We sincerely thank Reviewer #1 for his support for publication

A. Questions related to the contain of the paper

1. A flood simulation approach (1D and 2D models). The software used is not indicated?

Thanks for noting this. It’s a very important question, the flood inundation model we used is called FloodMap, this model is an established diffusion-based flood inundation model (FloodMap, Yu 2005; Yu and Lane 2006a, b, 2011)

We will add the introduction about this model in more detail as below:

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“we used a 1D/2D coupled flood inundation model named FloodMap (Yu and Lane, 2006a; Yu and Lane, 2006b), to simulate the inundation scenarios of fluvial flooding in various return periods; this model combines the 1D solution of the Saint-Venant equations of river flow with a 2D flood inundation model based on raster data to solve the inertial form of the 2D shallow water equations. The model is tightly coupled by considering the mass and momentum exchange between the river flow and floodplain inundation and it is employed to simulate the flood process and extract flood potential maps. It has been applied in a number of different environments and now Floodmap is the mainstream numerical simulation model used for flood scenarios (Yin and Yu et al., 2013; Yin and Yu et al., 2015). We use the FloodMap model to simulate the inundation area and depth following fluvial flooding for various return periods (100-year and 1000-year) in the Huangpu River Basin in the 2010s, 2030s, and 2050s.”

2. What is/are the innovative aspect-s of the paper?

Thanks for your summary, this research mainly proposed multi-coverage location optimization model well suited to model the emergency response to flood disasters and to conduct site selection of urban emergency facilities.

The innovative aspects are

- Improving the emergency service capacity from the aspect of service population and the coverage level(how often the demand point needs to be covered by emergency facilities) during disasters
- The implementation of a treatment chain including the development of flood scenarios (100 and 1000 years return periods).
- An interesting aspect is the “Coverage level analysis”

3. The aspect of “Disaster risk level” analysis (2.5 section) simply depends on the proximity of the flood hazard and EMS (Euclidean distance? See line 215).

Thanks for noting this. In our case study, we used ArcGIS 10.2 buffer tool to determine the Disaster risk level by Euclidean distance. Because the impact of fluvial flood hazards on emergency response is directly related to inundated areas, unlike other disasters such as earthquake and mudslide, flooding does not destroy buildings on a large scale (the disaster risk will be related to whether the buildings are strong or not), so in our case study, we analyzed the disaster risk level of the demand points and potential emergency points and classify the disaster level according to the distance of the emergency services from the source of the disaster. In future research, we will try to develop a quantitative assessment of the disasters risk level on emergency response, is considered to be reasonable.

We have added this discussion in Conclusion as below:

"The model also has some aspects that could to be improved in order to arrive at more robust solutions. Firstly, in our case study, we did not have a quantitative assessment of the disasters risk level on emergency response, we evaluated the disaster risk level only by the buffer distance to disaster source area, which is subjective……. The future studies will consider disaster risk factors such as the vulnerability of buildings comprehensively, evaluate the level of disaster risk quantitatively, and take the real terrain and construction cost of each potential point into full account."

4. Line 163: "To ensure the efficiency of rescue, the emergency response time must be minimized": for each ambulance (each rescue) or for all ambulances (all calls/rescues)?(need more detail)

Thanks for noting this. Yes, in line 146 we defined that parameter t_{ij} was the time needed for an ambulance to travel from emergency medical facilities j to demand point i. We use t_{ij} to constraint that the emergency response time cannot exceed T minutes in model (t_{ij} <T), which met Chinese emergency response time limit. In time limit, how to serve the largest number people is the objective of our model.

The sentence has been removed to Line 173 and changed as below:

"Constraint (4) ensures that the emergency response time cannot exceed T minutes to ensure the efficiency of rescue;"

5. However, calls usually come to a call center, which distributes them according to different aspects, such as the availability of ambulances, the remaining capacities of the nearest EMS of the site, and so on. But it seems that the paper is not in this configuration (sorry, I am not familiar with the Chinese rescue system). Please, see the comment above related to the assumption ②.

Thanks for your comments. Yes, in normal cases, ambulances distributed according by distance or other aspects. We also analyzed almost 40000 records of EMS calls of study in 2017(Figure 1). The results show that demand points can be served by multiple EMS stations. Therefore, the assumption ②(During a disaster, Each emergency facility has the same service capacity and the same number of ambulances;) is based on one single historical data and this is considered to be reasonable especially during disasters.

