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The impact of electrical hazards from overhead power lines on urban search and rescue operations during extreme flood events

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ABSTRACT

Accurate flood forecasting and efficient emergency response operations are vital, especially in the case of urban flash floods. The dense distribution of power lines in urban areas significantly impacts search and rescue operations during extreme flood events. However, no existing emergency response frameworks have incorporated the impacts of overhead power lines on lifeboat rescue operations. This study aims to determine the necessity and feasibility of incorporating overhead power line information into an emergency response framework using Manville, New Jersey during Hurricane Ida as a test bed. We propose an integrated framework, which includes a building-scale flood model, urban point cloud data, a human vulnerability model, and network analysis, to simulate rescue operation feasibility during Hurricane Ida. Results reveal that during the most severe point of the flood event, 46% of impacted buildings became nonrescuable due to complete isolation from the road network, and a significant 67.7% of the municipality's areas that became dangerous for pedestrians also became inaccessible to rescue boats due to overhead power line obstruction. Additionally, we identify a continuous 10-hour period during which an average of 43.4% of the 991 impacted buildings faced complete isolation. For these structures, early evacuation emerges as the sole means to prevent isolation. This research highlights the pressing need to consider overhead power lines in emergency response planning to ensure more effective and targeted flood resilience measures for urban areas facing increasingly frequent extreme precipitation events.

1. Introduction

The frequency and intensity of extreme precipitation events are rising across the world due to climate change. The risk of catastrophic flooding induced by these extreme precipitation events is a grave concern for places like the northeastern United States due to their dense population. During extreme precipitation-induced riverine or flash flooding, available emergency response time is limited, typically from just 3 to 6 h, and the response must be highly localized, strongly depending on micro-topography and drainage patterns.[1,2]. Typically, flash flooding leads to hazards associated with delayed or inappropriate self-evacuation actions due to under-estimation of shallow yet speedy water flow [3,4]. In riverine flood scenarios, water usually flows more slowly when compared to storm surge-induced flooding. Thus, the main risks arise from extended isolation and non-rescuability due to high water levels, which can result in a lack of access to emergency services. These factors underscore the importance of providing accurate and high-resolution flood forecasting information to support flood preparedness and emergency response.

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Implementations of effective emergency management can significantly reduce and in some cases prevent flood-related damages [5–8]. In the United States, there has been substantial research on emergency evacuation and rescue strategies before and during severe flood events. When considering pedestrian evacuation, previous studies highlight the importance of accounting for landscape features outside the road network [9] as well as identifying regions that become hazardous for walking [10,11]. Abenayake et al. (2022) [12] suggested a method to simulate traffic disruption during urban flooding, a crucial factor in phased evacuation planning to prevent traffic jams. Studies on rescue operations, a critical component of flood emergency response [13], demonstrate the effectiveness of rapid flood mapping techniques [14,15], the incorporation of unmanned aerial vehicles into the rescue procedure [16–18], and the optimization of current best practices and procedures [19,20].

In addition to the need for detailed, relevant evacuation and rescue plans for effective flood emergency management, previous research highlights the importance of functional early warning systems [21,22]. Pre-storm or pre-flood evacuation plans have grown more complete over the years. However, their effectiveness is challenged once a storm strikes the region. Past historical events such as Hurricane Katrina challenged pre-flood evacuation plans in that entire regions and pre-designed evacuation routes became submerged, especially after the failures of levees and flood walls [23,24]. This demonstrates how evacuation and rescue plans lose their utility without obtaining and disseminating detailed, high-precision flood information provided by urban-scale flood models.

To truly ensure effective rescue operations, the consideration of urban features, such as power lines, is also critical [25]. Power lines are common and densely distributed in built environments, typically positioned 3.05 m to 4.88 m above the ground over streets and driveways [26]. For safety considerations, the minimum clearance distance of the lowest power lines/communication lines is prescribed by the National Electrical Code (NEC) and the National Electrical Safety Code (NESC) [27]. To keep the public safe and prevent contact with electrical currents, the minimum clearance distance for the lowest overhead power lines/communication lines ranges from 2.9 m to 3.5 m above the ground and 4.0 m above the water surface [28–30]. In the present manuscript, the term ‘overhead power lines’ will be used to refer to both the lowest power lines and communication lines. Overhead power line detection [31–33] and extraction capabilities [34,35] have matured in recent years, and are now utilized in fire risk mitigation [36] and in power line maintenance [37] and inspection [38,39]. Several studies have highlighted potential risks posed by power lines during natural disasters, such as wind gusts, tornadoes, hurricanes, and floods [40–42]. However, overhead power line impacts on rescue operations during natural disasters, especially extreme floods, have received limited attention in the literature.

