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Referee #1
J.M. Marrero (Referee)
josemarllin@gmail.com
Dear Kai Schroter,
Many thanks for your invitation to review the above paper. I have found this paper of interest and value, particularly given the growing interest in the study of crisis and risk management. The author report an interesting analysis with some novel perspectives. However, I suggest a major revision and I provide some suggestions in order to improve the manuscript. Below I have outlined overarching comments, and then listed smaller and more specific edits. Should you or the authors have any further comments or questions, I would be happy to address these, and also review any further revisions.
[Authors]:
Dear Referee,
Thank you for the comments on our manuscript. We have modified the manuscript accordingly. A detailed point-by-point reply to all of the comments are provided in the following.
Yours,
Ming-Che Hu, Yi-Hsuan Shih, Tsang-Jung Chang

General comments
In my opinion, the evacuation model is decontextualised of what a real evacuation process means. The authors do not explain or describe the evacuation scenarios they want to simulate and how the multiple factors comprised by them are addressed by the evacuation model. It is very difficult to develop an evacuation model flexible enough to be used and adapted to whatever situation. The evacuation scenarios and behaviours that can be addressed/simulated by this model should be described in the methodology in order to understand the model's limitations and scopes.
In this work, different methods have been presented, however, the interaction between them and their specific characteristic are not very well explained. I think the authors should start explaining the type of evacuations process they want to simulate, according to the natural hazard and the characteristic of the threatened

area. Then they should follow describing the flood model more deeply and how it interacts with the evacuation model. And finally the evacuation model. I think it is important to separate this approaches first and then highlight the interaction between them in order to understand much better the presented work.
It would be also useful the use acronyms when referring to the developed models or methods throughout the text.

[Authors]:

Thank you for the comments. Evacuations process of this research is further explained as follows. The assumption and limitation of the flooding simulation and evacuation models are discussed in the methodology section; then interaction between models are addressed. Simulation of the flooding scenarios is described in the case study section.

> ***This study establishes a Kalman-filter based stochastic-multiobjective network optimization (KASMNO) model for analyzing both long-term and short-term inundation evacuation strategies. This KASMNO model determines (1) long-term shelter and transportation capacity expansion plans for authorities and (2) short-term evacuation routing for evacuees under flooding scenarios. For short-term evacuation procedures, authority decision, announcement, community reaction, and evacuation are considered. To simulate flooding scenarios, maximal-distance Latin hypercube method is used to sample three uncertain factors, including upstream inflow (upper boundary condition), downstream water level (lower boundary condition), and friction resistance of channel. Then potential flooding scenarios are simulated using the HEC-RAS hydraulic model and uncertain factors. The stochastic evacuation model can be further simplified to be a deterministic model by inputting deterministic inundation scenario.***
>
> ***Notice that the proposed model assumes that evacuees have the complete information about shelter capacity status and people would follow authority's evacuation plan. Otherwise, additional time needs to be estimated while people's individual behaviour exists under incomplete information cases. The weighting method is used to analyze the tradeoff between the shelter expansion cost and the evacuation time. The uncertain flooding scenarios, the associate evacuation plans, and tradeoff analysis of multiple objectives are conducted and displayed on the GIS platform. The framework of the Kalman-filter based stochastic-multiobjective network programming analysis of inundation evacuation planning is presented in Fig. 1.***

The HEC-RAS hydraulic model is used to simulate uncertain water stage of the Jingmei River in Muzha. Uncertain upstream flow (0%, ±7%, ±14%), downstream water level (0%, ±6%, ±12%), and channel roughness coefficient (ranging from 0.013 to 0.045 by interval of 0.002) are considered in the model. Fig. 3 plots uncertain simulation of water stage of the Jingmei River. In this study, potential inundation overflow locations are determined by comparing the water stage and levee height. Then areas within a 200-meter radius around potential overflow sites are regarded as evacuation zones. Accordingly, Fig. 4 displays the three cases of overflow location and inundation evacuation areas including three cases of Xinhai Road Sec 7, Hengkung Bridge, and Daonan Bridge in Muzha. The probability of each inundation scenario depends on the number of simulation for which the potential water stage exceeds the levee height. Based on the HEC-RAS simulation at each location, the probabilities for three inundation areas (Xinhai Road Sec 7, Hengkung Bridge, and Daonan Bridge) are 0.43, 0.15, and 0.42, respectively. People can be evacuated to six shelters located close to the inundation zones. The evacuation area of Xinhai Road Sec 7 area is 0.315 km^2. Hengkung Bridge area is 0.069 km^2, and Daonan Bridge area is 0.089 km^2. Data of people living on each floor are not available. This case study assumes that people living on the first floor needs to be evacuated; the rest of people living on upper floors are not evacuated due to shelter capacity. The proposed stochastic-multiobjective model can further develop complete evacuation plans for all of people in threatened area by assuming whole area as evacuation places.