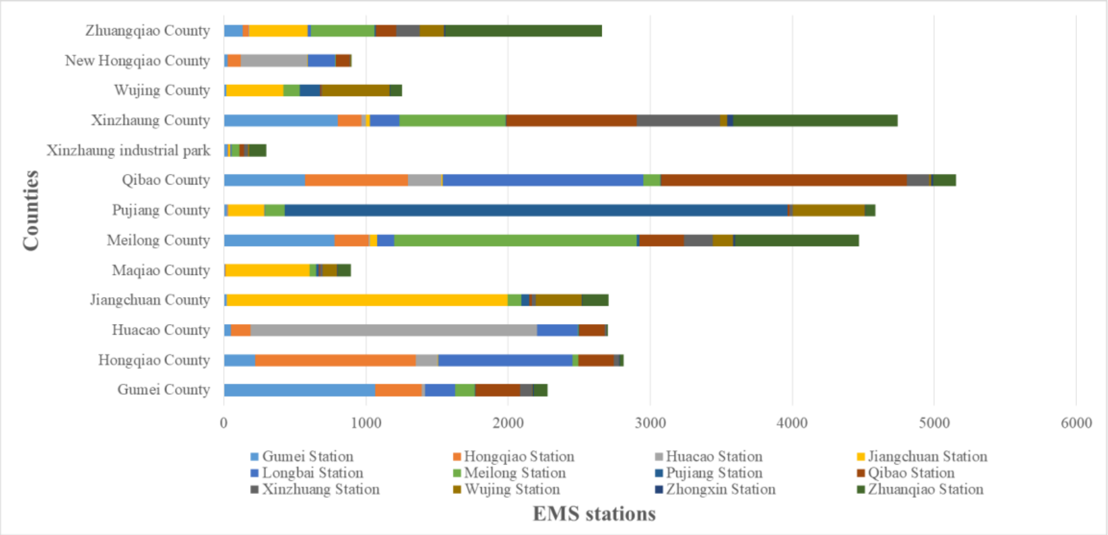


Fig.1 the EMS calls records of 13 counties (Minhang district) in 2017

6. Line 167 : $\boldsymbol{\sum_{i=1}^{n} y_j = F}$ **Or** $\boldsymbol{\sum_{j=1}^{n} y_j = F}$

Thanks for noting this. It has been corrected.

7. Line 255: "…in the Huangpu River Basin in the 2010s, 2030s, and 2050s (Fig. 2)" Does this mean that the flood simulation model takes into account aspects such as precipitation trends, urban sprawl and / or population change in 2010, 2030 and 2050 (in a context of climate change?). I imagine that all these aspects are considered in the cited references of Yu and Lane 2006a and 2006b (Line 249)

Thanks for noting this. Yes, the model(Floodmap) we used is a mature flood inundation model, and in our case study, the flooding inundation simulation results was took reference by Yin et al (2013) research, it considered sea level rise and land subsidence on storm tides induced flooding of the Huangpu River(Figure 2).