In rescue operations requiring the use of lifeboats, the high surface waters limit the available space between the water surface and overhead power lines, posing the threat of electrical shocks to emergency response workers and potentially obstructing planned rescue routes. Failure to consider this electrical hazard during search and rescue planning will significantly increase the risk of electrical shocks to search and rescue workers [43]. In light of the escalating demands on rescue operations, it becomes crucial to comprehend and address the impact of overhead power lines on rescue efforts in built environments during flooding scenarios. Ignoring the constraints of overhead power lines on search and rescue operations will lead to incorrect assumptions about the availability of emergency services, particularly rescue services, and increase the risk of loss of human life during extreme flood events. The absence of a comprehensive approach to account for power line hazards in rescue operations during such flood events represents a notable gap in current research, and it reduces the effectiveness of current emergency response planning approaches.

Building on the earlier discussion, this study seeks to answer two important questions: (1) How can electrical hazards caused by overhead power lines in search and rescue operations during urban flooding events be systematically considered? (2) To what extent do these electrical hazards impact search and rescue planning during urban flood events? It should be clarified that, in the absence of evidence to suggest that power systems are commonly deactivated during emergency rescue operations, this study assumes that the power system will remain operational throughout rescue activities. The present study first develops an analytic framework to model the impacts of electrical hazards from overhead power lines on the safety of search and rescue personnel during flood events. The study further assesses the necessity of incorporating overhead power line locations into an emergency response framework that includes emergency rescue route planning. Additionally, an investigation of potential spatial inequities pertaining to risks of isolation during an extreme flood event is performed through the implementation of this framework. Following this introduction, Section 2 details the development of this framework and its corresponding study scenario. The results of the power line extraction and the impacts of overhead power line locations on rescue operations are discussed in Section 3, followed by a discussion of the significance and potential applications of these results in Section 4. The conclusions put forth in Section 5 provide a summary of the framework’s structure and utility.

2. Methodology

The present study’s proposed emergency response framework accounts for the effects of overhead power line locations on emergency flood evacuations and rescues. This section details the production of this framework followed by a description of the flood scenario from which this framework has been produced.

2.1. Emergency response framework

The proposed emergency response framework integrates a 2-dimensional flood model [44], a human vulnerability model [4], the spatial distribution of overhead power lines, and ESRI’s Network Analysis module. Fig. 1 demonstrates the integration of these four framework components, and the following subsections detail each component.

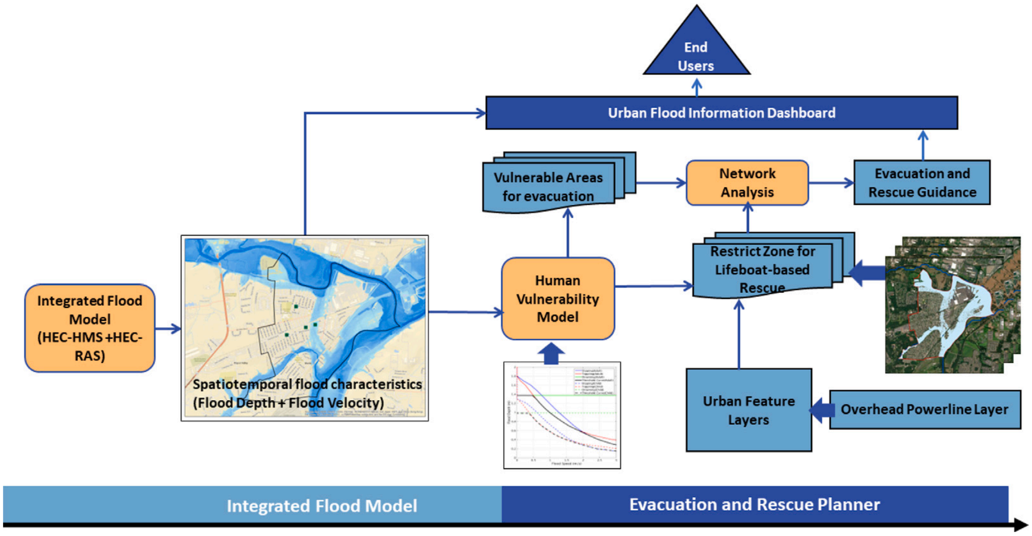

Fig. 1. Proposed Framework for Urban Search and Rescue Operation Planning during Urban Flooding Events.

