Interactive comment on "Multi-scenario urban flood risk assessment by integrating future land use change models and hydrodynamic models" by Qinke Sun et al.

The authors would like to thank the Anonymous Referee #1 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 #1 will enhance the quality of the manuscript. A point-by-point response is presented below.

R1: Thank you for letting me read the interesting manuscript that provides valuable results on urban flood risk scenarios for Shanghai. The manuscript fits the aims and scope of the Journal Natural Hazards and Earth System Sciences. The authors present their method and data transparently as well as provide a good presentation of the results. However, the manuscript lacks a general discussion of studies on urban flood risk assessment and a link of their findings to the literature. Therefore, I recommend the authors to add this to the manuscript. Also, I suggest a external language check. The manuscript includes some grammar mistakes. Next to smaller remarks I therefore recommend a major revision.

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.

R11: However, the manuscript lacks a general discussion of studies on urban flood risk assessment and a link of their findings to the literature. Therefore, I recommend the authors to add this to the manuscript.

A11: The manuscript provides an insufficient discussion of urban flood risk assessment, and we thank the reviewers for raising this point which has greatly improved to the quality of the manuscript. The authors have added rephrased the second paragraph of the introduction to take into account the latest research findings on urban flood risk assessment. The Referee can read the new part in the following:

However, high uncertainty in flood risk and urban growth leads to a lack of capacity of cities to respond to the flooding arising from future climate change (Du et al., 2015; Tessler et al., 2015; Fang et al., 2021). Therefore, there is an urgent need for specialist knowledge and techniques to address the conflict between urbanization and flood risk (Wang et al., 2015; Lai et al., 2016; Bouwer, 2018; Haynes et al., 2018). Studies on urban flood risk assessment are more likely to simulate flood risk using different climate change scenarios or integrating different flood sources (Huong and Pathirana, 2013; Muis et al., 2015; Dullo, 2021). For example, Zhou et al. examine the impact of urban flood volumes and associated risks under RCP2.6 and RCP8.5 scenarios (Zhou et al., 2019). Parodi et al. integrate the compound flood scenarios such as wave height, storm surge, and extreme sea level due to sea level rise to assess coastal flood risk (Parodi et al., 2020). However, ignoring the uncertainty of urban growth in urban flood risk assessment reduces the validity of the assessment (Gori, 2019), and hence an increased understanding of possible urban growth scenarios is needed, otherwise there is a lack of understanding of the consequences of future flooding (Zhao et al., 2017; Kim and Newman, 2020). Although there are some studies that have quantified future growth scenarios for urbanization (Nithila Devi, 2019; Lin et al., 2020), these studies have not considered the impact of existing planned policies that are designed to mitigate the impact of new development.

R12: Also, I suggest a external language check. The manuscript includes some grammar mistakes.

A12: Thanks, we will correct all grammatical and language-related idiosyncrasies in our revised manuscript. We invite members of the team who are good at English and native English-speaking foreign partners to read the full manuscript carefully and help correct grammatical errors in the manuscript.

Minor recommendations:

R2: Please do not use abbreviations, such GE or BU in the abstract.

A2: Thanks for your suggestion. We have replaced all abbreviations of BU, GU and GP that appear in the abstract.

R3: Please rephrase: "We also find that urban will tend to expand to areas vulnerable." What is meant by urban? Urbanization?

A3: Thanks for noting this. We have rephrased this sentence accordingly in our revised manuscript. Revised as follows: "We also find that urbanization tends to expand more towards flood-prone areas under the restriction of ecological environment protection."

R4: What is meant by "coupling model" (line 24)?

A4: Thanks for the comment. In line 24, the "coupling model" is the method that couples the future land use simulation model (FLUS) and floodplain inundation model (LISFLOOD-FP). This sentence we want to express the research significance of the simulation results of the model, so we have rephrased the sentence for better expression. The Referee can read the new part in the following:

The increasing flood risk information determined by model simulations help to understand the spatial distribution of future flood-prone urban areas and promote the re-formulation of urban planning in high-risk locations.

R5: Lines 31-32: "The United Nations reports that the global population will increase by 29% (7.6 billion) between 2017 and 2050 (United Nations, 2017b)," Is the increase taking place in coastal cities? If yes, please make this clear in the sentence.

A5: We thank the reviewer for raising this point which we believe may have been caused by lack of clarity in the manuscript. We have rephrased this sentence and also provide the supporting reference. The Referee can read the new part in the following:

The United Nations reports that the global population living in cities is projected to reach 6.7 billion by 2050 (United Nations, 2018), especially in low elevation coastal

areas, the population density is expected to be twice the current population density (Van Coppenolle and Temmerman, 2019), which means that population of coastal cities will become increasingly concentrated in the future and impervious surfaces will become more numerous (Chen et al., 2020; He et al., 2021)

R6: Line 44: Please give some examples what is meant by "environmental factors".

A6: Thanks for the comment. Environmental factors in the manuscript include study area topography, study area water level conditions, etc. Because we have rewritten this part of the introduction in conjunction with the general comments, the environmental factors and other influencing factors are described in detail in the second part of the manuscript.

R7: Line 54: "The FLUS model improves the simulation accuracy of the model…" Which model will be improved?

A7: Thanks for the comment. We describe the FLUS model in detail in the methodology of the manuscript (Line 147-148), so we did not expand the description in the introduction.