Specific comments

Abstract

Line 8. "The subject of this research is to develop..." The subject of this research is to present the development (I understand the work have been done).

[Authors]:

Thank you. The sentence is modified as follows.

The subject of this research is to present the development of Kalman-filter based stochastic-multiobjective network optimization and maximal-distance Latin hypercube sampling methods regarding uncertain inundation evacuation planning.

Introduction

Lines 25-32. I suggest to move this paragraph below and start the introduction in the current line 33.

[Authors]:

Thanks for the comments. The Introduction section is reorganized. The first paragraph starts with introducing natural hazards and inundation and the purpose of this research is addressed in the following. Details change are modified in the updated manuscript.

> ***Natural hazards, such as typhoons, hurricanes, and cyclones, lead to heavy rainfall, severe storms, and then possible inundation events. Inundation might result in serious damage to people, property, and facilities (Parker and Fordham, 1996; Rodrigues et al., 2002; Romanowicz and Beven, 2003). Hence, inundation evacuation planning is an important consideration for preventing the loss of life (Li et al., 2012; Parker and Priest, 2012; Hegger et al., 2014; Zhang and Pan, 2014; Wang etal., 2015; Wood etal., 2016; Azam et al., 2017). To achieve inundation evacuation planning, locations and capacities of protection refuges should first be designed and constructed. Subsequently, decision support systems of emergency evacuation must be planned (Barbarosoglu and Arda, 2004; Bird et al., 2009; Taubenböck et al., 2009; Marrero et al., 2010; Yeo and Cornell, 2009; Bozorgi-Amiri et al., 2013; Pourrahmani et al., 2015; Xu et al., 2016; Hou et al., 2017; Liu et al., 2017; Muhammad et al., 2017).***
>
> ***This study proposes an innovative framework for uncertain inundation evacuation planning. In this research, a Kalman-filter based stochastic-multiobjective network optimization (KASMNO) model is newly developed for inundation evacuation under uncertainty. In addition, a maximal-distance Latin hypercube sampling method is established to simulate flooding uncertain scenarios.***

Line 35. This is just an opinion. I think the evacuation plan mainly prevents the loss of life, but I am not sure about property damage (specially in an urban context), unless the evacuee carry with all his properties, which is not common. If people must be evacuated is because they live in a hazard area and very sure their houses will be left behind.

[Authors]:

We agree with the comment. The sentences are modified as follows.

> ***Natural hazards, such as typhoons, hurricanes, and cyclones, lead to heavy rainfall, severe storms, and then possible inundation events. Inundation might result in serious damage to people, property, and facilities (Parker and Fordham, 1996; Rodrigues et al., 2002; Romanowicz***

and Beven, 2003). Hence, inundation evacuation planning is an important consideration for preventing the loss of life (Li et al., 2012; Parker and Priest, 2012; Hegger et al., 2014; Zhang and Pan, 2014; Wang etal., 2015; Wood etal., 2016; Azam et al., 2017).

2. Methods

Before explaining how the evacuation model work, authors should explain or described what kind of evacuation scenarios they want to simulate and for what kind of evacuation scenarios is this evacuation model useful.

[Authors]:

Thank for the comment. The evacuation model and scenarios are addressed in the updated manuscript as follows.

This KASMNO model determines (1) long-term shelter and transportation capacity expansion plans for authorities and (2) short-term evacuation routing for evacuees under flooding scenarios. For short-term evacuation procedures, authority decision, announcement, community reaction, and evacuation are considered. To simulate flooding scenarios, maximal-distance Latin hypercube method is used to sample three uncertain factors, including upstream inflow (upper boundary condition), downstream water level (lower boundary condition), and friction resistance of channel. Then potential flooding scenarios are simulated using the HEC-RAS hydraulic model and uncertain factors.

The KASMNO model is constructed as follows. The model has two optimization stages including evacuation capacity expansion and evacuation routing. In the first stage, authority determines optimal expected solutions for shelter and transportation capacity expansion under flooding uncertainty. In the second stage, optimal evacuation routing is solved for each potential inundation scenario.

I think some of the following questions should be addressed, first as a general issue and then in the example: Is the evacuation process a self evacuation where people make the decision about where they want to go? Is an assisted evacuation, where authorities evacuate people using public transport or other approaches? Are people following a pre-established evacuation plan, where shelters locations and the evacuation routes are perfectly known by people? Or is it a random process? How is the shelter chosen by the evacuee (how this decision making is managed or represented by the model)? There should be a theoretical connection between these important questions and how they are solved or addressed by the model.