2.1.1. Flood and human vulnerability models

Flood characteristics, including floodwater depth and floodwater velocities, are provided by an integrated flood model built with HEC-HMS and HEC-RAS [44]. This system provides predictions with a 96-hour lead time, triggered by extreme precipitation forecasts.

The simulated flood characteristics serve as inputs to the human vulnerability model, which outputs the locations of vulnerable areas at each time step. The human vulnerability model accounts for hazards from both water flow and strong winds during hurricane events to identify vulnerable areas for standing pedestrians. The model categorizes flooded areas into four degrees of vulnerability: low, moderate, significant, and extreme, based on three threshold hazard rating (HR) values, 0.3, 0.6, and 1 [4]. The hazard rating, used as a categorization threshold, is determined by evaluating floodwater depth and velocity in both inland and coastal flooding cases, with an additional inclusion of wind velocity in cases of coastal flooding. However, considering that walking through moving floodwater is more hazardous than standing, we treat the original moderate vulnerable areas for standing as significant vulnerable areas for emergency evacuation and rescue operations. Thus, in this framework, any area with a hazard rating value greater than 0.3 is defined as a vulnerable area, and buildings in vulnerable areas are only permitted to be evacuated or rescued via lifeboats.

2.1.2. Network analysis module

To obtain the available walking evacuation and rescue routes during a flood event, we input the identified human vulnerability areas as hourly road network “barriers” represented as polygons. These “barriers” are considered unsafe for walking due to water depths and speeds. Subsequently, we use ESRI’s Closest Facility Analysis tool to determine the hourly shortest routes from each building that experienced at least 0.3 m of flooding at any time during the event (henceforth referred to as impacted buildings) to the municipality’s designated evacuation and/or rescue locations. The rescue resources identified in this framework include the municipality’s evacuation point and fire stations, as these are the locations from which rescue lifeboats are available. The Closest Facility Analysis tool snaps each building location to the closest road network location within a 60 m radius. Throughout the flood event, some families keep accessible and shorter evacuation/rescue routes, while others face elongated routes or periods with no viable routes.

The goal of the network analysis module is to find the evacuation and/or rescue routes for each hour of the flood event that are accessible by walking, driving, and/or lifeboats. In the rescue scenario, the only sections of the road network that are deemed inaccessible by any means are the inundated roads in which the clearance distance of overhead power lines is less than 3.05 m due to safety considerations for first responders on rescue boats [28]. We consider the clearance distances (Fig. 2) in the module based on Eq. (1) .

$$D_{clearance} = Elev_{pl} - (Elev_{ws} + d) + x \tag{1}$$

$$x = L_s - D_b \tag{2}$$

Where $D_{clearance}$ is the calculated clearance distance, $Elev_{pl}$ and $Elev_{ws}$ are the NAVD88 elevations of the power lines and water surface, respectively. d is the sitting height for people on the lifeboat and x is the difference between the height of the seating bench L_s and the boat draft D_b, as shown in Eq. (2). In this study, we assume x equals 0. We consider the 95th percentile sitting height of adult males, denoted as d in Eq. (1). An anthropocentric survey of army personnel [45] proposed a value of 0.97 m for the 95th percentile sitting height for adult males. More recent studies and data sets also provide a sitting height for 20-year-old males ranging