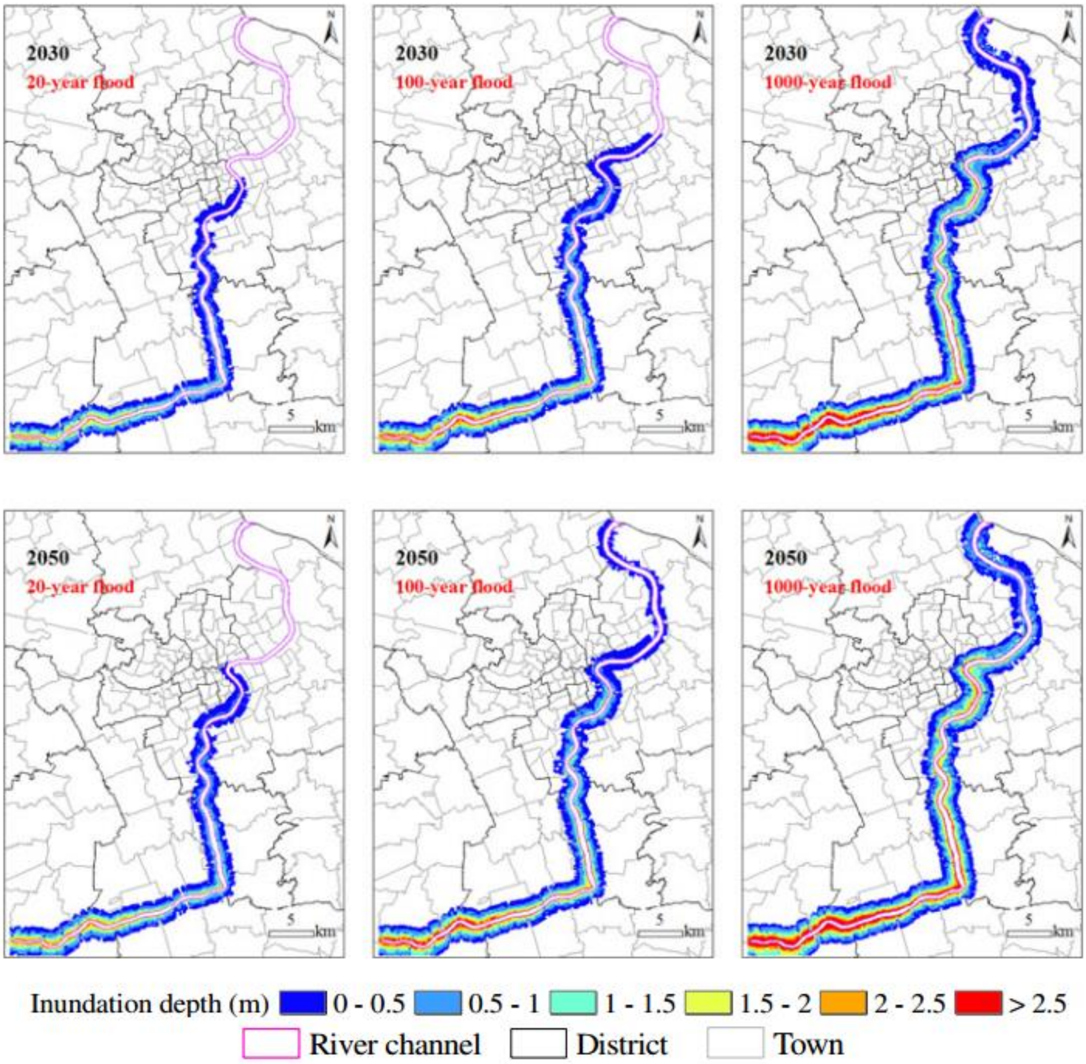


Fig.2 multiple scenario of Huangpu river flooding

8. Line 263 : "We used five levels for the road speed limit"

Remember that ambulances and rescue services (fire brigade) in general are allowed to exceed speed limits during an intervention. For low speed road sections (30 km/h for example), we could increase this speed in the model... (under ArcGIS, it is quite possible / easy to change the speed of a category / class of road sections with VB or Python script).

Thanks for noting this. Yes, in general, ambulance are allow to exceed speed limit. However, in fact, road conditions included height and weight always constraint road speeds, and not all roads have emergency vehicle lanes that's why ambulances are not so easy to exceed speed limits. Furthermore, there are too much uncertainties associated with how human behavior and patterns of congestion may differ under flood conditions. Therefore, the speed of the road is difficult to define accurately.

9. On the other hand, the method/process of designing the 514 demand points is less clear (red -dots, Fig. 4 - 5, page 11). Shanghai Minhang district Community unit (demand unit = smallest block unit)?

Thanks for noting this. Yes, in order to verify the model applicability, we set each community unit as the smallest unit, because in China, the EMS services always allocated by blocks or communities, while the same communities have same attributes, so there is reason to take community unit as the smallest unit. Another reason is we have Shanghai Communities' population and other detailed data, what make study more precisely. Because of the communities are small, it is scientific to take the central point as the rescue unit. Of course, it would be better if we had the building data, but the efficiency of model running would also increase significantly.

10. About the applied grid of 2 km * 2 km: can be discussed in the section of results / discussion/ conclusion of the article. Indeed, what is the impact of such division/regular zoning on the method and results obtained? Can we develop / imagine a multi-scale division with variable squared meshes taking into account the distribution density of the population (spatial distribution of red dots)?

Thanks for your suggestions. We have adde the discussion about the impact of such division/regular zoning on the method in conclusion:

"Lastly, the location of urban emergency service facilities has always been the focus of urban planning. Location selection should consider a variety of factors and the ability to respond to disasters is also a key factor to consider, while in this paper, we divided the area into grids with a cell size of 2 km * 2 km and assumed that every grid center point was a potential emergency station, The division of grid will affect the efficiency of model running efficiency and the accuracy of results. The smaller the scale, the higher the accuracy, but the greater the model running pressure. Therefore, in the future research, we will consider multi-scale division with variable squared meshes taking into account the distribution density of the population or other factors. "

11. Line 327: Tab 1. No need to display/show the coordinates of points 1, 2, 3, etc. (latitude and longitude values). However, it misses the values of: min (A1), min (A2), max (A1) and max (A2) (equation 8) to allow the reader (who wishes to do it) to calculate/verify Qi?

Thanks for your comments, we have altered the table in revised paper (shown in Table 1)

Tab.1 Demand point coverage level (sub-sample of the demand point data)

Point ID	Area(km^2)	Population	EMS calls	Population density(A1)	EMS calls density(A2)	Coverage level
1	0.1624119	5225	74	32,171.28	455.6315	4
2	0.06345485	3217	44	50,697.46	693.4064	6
3	0.09560105	3137	59	32,813.45	617.148	4
4	0.2068276	5955	89	28,792.10	430.3101	4
5	0.2035748	6451	150	31,688.60	736.8299	5
6	0.1510978	4728	173	31,290.99	1,144.95	6
7	1.463531	11332	273	7,742.92	186.5352	2
8	0.6317168	3317	76	5,250.77	120.3071	1
9	3.198358	8736	27	2,731.40	8.441831	1