[Authors]:

The model assumes that evacuation procedures involves authority decision, announcement, community reaction, and evacuation. The model assume that community follows the authority evacuation plan. The case study assumes that evacuees travel from their home to the shelters by walk. However, other transportation approaches can be considered and simulated by the model.

> ***This study establishes a KASMNO model for analyzing both long-term and short-term inundation evacuation strategies. This KASMNO model determines (1) long-term shelter and transportation capacity expansion plans for authorities and (2) short-term evacuation routing for evacuees under flooding scenarios. For short-term evacuation procedures, authority decision, announcement, community reaction, and evacuation are considered.***
>
> ***Notice that the proposed model assumes that evacuees have the complete information about shelter capacity status and people would follow authority's evacuation plan. Otherwise, additional time needs to be estimated while people's individual behavior exists under incomplete information cases.***

Have the evacuation time intervals been included or considered in this model? To assess the total evacuation time the model should manage many factors and time intervals (as has been described in the bibliography, see for example Urbanik et al. (1980); Lindell (2008); Opper (2003) and Frieser (2004), Marrero et al, (2013)) Has this evacuation model such ability? If so, it should be very well explained. Other way, the results may be underestimate. For example, how do people know that a shelter is full? I think they only know that when they reach the shelter. Then, they need an extra time to find out where they can go (next shelter), which it will be conditioned by how the shelters spread the information about their capacity status. Has this consideration been included in the model in order to assess the evacuation time? Adapting an evacuation model to an specific context is also important to get the best results.

[Authors]:

This research considers authority decision, announcement, community reaction, and evacuation. The model is able to evacuate community for deterministic and uncertain flooding events. This research assumes that the community follows the proposed evacuation plan while evacuation decision is made by the authority. Extra evacuation travel time needs to be added if people don't the complete information about shelter capacity status. The section is modified as follows. In addition, related studies are reviewed and cited.

This KASMNO model determines (1) long-term shelter and transportation capacity expansion plans for authorities and (2) short-term evacuation routing for evacuees under flooding scenarios. For short-term evacuation procedures, authority decision, announcement, community reaction, and evacuation are considered (Urbanik et al., 1980; Opper, 2003; Frieser, 2004; Lindell, 2008; Marrero et al, 2013).

The proposed model assumes that evacuees have the complete information about shelter capacity status and people would follow authority's evacuation plan. Otherwise, additional time needs to be estimated while people's individual behaviour exists under incomplete information cases.

- ***Frieser, B. I.: Probabilistic evacuation decision model for river floods in the Netherlands, TU Delft master thesis, 2004.***
- ***Lindell, M. K.: EMBLEM2: An empirically based large scale evacuation time estimate model, Transportation Research Part A: Policy and Practice, 42 (1), 140-154, 2008.***
- ***Marrero, J. M., García, A., Llinares, A., la Cruz-Reyna, S. D., Ramos, S., and Ortiz, R.: Virtual tools for volcanic crisis management, and evacuation decision support: applications to El Chichón volcano (Chiapas, México), Nat. Hazards, 68: 955-980. https://doi.org/10.1007/s11069-013-0672-4, 2013.***
- ***Opper, S.: Emergency planning for the Hawkebury Nepean Valley, 40th Annual conference of the floodplain management, 2003.***
- ***Urbanik, T., Desrosiers, A., Lindell, M. K., and Schuller, C. R.: Analysis of techniques for estimating evacuation times for emergency planning zones, Battelle Human Affairs Research Centers Report No. BHARC-401/80-017, U.S. Nuclear Regulatory Commission, Washington, D.C., 1980.***

Here I think the authors should differentiate the use of the model during a real crisis or in the context of a long-term designing process of an emergency planing. In the former, the capacity of a shelter or even the transportation network can not be expanded easily during the evacuation, even if it is necessary (the transportation network can be modified with a very well evacuation planning designed in advance, but more time is needed to improve the shelters). Related with the transportation network capacity, how the evacuees travel from their home to the shelters? do they travel by car, bus or they go by walk?. This considerations affects the transportation network capacity and the travel time and they have not been addressed throughout the text.

[Authors]:

The problem we want to solve, the model, the scenarios, and the limitation are further addressed in the updated manuscript. The paragraphs are modified and the questions are addressed as follows.