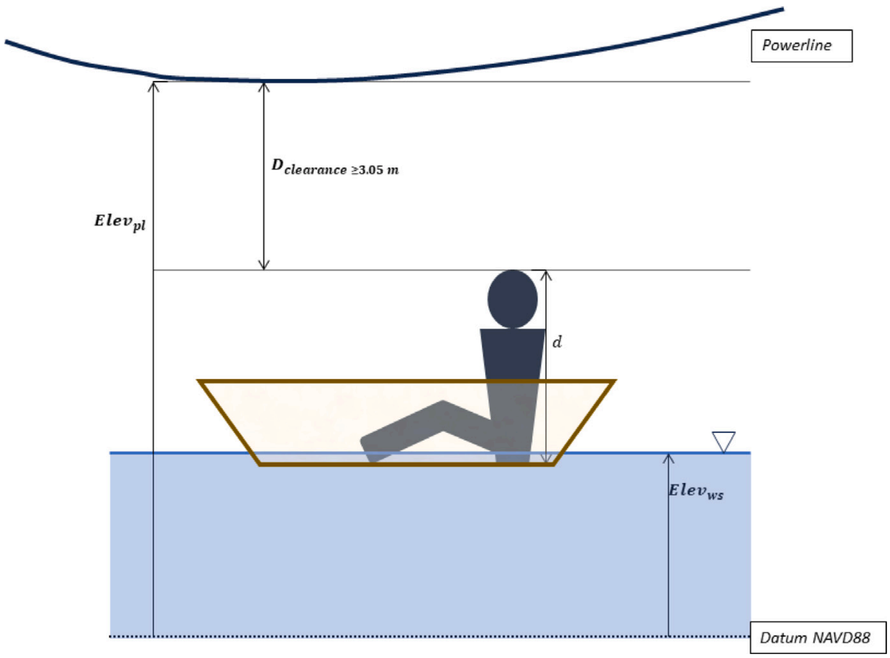

Fig. 2. A diagram illustrating the Clearance Distance threshold highlighting the Sitting Height d, Clearance Distance $D_{clearance}$, Elevation of Power Lines $Elev_{pl}$, and Water Surface Elevation $Elev_{ws}$.

from 0.86 m to 0.97 m [46]. For safety considerations, we adopt a higher value, 0.97 m, as the sitting height d for the construction of network barriers. Given the sitting height, the required clearance distance from overhead power lines/communication lines in this study is 4.02 m, matching the minimum clearance distance above the water surface required by NESC [29,30].

In the present study, the usage of the Network Analysis Module focuses on rescue operations. The evacuation analysis has been reported in a previous study [47] and will only be discussed in terms of comparison and analysis.

2.1.3. Overhead power line extraction

We digitize overhead power lines into 3D polylines using a citywide point cloud data set collected in Manville, New Jersey prior to Hurricane Ida in 2021. The collected data contains a wealth of valuable information for assessing risks and enhancing resilience in urban environments during natural disasters. In addition to making power line extraction feasible, this data set enables the detection and extraction of various critical details such as first-floor elevations, building diagrams, and the distribution of trees.

Two software products, VRMesh V11.8.1, which specializes in point cloud and mesh processing, and ArcGIS 10.8.1, were used to digitize the power lines. The aim of extracting the power lines from the point cloud data set is to determine the locations of the power lines closest to the ground among a cluster of power lines. The elevation and location information associated with the overhead power lines are extracted and exported as raster layers and polyline features respectively, using a semi-automated procedure available in VRMesh V11.8.1. Some extracted overhead power lines are spatially discontinuous due to vegetation occlusion. To solve this issue, ArcGIS is employed for spatial interpolation. Initially, the exported polylines are converted to polygons with a 3.05 m buffer distance. Then, the overhead power line raster layers are converted to points for spatial interpolation, utilizing the buffered polygons as barriers. Fig. 3 shows a typical diagram of the point cloud data set and the extracted power lines used in this study. Fig. 3c shows an example portion of the final extracted overhead powerline points, with two example points corresponding to the those highlighted in Fig. 3b.