Line147-148: *"The FLUS model is an upgraded version of cellular automata model (Liu et al., 2017), which can solve the complex land use simulation problems by self-adaptive inertia and competition mechanism."*

R8: Please rephrase: "To answer this question, we first consider how urban grow under different environmental and planning factors in the future." (lines 61-62).

A8: We thank the reviewers for raising this point. We have rephrased the sentence. The Referee can read the new part in the following: *To answer this question, we first assume some future simulation scenario by considering the factors that influence urban growth and lead to flood risk.*

R9: Please include a presentation of the further content of the paper in the Introduction.

A9: Thanks for your comments. We have added a presentation of the further content in

the introduction. The Referee can read the new part in the following:

The rest of paper is organized as follows: section 2 describes the characteristics of the study area and presents the data used in this paper; followed by a description of the methodology for integrating future land use change models and hydrodynamic models in Section 3. The results and discussion in Section 4 and Section 5. We divided the discussion section into two parts, on the one hand discussing the sources of uncertainty in the study, and the other part discussing adaptation policies for urban flood risk in the context of climate change. The conclusion of the study is described in Section 6.

R10: Line 149-150: Can you please further explain why do you choose 2,768 km^2 in 2030 and 3,200 km^2 in 2050 as reasonable city growth pathways?

A10: Thanks for the comment. First of all, we base on the prediction results of Markov chain model that the urban area is 2768 km^2 in 2030 and 3270 km^2 in 2050, next, we combine the master plan of Shanghai requires that the total area of planned urban construction land does not exceed 3,200 km^2 in 2035. Therefore, we choose an urban area of 2768 km^2 in 2030 and 3200 km^2 in 2050 as the constraints under the GP scenario. We have rephrased this sentence in the manuscript. The Referee can read the new part in the following: *We choose an urban area of 2768 km^2 in 2030 and 3200 km^2 in 2050 as the constraints under the GP scenario. The reason is that the Markov chain model projections result in an urban area is 2768 km^2 in 2030 and 3270 km^2 in 2050, and the total urban construction land area in 2035 of the Shanghai Master Plan does not exceed 3200 km^2.*

R11: Line 169-170: Please add some references to justify the useful applicability of the LISFLOOD-FP model.

A11: Thank you very much for your suggestion. We have added some recent references to the manuscript.

Line 169-170: The model has been widely used in the applications of small-scale and large-scale urban waterlogging and flooding (Hoch et al., 2019; Rajib et al.,

2020; Zhao et al., 2020).

[1]. Hoch, J. M., Eilander, D., Ikeuchi, H., Baart, F. and Winsemius, H. C.: Evaluating the impact of model complexity on flood wave propagation and inundation extent with a hydrologic-hydrodynamic model coupling framework, Nat. Hazards Earth Syst. Sci., 19(8), 1723–1735, doi:10.5194/nhess-19-1723-2019, 2019.

[2]. Rajib, A., Liu, Z., Merwade, V., Tavakoly, A. A. and Follum, M. L.: Towards a large-scale locally relevant flood inundation modeling framework using SWAT and LISFLOOD-FP, J. Hydrol., 581, 124406, doi: 10.1016/j.jhydrol.2019.124406, 2020.

[3]. Zhao, G., Bates, P. and Neal, J.: The Impact of Dams on Design Floods in the Conterminous US, Water Resour. Res., 56(3), 1–15, doi:10.1029/2019WR025380, 2020.

R12: Line 187: Please explain what is meant by the abbreviation LUCC.

A12: Thanks for your suggestion. LUCC is the land use/cover changes, we have added explanations before the abbreviation in the manuscript.

R13: I propose to include the explanations contained in the titles of the figures and tables in the text of the manuscript and to refer to the figures and tables.

A13: Thanks for the comment. The titles of the figures and tables in the manuscript are described with reference to the format of the journal with previous issues of the literature, in other words, the titles of the figures and tables in the manuscript are described in detail. We have also revised the descriptions of the figures and tables in the text of the manuscript to give more detail.

R14: Lines 250-253: I suggest presenting either relative numbers (in %) or the absolute number of inundated land area. For RCP2.6 scenario you are using the land area but for RCP 8.5 you present relative numbers.

A14: Thank for your suggestion. We have revised the sentences in the manuscript and checked for similar issues in the manuscript. The Referee can read the new part in the following:

Under the RCP2.6 scenario, new growth in urban land area affected by flooding in

2030 are respectively 55.11 km^2, 23.22 km^2, and 30.92 km^2 at BU, GP and GE scenarios. Under the RCP8.5 scenario, future more urban growth areas would be affected by the flooding, which will be reached 115.53 km^2, 70.36 km^2, and 81.71 km^2 at BU, GP and GE scenarios in 2050, respectively.

R15: Line 260-261: Please make clear whether this findings means in absolute and/or in relative numbers.

A15: Thanks for your comments. Inundation results in the study manuscript are absolute numbers. The findings from in our research are relative conclusions by comparing the absolute inundation numbers of different land types. We have rephrased this sentence in the corresponding place in the manuscript.

R16: Line 329: "…range and spatial distribution of flood risk in future urban" Please add "areas" at the end of the sentence.

A16: Thank you very much for your suggestion. We have revised this sentence in the manuscript.