> ***This KASMNO model determines (1) long-term shelter and transportation capacity expansion plans for authorities and (2) short-term evacuation routing for evacuees under flooding scenarios. For short-term evacuation procedures, authority decision, announcement, community reaction, and evacuation are considered.***
>
> ***The case study assumes that evacuees travel from their home to the shelters by walk. However, other transportation approaches can be considered and simulated by the model.***
>
> ***The model has two optimization stages including evacuation capacity expansion and evacuation routing. In the first stage, authority determines optimal expected solutions for shelter and transportation capacity expansion under flooding uncertainty. In the second stage, optimal evacuation routing is solved for each potential inundation scenario.***

Given the importance of the weighting method in this work, I think It should be better explained. What does the weighting method mean in the context of a real evacuation? What specific part of the evacuation process have been simulated by this method? If I understood, the efficiency of the evacuation strategy depends on the tradeoff analysis, that is, the relation between the shelter expansion cost and the evacuation time. For such relationship, people should know the emergency plan in advance (evacuation routes and shelters location and capacity), but what they will not know is whether the shelter capacity has been increased or not, and the next shelter they can go if the one they found first is totally full. Probably I do not understand very well why this factor is so critical if people do not know the information in advance? If authors want to predict the decision behaviour of evacuees that should be better explained.

[Authors]:

Yes, the weighting method is used by authorities to analyze the tradeoff between the shelter expansion cost and the evacuation time. The proposed stochastic-multiobjective model assumes that evacuees have the complete information about shelter capacity status and people would follow authority's evacuation plan. Notice that extra evacuation travel time needs to be estimated if people don't have the complete information about shelter capacity status. The paragraph is modified as

follows.

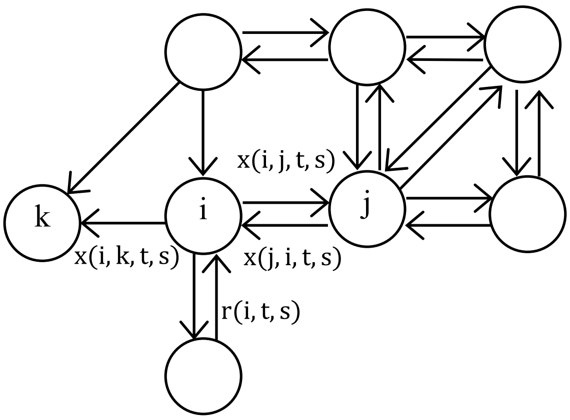
The weighting method is used to analyze the tradeoff between the shelter expansion cost and the evacuation time. The uncertain flooding scenarios, the associate evacuation plans, and tradeoff analysis of multiple objectives are conducted and displayed on the GIS platform. The framework of the Kalman-filter based stochastic-multiobjective network programming analysis of inundation evacuation planning is presented in Fig. 1.

In order to understand the proposed method, it would be helpful to add a Figure where all important elements are present (nodes, arcs. Etc.) with their attributes an letters (i, j, k. etc.), not as a flow chart but as a schematic drawing.

[Authors]:

An example of the transportation network model is presented. Notation is listed as follows.

$r(i,t,s)$	***Stay in node i at time t in scenario s***
$x(i,j,t,s)$	***Transportation from i to j at time t in scenario s***
$x(i,k,t,s)$	***Transportation from i to shelter k at time t in scenario s***



Line 94. "...are conducted and displayed on the GIS..." has the software been developed in a GIS? If so, which programming language, which GIS platform? Is it available on web?

[Authors]:

The results are displayed on a free and open-source platform, Quantum GIS (QGIS). The inundation evacuation plans for uncertain scenarios are plotted in Figs. 5-9. Details are added in the manuscript.

Line 101. What do the authors mean by "...The model also considers uncertain

inundation scenarios"? Flooding scenarios/areas with a very low probability of occurrence. If I understood, the evacuation model does not define the flooding area, that process is conducted by the flood models.
If so, the evacuation model should evacuated the affected areas or whatever zone given as an input data, no matter how uncertain it is. Please, make more clear this question because it is not clear if the authors are referring to the flooding scenario probabilities or the evacuation scenario probabilities.

[Authors]:

First, flooding scenarios are simulated by using the HEC-RAS with uncertain factors. Next, a stochastic-multiobjective evacuation model with two optimization stages is proposed for evacuation investment and routing. In the first stage, decision maker decides expected optimal solution for shelter and transportation capacity expansion under flooding uncertainty. In the second stage, optimal evacuation routing is determined for each inundation scenario. The manuscript is modified as follows.