2.2. Study scenario: Manville, NJ during Hurricane Ida

On August 29th, 2021, Hurricane Ida made landfall in Louisiana as an "extremely dangerous" category 4 storm, boasting sustained winds of 150 mph. Although it later weakened into a tropical storm, Ida's impact was still felt in the greater New York metropolitan area on the night of September 1st, 2021, resulting in heavy rainfall, numerous flash flood warnings, and various emergencies. Manville Township in New Jersey, situated at the confluence of the Raritan River main stem and Millstone River tributary (Fig. 4), has a history of facing flood hazards induced by heavy precipitation during extreme weather events. Manville was one of the hardest-hit areas during Hurricane Ida due to the severe riverine flooding. During the storm, the nearby Raritan River reached a record-breaking water level of 8.43 m, surpassing the previous record set during Hurricane Floyd in 1999. The widespread flash flooding during Hurricane Ida caused significant disruptions, rendering roads impassable and resulting in substantial delays in

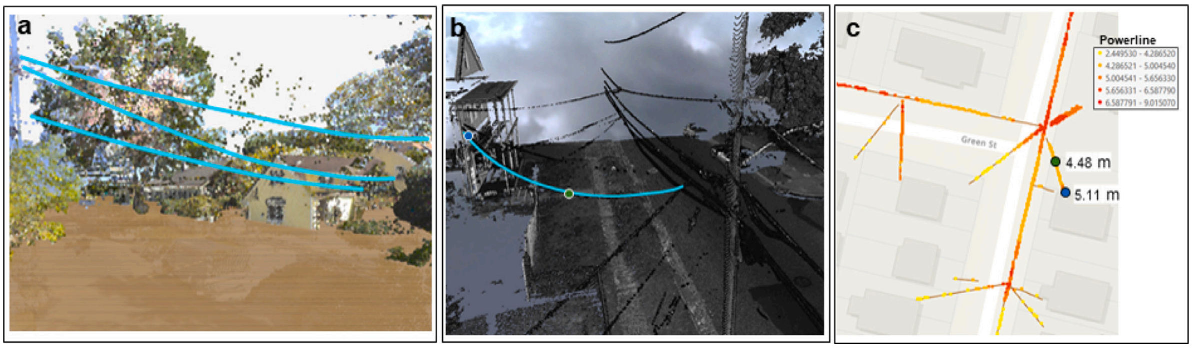

Fig. 3. A typical diagram showing (a) the collected point cloud data set with power lines highlighted in light-blue; (b) the detected overhead power lines in the point cloud data with an example line highlighted in light-blue and two example points highlighted in green and blue; and (c) the final extracted overhead powerline layer and the two. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

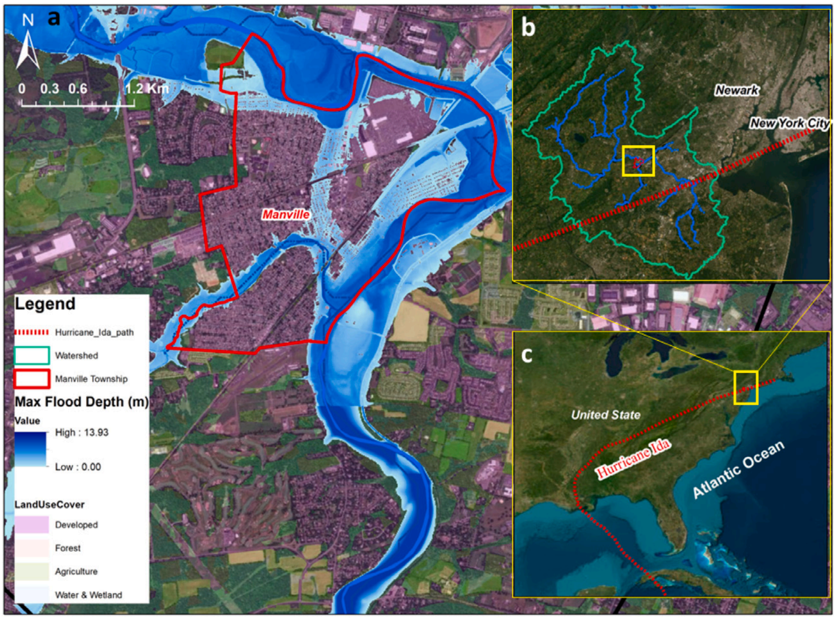

Fig. 4. (a) The simulated maximum flood depth during Hurricane Ida in Manville Township, New Jersey, United States. (b)The Raritan River watershed (green polygon) and the river reaches (blue solid lines). (c) The track of Hurricane Ida (red dashed line) reaching New Jersey in the evening of September 1, 2021. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

search and rescue operations. Three buildings caught on fire and burned completely because the flood water completely inundated the road networks leading to the buildings, and made it impossible for emergency response teams to access the burning buildings.