10	0.1303969	3970	61	30,445.52	467.8027	4
11	0.1299455	5082	57	39,108.70	438.6454	4
12	0.3076447	4113	123	13,369.32	399.8118	2
13	0.254323	3115	71	12,248.21	279.1726	2
14	0.08798262	4396	51	49,964.41	579.6599	5
15	0.1688578	4294	37	25,429.68	219.1193	3
16	0.1297367	3815	69	29,405.72	531.8465	4
17	2.101426	2801	113	1,332.90	53.773	1
18	3.886865	6481	90	1,667.41	23.15491	1
19	0.2178247	4066	58	18,666.38	266.2691	2
20	0.3022524	5911	114	19,556.50	377.1681686	3
…	…	…	…	…	…	…
Max	10978496.3425	25419	608	76608.25	1870.493324	8
Min	20271.96894	86	0	25.7722	0	1

12. So, do you know the number of real trips (statistical data of 2017)1 done by ambulances between EMS and Point ID 1 (or at least the ratio between calls and trips)? If possible to compare the distribution of Qi (calculated values) with the values observed on the site in the recent past (a way to appreciate/validate the values obtained/calculated of Qi).

Thanks for your comments. Sorry, we don’t have the real trip of ambulances, but we analyzed the EMS calls records of 13 counties (Minhang district) in 2017(Figure 1), the vertical axis is the source county of the demand points and horizontal axis is the number of EMS calls. The results showed that each demand point can be served by multiple EMS stations, however, in normal cases the ambulance are always allocated by distance especially in a short time. For example, the demand points of some counties, such as Xinzhuang county, can be served by multiple EMS service stations (with high coverage level Qi), while some counties such as Jiangchuan county can only be served by Jiangchuan EMS station in most cases (with low coverage level Qi), which means that if the station is destroyed disasters (eg.1000-y fluvial flooding in 2050s), the emergency response time of Jiangchuan county will be greatly delayed.

We also compared how many times every demand point would be covered in 8, 12, and 15 minutes during the no-flooding and the worst-case flooding scenarios (Figure 3). The percent coverage is expressed as percentage of demand points for different coverage levels. The results were interesting, for example, in 8-min response time or 12-min response time, the model greatly improved the coverage level of interval 5~8, what’s more, we also found that the optimized coverage level almost same during the no-flooding or the worst-case flooding scenarios, what means extreme fluvial flooding have little impact on EMS emergency response.

We will supplement the results in revised paper

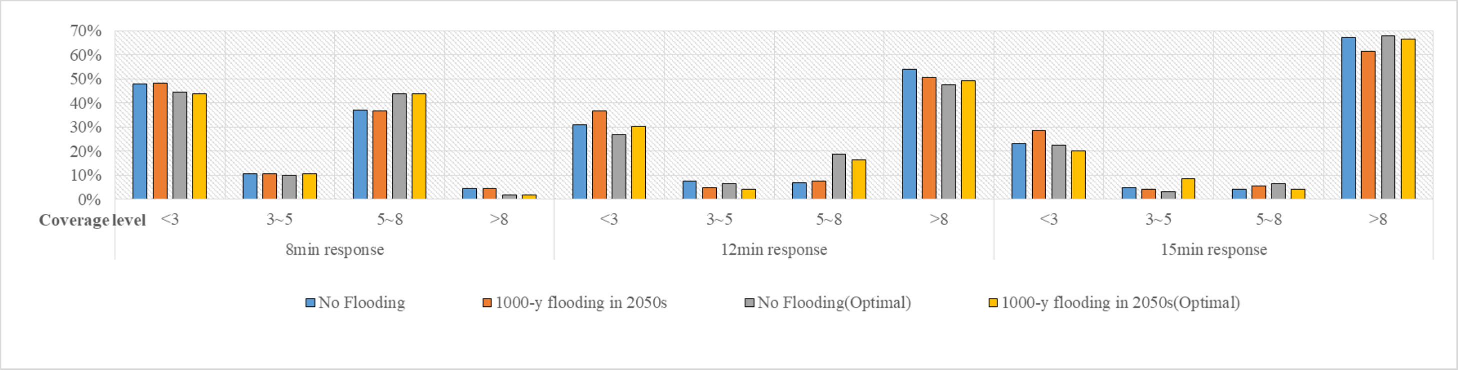


Fig 3 Comparisons of the coverage level

13. Line 340, Section 3.3.2: which flood scenario is considered in Fig. 5?

The 3 buffers of 1 km each used to characterize the indicator "Disaster Risk Level" are more relevant (pertinent) especially if it is the flood scenario of 100-y (rather than 1000-y). In this case, the spatial discretization (by the 3 buffers) will be interesting to take into account the variability (uncertainty) of the flood extension between the simulated scenario and the observed one (flooding closer to 150 or 200-y ... than 100-y).

A flood of 1000-y, may already be considered as an extreme event (I am not familiar with the site studied). To have water beyond the flooded area of 30 cm (Fig.5), it would take a more extreme flood event (1500-y ...). Is this possible in the context of the study site (climate change)?