> ***Incorporating the HEC-RAS model with uncertain factors simulates inundation scenarios, including possible damage to residential areas and transportation networks. The optimization model with two optimization stages is proposed for evacuation investment and routing. In the first stage, authority decides expected optimal solution for shelter and transportation capacity expansion under flooding uncertainty. In the second stage, optimal evacuation routing is determined for each inundation scenario. The notation s and $P(s)$ represent a stochastic scenario and its corresponding probability for uncertainty analysis.***

Line 100. Why are the arcs bidirectional?

[Authors]:

This research assumes roads of transportation network are bidirectional. Then our proposed optimization model determines the optimal evacuation direction for each road. To make it clear, the paragraphs is modified as follows.

> ***In this paper, i and j indicate transportation network nodes, and k represents shelter nodes. Arcs represent transportation roads connecting two nodes; each road has its own transportation capacity. The roads can be traveled both directions so arcs of transportation network are assumed to be bidirectional. The optimal evacuation direction of each arc is determined by the optimization model.***

Line 103. "...decisions for shelter and transportation capacity..." Who make the decision to expand shelters and roads capacity?, and why?. This is an strategy and it should be linked with a more global emergency plan.

[Authors]:

The stochastic-multiobjective model includes two optimization stages. In the first stage, the authority (local government) decides investment of shelter and transportation capacity. The optimal evacuation plan is determined in the second stage. The paragraph is modified.

> ***The optimization model with two optimization stages is proposed for evacuation investment and routing. In the first stage, authority decides expected optimal solution for shelter and transportation capacity expansion under flooding uncertainty. In the second stage, optimal evacuation routing is determined for each inundation scenario.***

Line 105. "...Following the occurrence of uncertain flooding events" Does it mean that the methodology is only useful for such uncertain flooding events and it cannot be applied for the most common flooding events.

[Authors]:

This research deals with inundation evacuation under uncertainty. However, the framework is still valid for common scenarios without uncertainty. For deterministic flooding event, the optimal evacuation can be solved by inputting one inundation scenario in the model. The paragraph is modified as follows.

> ***The notation s and $P(s)$ represent a stochastic scenario and its corresponding probability for uncertainty analysis. The model can still be applied for deterministic evacuation planning by inputting one deterministic flooding scenario in the model.***

Line 109. "...optimal evacuation plan..." I would say evacuation strategy, and apparently for one threatened area. Are the best routes chosen or just the available routes?

[Authors]:

The sentence is modified as follows.

> ***Eq. (1) determines the optimal facility investment and evacuation routes for each flooding scenario.***

Line 118. "...At the initial time..." What does initial time mean here? Did the authors consider the response time, the warning time, etc.? When the evacuation order was given? Or the evacuation proses starts when everybody is ready. In such a case, the final result of the model should represent the travel time, not the evacuation time.

[Authors]:

The total evacuation time of this research considers authority decision time (DT), notification time (NT), reaction time of the community (RT), and evacuation transportation time (ET). The initial time means the beginning of evacuation transportation time (ET). The sentences are modified.

Line 120. "...demands that all evacuees must end up in a shelter..." Why must all evacuees end up in a shelter? In real evacuations it is very common that people evacuate with their relatives or in other places, outside the dangerous area, which means they could follow different routes. If all evacuees must reach a shelter, the authors should explain why (see comments above related with the description of the evacuation scenario).

[Authors]:

The model assumes all evacuees must end up in a shelter or some places outside the dangerous area. The manuscript is modified.

> ***Eq. (8) demands that all evacuees must end up in a shelter or some places outside the dangerous area;*** $\boldsymbol{k}$ ***is defined as nodes of shelters or other safe places,*** $\boldsymbol{k=1,\dots K}$.
>
> $$\sum_t \sum_{k,i\in nb(k)} x(i,k,t,s) = \sum_i^n IN(i,s) \qquad \forall k,s \qquad (8)$$

3. Results and discussion

Line 168. "...is applied to simulate uncertain inundation scenarios..." Probably I do not understand well, but why are the results of the uncertain inundation scenarios compared to the normal behaviour of the river during a flood? Are they specific or common flooding scenarios? Were the flooding areas assessed using only flood models or they also include real scenarios based on past events?

[Authors]:

The flooding scenarios are simulated by HEC-RAS model under uncertainty of upstream flow, downstream water level, and channel roughness coefficient. The simulated water stages of the Jingmei River are compared with the levee to determine potential inundation locations. The paragraph is modified as follows.

> ***In this study, the HEC-RAS hydraulic model is applied to simulate uncertain inundation scenarios of the Jingmei River. The cross section geometry and characteristics of Jingmei River are obtained from Taiwanese Water Resources Agency. The accuracy of the HEC-RAS model's representation of the real system has been validated. The validation shows that water inflow of 1554 cms, water level of 12.81 m, and manning's roughness coefficient of 0.025 yields accurate water level simulation of***

Jingmei River.

