic pathway, I encourage the authors to clarify why RCP4.5 is preferred over a lower forcing level (e.g., RCP2.6, or a slightly higher level than that, RCP3.7) that may better align with the stated goals of early peaking and deep emissions reductions. For example, are there data limitations, scenario availability issues, or region-specific considerations that motivate this choice? Clarifying this point would strengthen the internal consistency of the scenario justification.

Response: We sincerely thank the reviewer for this highly insightful and technically precise observation. The reviewer is absolutely correct that our previous phrasing inadvertently conflated the idealized policy goal of "deep post-peak reductions" (which aligns closely with lower forcing pathways like SSP1-2.6) with the intermediate stabilization characteristics of SSP2-4.5. We appreciate the opportunity to clarify our rationale.

Our selection of SSP2-4.5 over lower forcing pathways (e.g., SSP1-2.6) is primarily driven by region-specific realism in the Yellow River Basin (YRB).

While China's national goal aims for carbon neutrality by 2060, the YRB specifically serves as the nation's primary energy base, overwhelmingly dominated by coal mining, thermal power, and heavy chemical industries. Given the massive existing fossil-fuel infrastructure and the socio-economic inertia of the region, achieving the drastic, immediate global decarbonization required by SSP1-2.6 is considered highly optimistic for this specific basin. Therefore, SSP2-4.5—a "middle-of-the-road" stabilization pathway that incorporates moderate climate policies and gradual technological changes—serves as a much more realistic and plausible baseline projection for the YRB's actual transitional trajectory over the coming decades. More importantly, the

model used the projected climate change information under different SSP as external climate forcing rather than adopting the scenario's assumed global socio-economic trajectories which are very different from the reality in the Yellow River Basin and China.

Technically, the model is capable of simulating climate change scenarios such as SSP1-2.6, SSP3-7.0, and SSP5-8.5 scenarios. Exploring the sensitivity to other pathways (SSP1-2.6 and SSP5-8.5) is a valuable direction for future scenario comparisons.

In the revision, we explicitly added this point in discussion as:

Given the uncertainty in future climate change, the sensitivity of the system's future projections to alternative climate change scenarios (SSP1-2.6, SSP3-7.0, or SSP5-8.5) warrants exploration.