In the past, has there been a higher (historical) flood than the 1000-y scenario?

Here is a proposal for the flood of 1000-y:

- **pj = 0 if water height is > 30 cm (EMS is completely inundated)**
- **pj = 1 if water height is <= 30 cm**
- **pj = 2 if water height is = 0 cm (EMS is not inundated)?**

The method shown in Fig.5 seems more suitable (pertinent) for the 100-y flooding scenario.

Thanks for noting this. They are very important comments.

(1)We used the 1000-y fluvial floods of Huangpu River as the extreme flood scenario because in Huangpu River, to protect against flooding, flood walls have been built since the 1950s. This has since been reinforced and upgraded, resulting in most of the study area along the Huangpu River being protected by 511 km flood walls, mostly in urban area(including our study area), can defend a 1000-y flood (based on the frequency analysis undertaken in 1984)(Yin et al,. 2013). Therefore, 100-y flooding can be well defended by flood wall and **1000-y flooding could be more representative.**

(2)We tried to redefine the Pj parameter as you suggested, however, the simulation area of ‘water depth <= 30 cm’(Figure 4) in the extreme scenario(1000-y flooding in the 2050s) was **too small**, few potential stations are in this area, which is not conducive to further analysis.

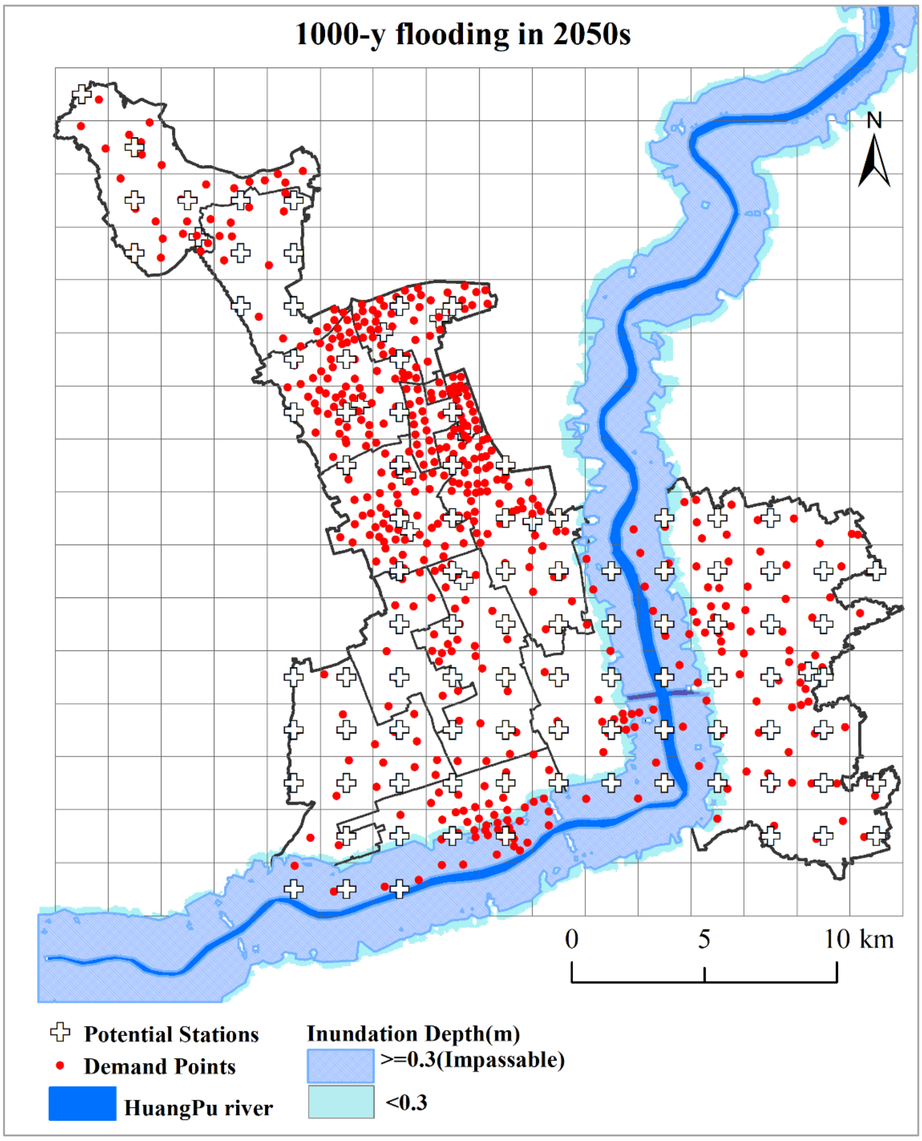


Fig.4 Inundation scenario of 1000-y flooding in the 2050s

14. Line 355: The calculation of the OD matrix with the ArcGIS Network Analyst extension does not take into account the traffic jam? (see Line 192)

Thanks for noting this. Although congestion data could be implemented into the modelling framework based on historic traffic data, we didn't use the congestion data due to uncertainties associated with how human behavior and patterns of congestion may differ under flood conditions when compared to normal conditions on which the traffic data were based. Furthermore, emergency vehicle lanes can also supply emergency vehicles in some roads so that unless road facilities are damaged in the case of disasters, emergency vehicles can drive at the maximum speed permitted by the road conditions.