The HEC-RAS hydraulic model is used to simulate uncertain water stage of the Jingmei River in Muzha. Uncertain upstream flow (0%, ±7%, ±14%), downstream water level (0%, ±6%, ±12%), and channel roughness coefficient (ranging from 0.013 to 0.045 by interval of 0.002) are considered in the model. Fig. 3 plots uncertain simulation of water stage of the Jingmei River. In this study, potential inundation overflow locations are determined by comparing the water stage and levee height.

Line 173. "...The transportation network system of Muzha is plotted.." Does the evacuation model address the total transportation network or just the main roads? That should be explained in the methodology and highlighted here.

[Authors]:

The proposed evacuation model considers the total transportation roads. The details are explained and the paragraph is modified as follows.

The transportation network system of Muzha is plotted in Fig. 2. The transportation network considers all transportation roads. There are 1079 arcs and 774 nodes for the network. All of the arcs are bidirectional in the traffic network. Shelters accommodate people and save evacuees from danger. Most of the shelters in Muzha are schools or regional activity centers, because these places often incorporate an auditorium and they are convenient locations for delivering to. According to the Disaster Prevention and Protection Organization of Taiwan, there are 17 shelters in the study site with various capacities. The capacities range from 10 to 300 people, and the total of 1277 residents in this area can be accommodated. Shelter locations and capacities are represented by grey circles in Fig. 2.

Line 175. About shelters, are they known by people at risk? Have they been included in an evacuation plan? Do people know the shelter they should go or is it a free choice? Please, be more specific in the description of the evacuation model you are trying to simulate an how this kind of emergencies are managed in Muzha.

[Authors]:

The proposed stochastic-multiobjective model optimizes evacuation investment and routing. This research assumes that evacuees have the complete information about shelter capacity status and people would follow authority's evacuation plan. The paragraphs are modified as follows.

The evacuation procedures including authority decision, announcement, community reaction, and evacuation. The research

develops a framework to analyze evacuation plans for deterministic and uncertain flooding events; then optimal evacuation plan for community is presented. This research assumes that evacuees have the complete information about shelter capacity status and people would follow authority's evacuation plan.

The optimization model with two optimization stages is proposed for evacuation investment and routing. In the first stage, authority decides expected optimal solution for shelter and transportation capacity expansion under flooding uncertainty. In the second stage, optimal evacuation routing is determined for each inundation scenario.

Line 178. "...Shelter locations and capacities..." Is the maximum capacity shown? Is the capacity included in the management of the global emergency plan as a key factor?

[Authors]:

The capacity information of shelters is displayed. The capacity management is included in the global emergency evacuation plan.

Table 1. Location and capacity of shelters in Muzha.

Shelter	Address	Capacity (people)
Zhongshun Temple	No. 13, Zhonglun Rd., Muzha	10
Muzha District Activity Center	No. 3, Ln. 13, Baoyi Rd., Muzha	37
Muxin District Activity Center	No. 4, Ln. 310, Sec. 3, Muxin Rd., Muzha	34
Youngjian District Activity Center	No. 177, Sec. 1, Muzha Rd., Muzha	38
Auditorium, Administration Center	No. 220, Sec. 3, Muzha Rd., Muzha	60
Zhongshun District Activity Center	No. 22, Sec. 2, Zhongshun St., Muzha	19
Shihjian District Activity Center	No. 290-1, Sec. 1, Muzha Rd., Muzha	20
Zhangxin District Activity Center	No. 22, Yishou St., Muzha	87
Lixing Junior High	No. 7, Ln. 155, Sec. 3, Muxin Rd., Muzha	30
Muzha Elementary School	No. 191, Sec. 3, Muzha Rd., Muzha	155

Muzha Junior High	**No. 12, Ln. 102, Sec. 3, Muzha Rd., Muzha**	**30**
Youngjian Elementary School	**No. 2, Shiyuan Rd., Muzha**	**30**
Mindaw Elementary School	**No. 61, Ln. 138, Sec. 2, Muzha Rd., Muzha**	**42**
Jingmei Girls High School	**No. 312, Sec. 3, Muxin Rd., Muzha**	**300**
Shihjian Elementary School	**No. 4, Sec. 1, Zhongshun St., Muzha**	**75**
Shihjian Junior High	**No. 67, Sec. 7, Xinhai Rd., Muzha**	**300**
Zhangjiao District Activity Center	**No. 45, Hengguang St., Muzha**	**10**

Fig. 4. Please add an arrow to show the flow direction of the river.

