Dear Editor,

Thank you very much for your consideration of our manuscript (nhess-2021-200) for the potential publication and your suggestions about the major revision. We have revised the manuscript according to the reviewers' suggestions, and proof-read the manuscript to minimize typographical, grammatical, and bibliographical errors. We prepared three documents as requested: (1) a point-to-point reviewer response document including original comments, our response, and corresponding revisions made in the manuscript, (2) a marked-up manuscript version showing all the detailed modifications in the manuscript, and (3) a revised manuscript.

We appreciate your kind help in the process of review and revision. We look forward to further updates from you.

Sincerely,

Qinke Sun
On behalf of the co-authors

Response to Referee #3

The authors would like to thank the Anonymous Referee #3 for the insightful and constructive comments. We have reviewed the comments and provided our responses herein. We truly believe that the changes suggested by Referee #3 will enhance the quality of the manuscript. A point-by-point response is presented below.

R1: The interesting manuscript fits the aims and scope of the Journal Natural Hazards and Earth System Sciences. The authors propose an integrated approach to flood risk assessment that takes into account future land use changes and hydrodynamic effects. The results of the study also show the reader the probability of flood risk under different scenarios. Further analysis of adaptation measures might next yield better results if carried out, but this is only a suggestion. In general, I agree with the authors' revised manuscript, the following minor changes need further improvement.

A1: We greatly appreciate your kind help in the reviewing the manuscript and all constructive comments. And we have revised the manuscript based on these comments and suggestions. Also, we are grateful for your suggestion of adaptation measures, which is also a key area of research for our team and we will do an in-depth study in our next work.

Minor recommendations

R2: Lines 42: Please add a space before "studies".

A2: Done.

R3: Line 61: Please change "are" with "is".

A3: Done.

R4: Lines 73-77: This section is somewhat redundant in the introduction and is proposed to be deleted.

A4: Thank you very much for your suggestion. We have deleted this section.

R5: Lines 86-87: Please add a citation or source for this information.

A5: Thanks for the comment. We have added the citations in the corresponding sections of the manuscript. The Referee can read the following explanations in the revised manuscript.

Line 86-87: *In 1905, one of the deadliest storm surges occurred in Shanghai, killing more than 29,000 people (Du et al., 2020). Two years later, Typhoon Winnie made landfall in Shanghai, flooded more than 5,000 households (Wen, 2006).*

[1]. Du, S., Scussolini, P., Ward, P. J., Zhang, M., Wen, J., Wang, L., Koks, E., Diaz-Loaiza, A., Gao, J., Ke, Q. and Aerts, J. C. J. H.: Hard or soft flood adaptation? Advantages of a hybrid strategy for Shanghai, Glob. Environ. Chang., 61, 102037, doi:https://doi.org/10.1016/j.gloenvcha.2020.102037, 2020.

[2]. Wen, K.: Meteorological Disasters in China (in Chinese). China Meteorological Press, Beijing, China. 2006.

R6: Lines 122: Please delete the extra "in".

A6: Done.

R7: Lines 255: Please change "flood water depth" with "flood depth".

A7: Done.

R8: Lines 349: Please change "potential" with "potentially".

A8: Done.

R9: Lines 353: Please change "multi scenario" with "multi-scenario".

A9: Done

Response to Referee #4

The authors would like to thank Anonymous Referee #4 for reviewing the paper and providing these thought-provoking perspectives. We really appreciate the comments and suggestions and have given them careful consideration. Below are our point-by-point responses to the comments.

R1: My major concern is on the paper's similarity/difference with the one published on Nature Hazards recently by Shan et al (2021), entitled "Risk assessment of shanghai extreme flooding under the land use change scenario". Shan's paper also used the FLUS model, focused on coupling land use modelling and flood process modelling, and used Shanghai as the study case; it is recommended to include the work in the reference list and comparison will be valuable.

A1: Thank you for your comments. Shan et al have done excellent work on extreme flood risk assessment in Shanghai. Shan's paper analyses the losses and risks of different land use types by combining the results of the FLUS model with the simulation results of extreme storms and floods. However, they do not consider the development of urban areas under different growth scenarios and the assessment of flood impacts after the implementation of these scenarios. Our manuscript also uses Shanghai as an example to implement an assessment of urban flood risk under multiple scenarios. **The main differences are: (1). This paper simulates urban expansion under different future growth scenarios.** Our manuscript considers urban expansion under three growth scenarios (Business as usual, Growth as planned, Growth as eco-constraints) and simulates future flooding changes based on land use changes. This difference can also be clearly distinguished in the research framework diagram (Fig.1 and Fig.2). **(2). Integration of land use models and the LISFLOOD-FP hydrodynamic model for flood risk assessment.** The future land use change simulations are carried out according to the land use level categories of cropland, grassland, woodland, water area and urban land, and then combined with friction

coefficients of different land use level categories are substituted into the flood model to achieve dynamic propagation of flood. Hence, the manuscript title is "Multi-scenario urban flood risk assessment by integrating future land use change models and hydrodynamic models". **Shan's paper carries out a flood exposure analysis by overlaying the land use simulation with a raster of flood inundation (Fig.2),** and then an expected annual damage analysis, which is what distinguishes Shan's paper from ours.