The vulnerability of Manville's population is a major concern, as 40% of its residents are minors under the age of 18 or seniors over the age of 65 [48]. These demographic groups are particularly at risk during flood events. To mitigate their vulnerability and enhance community resilience, it is essential to develop reliable and accurate flood damage predictions and assessments. Such assessments will build the foundation for identifying effective rebuilding strategies and ensuring a safer and more prepared community in the face of future flood events.

3. Results

3.1. Extracted overhead power lines

In Manville Township, the heights of the overhead power lines above the ground range from 3.85 m to 6.60 m in the 5th to 95th percentile (Fig. 5). More than half of the overhead power lines are higher than 5.26 m above the ground, which is much higher than the minimum requirement of 3.05 m determined by the Institute of Electrical and Electronics Engineers (IEEE). However, our results indicate that overhead power lines still significantly impact lifeboat rescue operations in Manville Township.

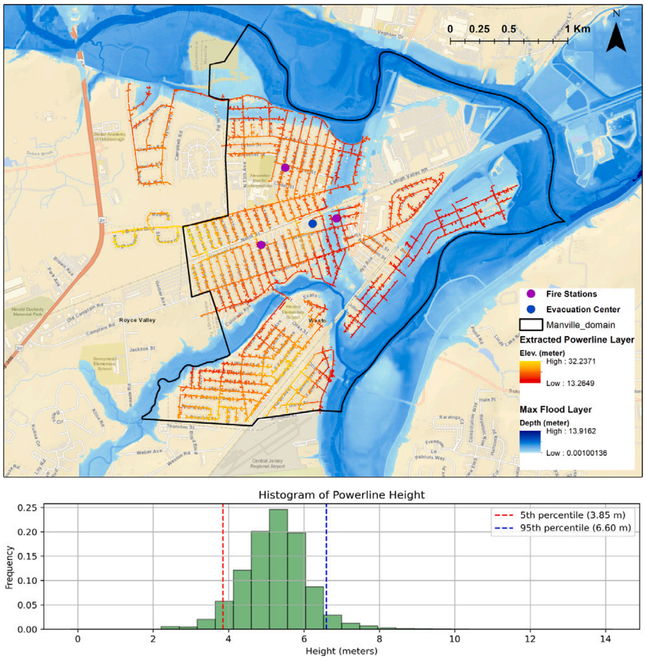

Fig. 5. Overhead power lines throughout Manville Township. Magenta points represent the available rescue resources in the township, including three fire stations and one evacuation point. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.2. Overhead power line impacts on emergency response

In theory, lifeboat rescue is possible for all flooded buildings when the water is deep enough for lifeboat operations. However, the practical reality is that overhead power lines pose significant risks and obstacles. As floodwaters increase in elevation, more overhead power lines become dangerously close to the water surface, leaving insufficient space for lifeboats and first responders to pass through safely and reach specific locations. In this study, we simulate the evacuation and rescue conditions for Manville Township during Hurricane Ida from September 2nd 00:00 to September 3rd 02:00 (Fig. 6a). As the floodwater rises, the number of buildings that are both non-evacuable and non-rescuable increases. On September 2nd at 12:00, the number of non-rescuable buildings reached its peak, with 459 out of 991 impacted buildings (46%) being both non-rescuable and non-evacuable due to the obstruction of the overhead power lines. Additionally, 361 out of the 991 impacted buildings (36%) were non-evacuable but rescuable, leaving only 17% of the impacted buildings accessible for evacuation and rescue. In the most severe hours of the flood event, nearly half of the impacted buildings were non-rescuable, indicating a high potential risk to the community due to the limited emergency service. Moreover, the results illustrate that the high proportion of non-rescuable buildings persisted for 10 h, from September 2nd at 9:00 to September 2nd at 18:00, during which at least 34% of impacted buildings were non-rescuable.

Focusing on the time-varying nature of each non-evacuable building and its rescue conditions (Fig. 6b), the results indicate a notable increase in the number of non-evacuable and non-rescuable buildings approximately 1 h before the peak water level observed in the nearest river gage (September 2nd, at 9:30 am). During this period, the number of non-evacuable homes experienced a substantial rise of 220%. Following this time, an average of 430 buildings remained completely isolated and non-rescuable over a continuous span of 10 h.