[Authors]:

Flow direction of the river is added in the figure as follows.

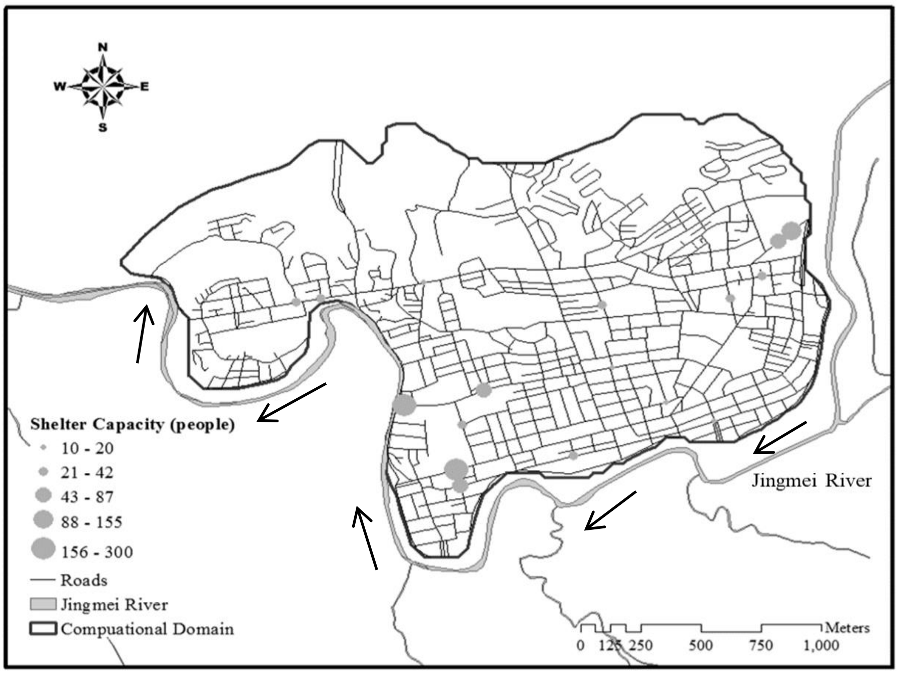


Figure 3. Shelter and transportation network system of Muzha.

Line 184. "...Based on the HEC-RAS simulation of 425 times..." Given the same water level and levee heights, how the HEC-RAS compute the variation in the results?

[Authors]:

Uncertain factors of upstream flow (0%, ±7%, ±14%), downstream water level (0%, ±6%, ±12%), and channel roughness coefficient (ranging from 0.013 to 0.045 by interval of 0.002) are simulated by the HEC-RAS model. The total simulation time is 425 (=5*5*17) time. Details of uncertain simulation are explained in the updated

manuscript.

> ***The HEC-RAS hydraulic model is used to simulate uncertain water stage of the Jingmei River in Muzha. Uncertain upstream flow (0%, ±7%, ±14%), downstream water level (0%, ±6%, ±12%), and channel roughness coefficient (ranging from 0.013 to 0.045 by interval of 0.002) are considered in the model. Fig. 3 plots uncertain simulation of water stage of the Jingmei River. In this study, potential inundation overflow locations are determined by comparing the water stage and levee height. Then areas within a 200-meter radius around potential overflow sites are regarded as evacuation zones. Accordingly, Fig. 4 displays the three cases of overflow location and inundation evacuation areas including three cases of Xinhai Road Sec 7, Hengkung Bridge, and Daonan Bridge in Muzha. The probability of each inundation scenario depends on the number of simulation for which the potential water stage exceeds the levee height. Based on the HEC-RAS simulation at each location, the probabilities for three inundation areas (Xinhai Road Sec 7, Hengkung Bridge, and Daonan Bridge) are 0.43, 0.15, and 0.42, respectively.***

Line 186. Why are there shelters located in the evacuation area? Is there any problem with the local authorities in the design of the emergency strategies? Are this shelters considered by the evacuation model as sink nodes?

[Authors]:

The manuscript is modified. People are evacuated to shelter located closed to the inundation area. Shelters located in the flooding area is not available for evacuation.

> ***This case study assumes that people living on the first floor needs to be evacuated; the rest of people living on upper floors are not evacuated due to shelter capacity. The proposed stochastic-multiobjective model can further develop complete evacuation plans for all of people in threatened area by assuming whole area as evacuation places.***

Lines 188. Why people living on higher floors do not need to be evacuated? Is it a question related with the capacity of the evacuation model or an evacuation plan design? Please, explain this important question, because people do not use to do what it is expected during an emergency situation (more people travelling could cause traffic jams) and an evacuation simulation never should be done for crisis management considering just part of the people living in a threatened area.