Thank you very much for your suggestion. **We have added analysis and citations to the corresponding section of the introduction in the manuscript.** The Referee can read the following explanations in the revised manuscript.

Line49-52: *Although there are some studies have quantified urban growth and assessed flood risk, such as Chennai (Nithila Devi et al., 2019), Guangzhou (Lin et al., 2020), Shanghai (Shan et al., 2022), these studies have not considered the development of urban areas under different growth scenarios and the assessment of flood impacts after the implementation of these scenarios.*

[1]. Nithila Devi, N., Sridharan, B. and Kuiry, S. N.: Impact of urban sprawl on future flooding in Chennai city, India, J. Hydrol., 574, 486–496, doi:10.1016/j.jhydrol.2019.04.041, 2019.

[2]. Lin, W., Sun, Y., Nijhuis, S. and Wang, Z.: Scenario-based flood risk assessment for urbanizing deltas using future land-use simulation (FLUS): Guangzhou Metropolitan Area as a case study, Sci. Total Environ., 739, 139899, doi:10.1016/j.scitotenv.2020.139899, 2020.

[3]. Shan, X., Yin, J. Wang, J. Risk assessment of shanghai extreme flooding under the land use change scenario. Nat Hazards, 110, 1039–1060, doi.org/10.1007/s11069-021-04978-1, 2022.