To simulate the traffic jam during disaster, we considered that use the Risk Level to express the traffic jam during the crisis, we assumed that high risk level could bring heavy traffic jam, it could on behalf of the difficulties of the rescue.

So in this paper we used different road speed limit based on the People's Republic of China Technical Standard of Highway Engineering (JTG B01-2003) as the max speed to calculate the OD matrix.

15. Line 374: "…i.e., the larger the service area, the larger the number of people who can be served by this station": this statement (affirmation) is not always true.

Thanks for your comments. Yes, we know that the service area cannot replace the number of people who can be served by this station, we will modify the expression. But it is undeniable that the service area is also an important indicator of service capacity evaluation of an emergency rescue station. Many researches use service area to evaluate emergency responder accessibility. So in this paper we both used the service area and the served population as the judgment criteria to compare the service capacity of stations. In fact, in our study we have compared the difference of service area and the service population (Table2), we can see that in most case in our study area, larger service can serve more people.

Tab.2 Comparisons of service capacity under different disaster scenarios

Scenarios	Response time(min)	Current service area(km^2)	Optimal service area(km^2)	current service population	optimal service population
no flood	0-8	236.63	256.7	2088905	2174649
	0-12	300.52	306.8	2318052	2334324
	0-15	318.59	314.9	2368158	2356228
1000-year flood in 2050	0-8	205.66	236.44	1838621	2081456
	0-12	265.97	279.7	2186255	2213578
	0-15	282.93	286.52	2221628	2228562

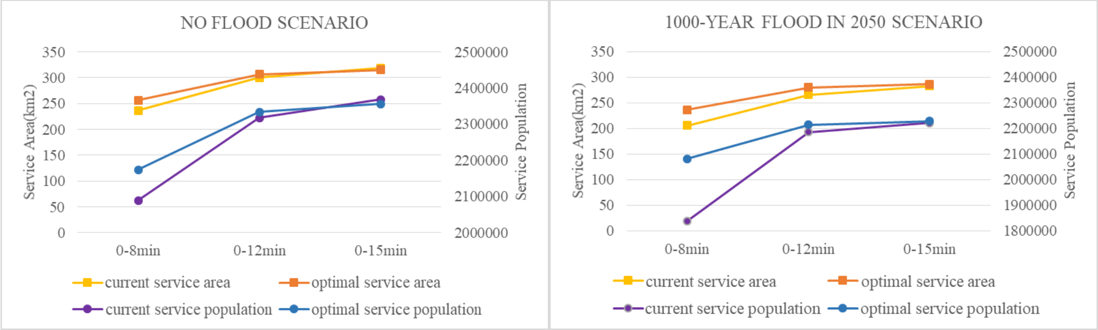


Fig.5 Service capacity comparison with line chart

16. Finally, what about the indirect impact of flooding (indirect vulnerability)?

Apart from causing casualties, flooding may also damage emergency facilities(Figure 2); furthermore, flood inundation could damage to buildings and roads will lead to traffic congestion and render emergency rescue more difficult than usual, making rescue more difficult than usual and delaying the emergency response. The surface water flooding was shown to cause more disruption to emergency responders operating within the city due to its widespread and spatially distributed footprint when compared to fluvial flood events of comparable magnitude (Green et al., 2017).

B. Questions related to the form of the article ("technical corrections")

1 Concerning the two selected flood scenarios (100 and 1000-years), what is the major historical flood that has been observed on the site? It would be interesting to consider the major historical hazard?

Thanks for noting this. Our flooding scenarios results took reference by (Yin et al., 2011) research, and we choose two representative scenarios (100y or 1000y scenario)(Figure 2) to analysis the emergency response during flooding disasters.
As a typical tidal river, the Huangpu River is influenced by tides of the East China Sea with an average tide range of around 2.3 m at the river estuary. Given the low relief of the Huangpu River floodplain, it is subject to significant flood hazards from both the coastlines and the Huangpu River in the event of high tides. Indeed, the study area was frequently inundated by the Huangpu River until flood walls were erected during the 1950s. These have since been extended and reinforced. As a result, most of the study site is now protected from coastal and fluvial flooding, albeit again events with various return periods. Based on flood probability analysis carried out in 1984 by the Shanghai Water Authority, the design standard for flood walls along the Huangpu River was one in 1,000 years for urban area and one in 50 years in rural areas. However, our study area is rural area, so we it can be attacked by fluvial flooding more easily. Whatever flooding may destroy this area easily.