[Authors]:

We agreed that people do not follow what they are expected to do during an emergency situation. Our current case study calculates average number of people living on lower floors and only evacuates people on lower floors. The proposed stochastic-multiobjective model can further develop complete evacuation plans for all of people in threatened area by assuming whole area as evacuation places. The paragraph is modified as follows.

> ***The probability of each inundation scenario depends on the number of simulation for which the potential water stage exceeds the levee height. Based on the HEC-RAS simulation at each location, the probabilities for three inundation areas (Xinhai Road Sec 7, Hengkung Bridge, and Daonan Bridge) are 0.43, 0.15, and 0.42, respectively. People can be evacuated to six shelters located close to the inundation zones. The evacuation area of Xinhai Road Sec 7 area is 0.315 km^2. Hengkung Bridge area is 0.069 km^2, and Daonan Bridge area is 0.089 km^2. Data of people living on each floor are not available. This case study assumes that people living on the first floor needs to be evacuated; the rest of people living on upper floors are not evacuated due to shelter capacity. The proposed stochastic-multiobjective model can further develop complete evacuation plans for all of people in threatened area by assuming whole area as evacuation places.***

Line 193. "...evacuation times of 55, 12, and 24 minutes??

[Authors]:

Thank you. The sentence is corrected.

Line 194. "… Shihjian Activity Center is the only shelter that is required to be expanded..." that assuming that no one living above the first floor will make the decision to evacuate.

[Authors]:

People living on lower floors and people living on upper floors are calculated as follows. The paragraph is modified accordingly.

> ***People can be evacuated to six shelters located close to the inundation zones. The evacuation area of Xinhai Road Sec 7 area is 0.315 km^2. Hengkung Bridge area is 0.069 km^2, and Daonan Bridge area is 0.089 km^2.*** **Data of people living on each floor are not available. This research assumes the buildings have five floors on average. Then 1/5 of people living on the first floor needs to be evacuated; the rest of people living on upper floors are not evacuated.**
>
> ***The results show that the Shihjian Activity Center is the only shelter***

that is required to be expanded. Xinhai Road Sec 7 flooding scenario dominates the Shihjian Activity Center expansion, because the scenario involves the largest probability of occurrence, the largest inundation area, and the highest number of people to be evacuated. Since the flooding evacuation area of this scenario contains the highest number of residents, the western area of Muzha is the potential critical zone for evacuation. For comparison, the shelter expansion and evacuation planning for the inundation scenarios in Xinhai Road Sec 7, Hengkung Bridge, and Daonan Bridge areas are plotted in Figs. 5-7.

Line 219. "...further to shelters..." here, do the authors mean that people have to travel far away to find shelters because the closer ones were not expanded and they are full?.

[Authors]:

The sentence means that people need to travel far away to find shelters while the capacity of closer shelter is not sufficient. The sentence is not clear; the paragraph is modified as follows.

Case 2 puts higher weighting to expansion cost, and evacuation time would receive less weighting. Hence, in Case 2, evacuees for Daonan Bridge need to travel far away to find shelters while the capacity of closer shelter is not sufficient.

4. Conclusions

Line 239. "...Evacuation planning is analyzed for various disasters..." Analyzed or used?

[Authors]:

The sentence is corrected as follows.

This study analyzes stochastic inundation evacuation planning used for flooding events.

Line 240. "... inundation evacuation under uncertainty..." Again, does it means the framework developed is not valid for more common scenarios whit less uncertainty.

[Authors]:

The framework developed in this research deals with inundation evacuation under uncertainty. However, the framework is still valid for common scenarios with less uncertainty. More specifically, inundation evacuation without uncertainty can be solved by inputting one flooding scenario in the model. The paragraph is modified as follows.

This study analyzes stochastic inundation evacuation planning used for flooding events. The KASMNO model was newly established for iterative prediction, measurement, update, and optimization of stochastic inundation simulation and evacuation.

The proposed framework can still be applied for deterministic evacuation planning by inputting one deterministic flooding scenario in the model.

Line 245. "...and evacuation planning have been presented on the GIS platform...". If the presentation on the GIS is oriented to decision makers, all figures should keep the hazard areas (authors should not delete the hazard limits just to show the results of the evacuation model). Decision makers need to understand the global process and where are located the threatened areas (all of them).

[Authors]:

Decision makers indeed need to know the global process and location the threatened areas. We modified Figs. 2-9 to present complete flooding scenarios, shelter expansion, and evacuation routing.