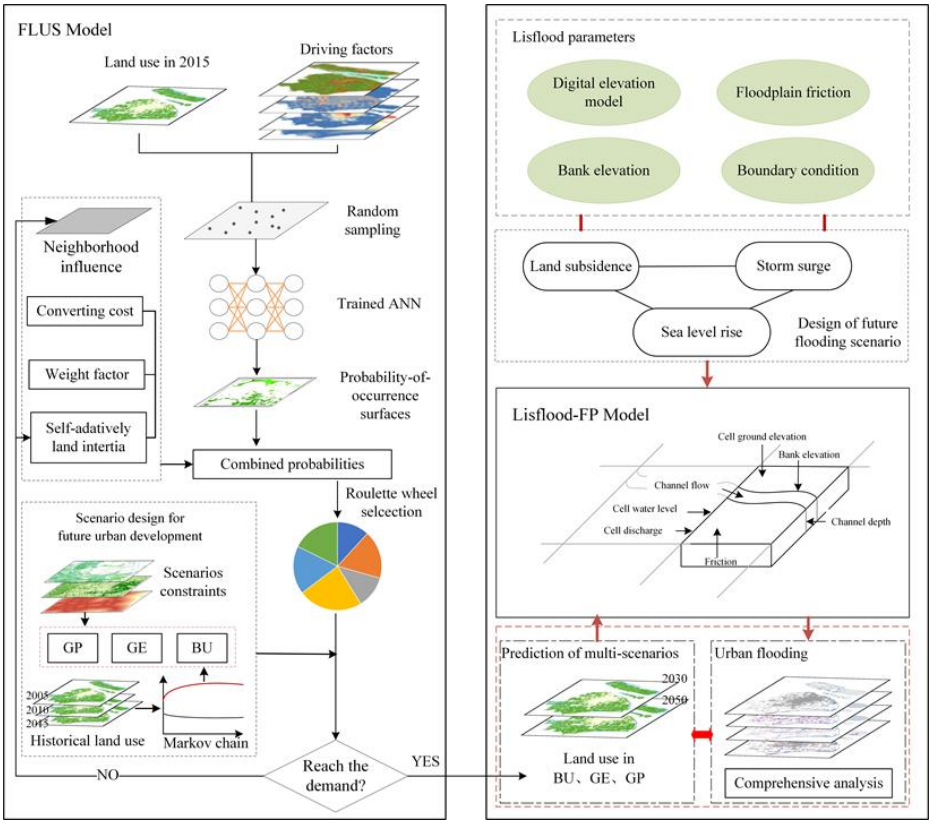

Figure 1. research framework of our manuscript

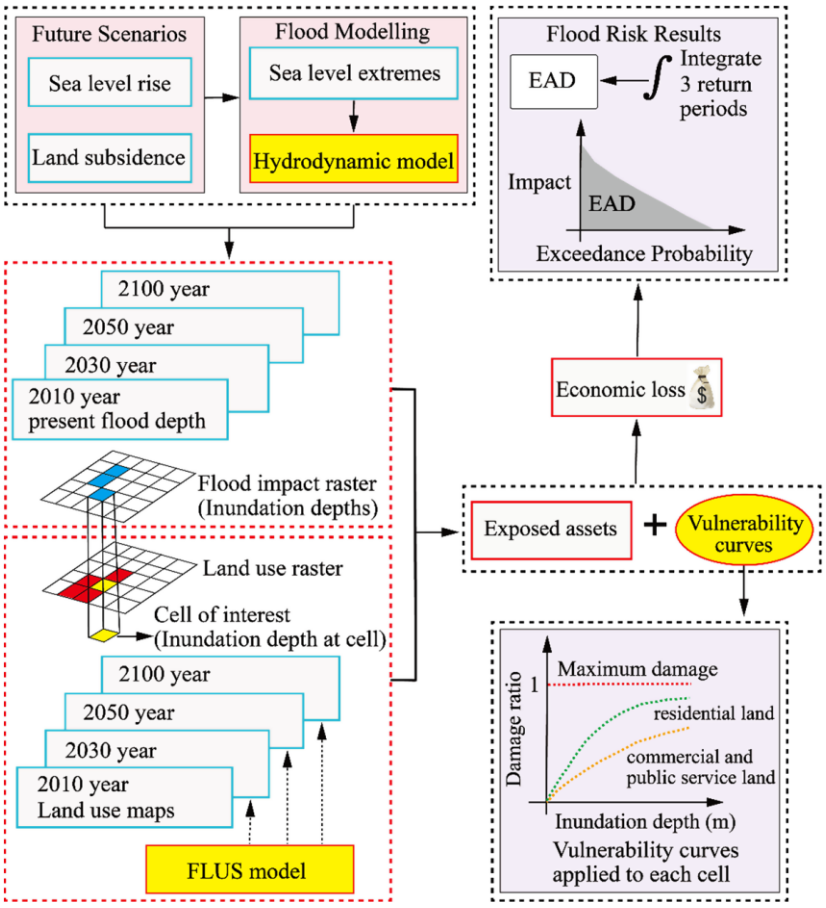

Figure 2. research framework of Shan's paper

R2: Moreover, the built-up lands are expected to increase by a limited extent as shown in lines 226-227 and figures 3-4, compared with other cases. In this case, if one assumes that land use does not change, then the model accuracy should be high, damping the significance of the accuracy reports in lines 209-210.

A2: Thanks for your comments. FLUS model predicts future land use/land cover determined by the amount of future land use type demand and the driving factors affecting land use change. **The amount of future land use demand is predicted by Markov chain.** The Markov chain model requires at least two periods of historical land use data to predict the amount of land use for the same time interval in the next period. In other words, the amount of future land use for each type (6 types) shows a different proportional change under the Markov chain model calculation. In addition, we used two steps to predict future land use changes, one is model validation and the other is model prediction.

1. Model validation. We predict the land use change in 2015 based on the land use data in 2010. In this process, the quantity of land use demand in 2015 was predicted by Markov chain model based on the land use data in 2005 and 2010, and then it was combined the impact factor data input into the FLUS model to simulate the type of land use in 2015. Finally, we compared the simulated results and the actual land use in 2015 pixel by pixel to test the reliable performance of the model. This means that the model validation stage **(Line 209-210, Figure 3)** carries out an accuracy analysis of the simulated land use data and the real land use data.

2. Model prediction. After the model and impact factor selection were evaluated by reliability accuracy, we predicted the future land demand quantity in 2020, 2030, through Markov chain model based on the land use data in 2010 and 2015. Then we combine impact factor data, future land demand, and future scenario requirements to predict future land use results **(Lines 226-227, Figure 4).**

In summary, the model validation stage (Line 209-210, Figure 3) is a comparative analysis of simulated and real data from 2015 to test the simulation accuracy of the model. **This means that the model validation stage is not constrained by the future scenarios (no constrained for some types of land use), but is only related**

to the prediction results of the Markov chain and the selection of the impact factor data. Therefore, the simulation accuracy of the model in the model validation stage has no relationship with the future scenario assumptions. In addition, the model prediction stage (Line 226-227, Figure 4) is the projected data for 2030 and 2050. This stage is constrained by the future scenario, but the forecast results under the future scenario constraint are not able to test the accuracy of the model.

Thank you again for your comments.