2 Line 188 : “… the disaster risk level m_i/p_j of the demand points/potential facilities

Thanks for noting this.
The sentence has been revised as follows:
“the disaster risk level of the demand points(m_i) and potential facilities(p_j).”

3 Line 322: why the alpha and beta weights are the same (equal)?

It’s an important question, in line 204 we calculated coverage level by Eq (9)

$$Q_i = INT(\alpha A1_i + \beta A2_i + \cdots + \varepsilon An_i + 1)$$

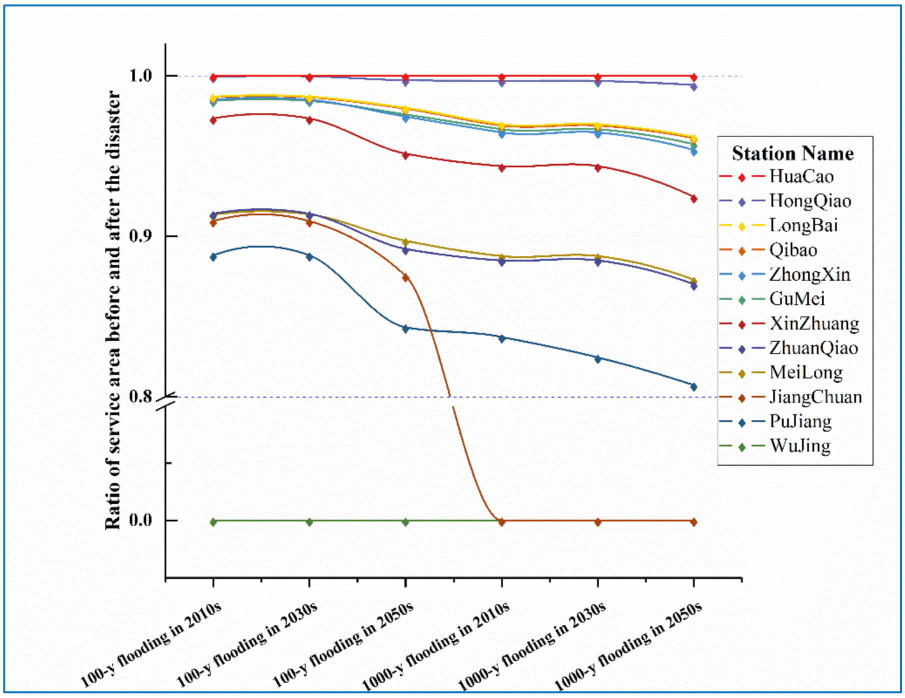
Where $\alpha, \beta \cdots \varepsilon$ represent the weights of the different indicators, i.e., their relative contributions to the estimated demand. The weights can be determined according to the actual situation of the study area, in case study, we regarded the population and the historical EMS calls for help at each demand point as the influencing factors A_1 and A_2. Both factors are important, so we did not quantify the weights of each factor, set alpha and beta weights the same.
We have added the explanation on this:
“we regarded the population density and the historical EMS calls for help at each demand point as the influencing factors A_1 and A_2, respectively of the demand coverage level (using Eq. (9)) and used equal weights for the two factors as for a specially instance ($\alpha = \beta = 0.5 * 10$)”

4 Line 290: “Figure 3 shows the impact on the area serviced by each station for the different flood scenarios.
Line 298: it is difficult to make visually and easily the link between the coloured curves and the legend (the name of each EMS).
At least, the order of the name of the stations (12 EMS) in the legend must be the same than

the order of the curves to improve the reading of this Fig.

Thanks for your comments, sorry for the low readability of Figure 3 in paper,

The Figure 3 in paper has been revised as follows:



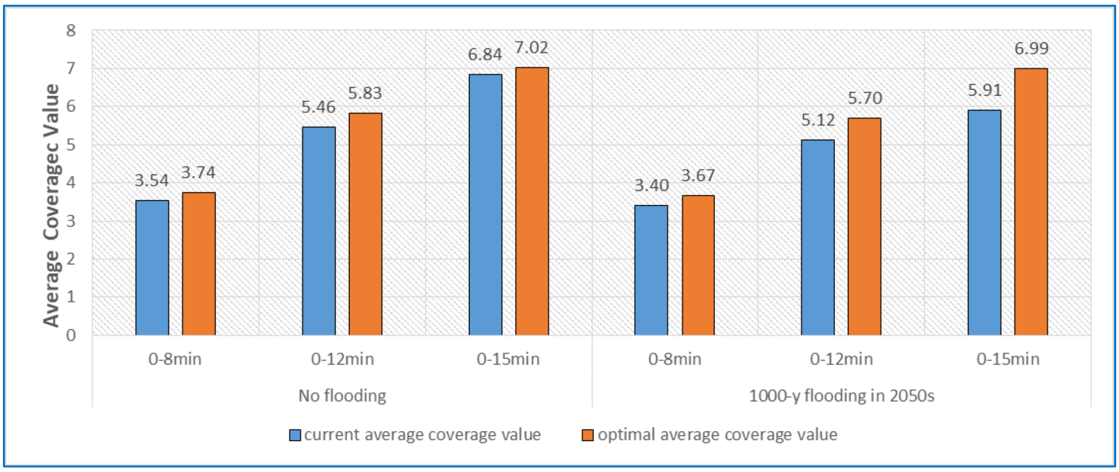
5 Line 411: Fig. 9 Comparisons of the average coverage level

Figure 9 shows “coverage level” in REAL values (3.54, 3.74 etc.) and not in INTEGER values? (See equation 9, page 5)

Thanks for noting this. Sorry, we didn’t have a clear distinction between average coverage and coverage level.

The description and the Figure has been revised as：

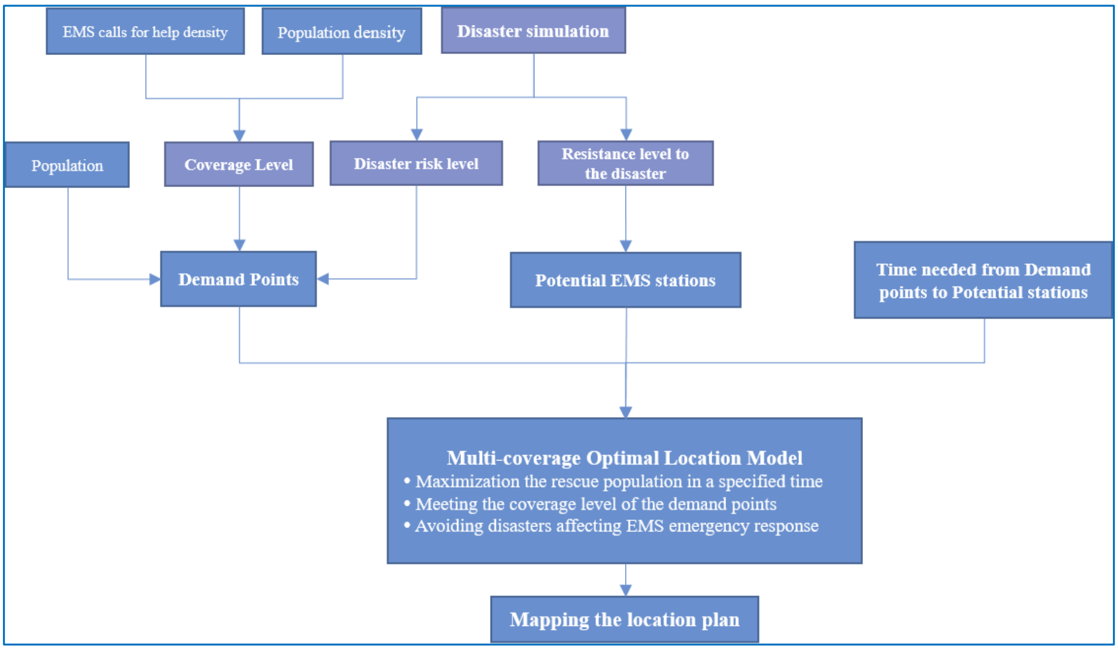
“We combined the service areas of all emergency stations and used the Spatial Join tool in ArcGIS 10.2 to calculate how many times every demand point would be covered in 8, 12, and 15 minutes during the no-flooding and the worst-case flooding scenarios. To compare precisely, we then compared the average values (Figure 11).”



（Fig. 11 Comparisons of the average coverage value）

6 Finally, I propose to the authors (if possible) to design a logi-gram related to the developed methodology and results. Please, see example of the Figure 2, page 689, Alaeddine et al., 2015.

Thanks for your comments, we added a logi-gram as below:



7 We appreciate all the other technical corrections comments, and changes have been made accordingly.

Reference

Green, D., Yu, D. P., Pattison, I., Wilby, R., Bosher, L., Patel, R., Thompson, P., Trowell, K., Draycon, J., Halse, M., Yang, L. L., and Ryley, T.: City-scale accessibility of emergency responders operating during flood events, Nat Hazard Earth Sys, 17, 1-16, 2017.

Yin, J., Yin, Z. E., Hu, X. M., Xu, S. Y., Wang, J., Li, Z. H., Zhong, H. D., and Gan, F. B.: Multiple scenario analyses forecasting the confounding impacts of sea level rise and tides from storm induced coastal flooding in the city of Shanghai, China, Environ Earth Sci, 63, 407-414, 2011.

Yin, J., Yu, D., Yin, Z., Wang, J., and Xu, S. J. C. C.: Modelling the combined impacts of sea-level rise and land subsidence on storm tides induced flooding of the Huangpu River in Shanghai, China, 119, 919-932, 10.1007/s10584-013-0749-9, 2013.