The ratio of inaccessible to accessible areas within the study scenario illustrates the pronounced impact of power lines on rescue operations during flooding. During the worst rescue conditions, which occurred at 12:00 pm on September 2nd, a substantial 67.7% of vulnerable areas were inaccessible (Fig. 7a) using lifeboats. This indicates that a considerable number of areas that appear rescuable without considering overhead power lines are rendered non-rescuable after incorporating overhead power line information into rescue route planning. In this study, we also calculate the rescue service interruption duration for all impacted buildings (Fig. 7b). Generally, 50% of the impacted buildings experienced isolation for over 2 h. 5% of impacted buildings faced a loss of rescue services for more than 15 h. The spatial distribution of rescue service interruption duration is also of interest. The southern part of the municipality exhibits a greater number of buildings with extended interruption duration, whereas the northern part experiences a higher density of buildings facing interruptions. Additionally, when comparing the eastern and western parts of the municipality, the eastern part features both a higher count of buildings enduring longer interruptions and a larger number of buildings overall experiencing interruptions. Throughout the simulated 26-hour time frame of this study, the eastern and southern areas of Manville Township exhibited a higher concentration of buildings with extended rescue service interruption duration. Especially among buildings with a rescue interruption duration exceeding 5 h, a substantial 84.7% were located in the eastern part of the township. Likewise, among buildings facing interruption durations surpassing 15 h, a considerable 88.1% were located in the eastern-southeastern region of the municipality.

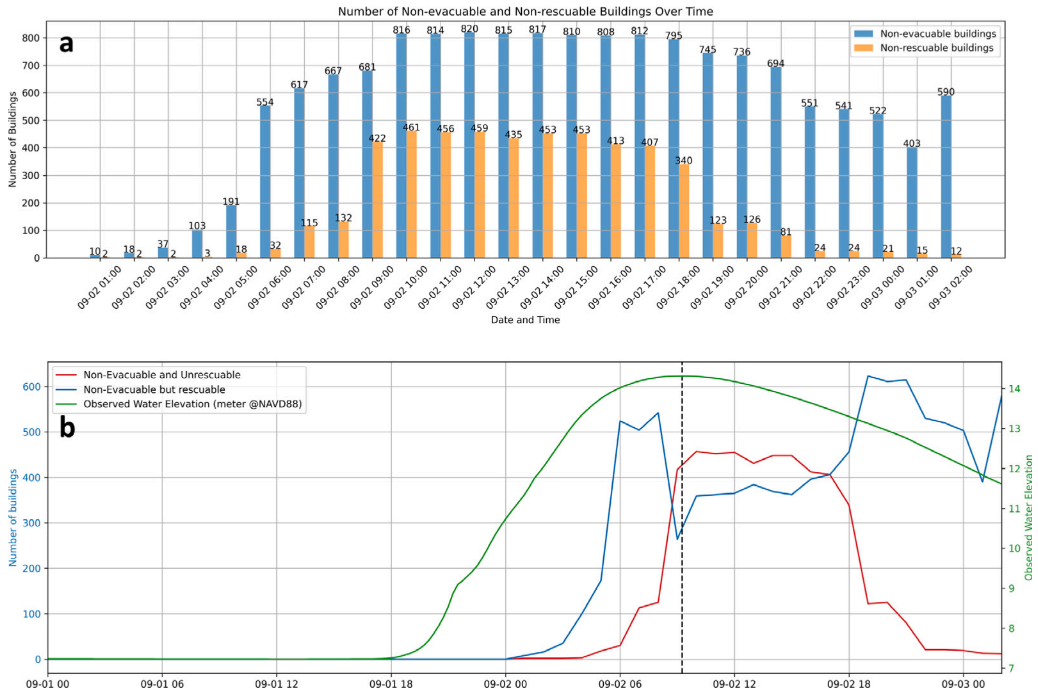

Fig. 6. The time series of (a) the number of non-evacuable buildings and non-rescuable buildings and (b) the summary of rescue conditions for cases of non-evacuation in Manville Township, NJ during Hurricane Ida, from September 2nd to September 3rd. The black dashed vertical reference line indicates the peak time of observed water elevation of the nearest river gauge at 9:30 am on September 2nd.

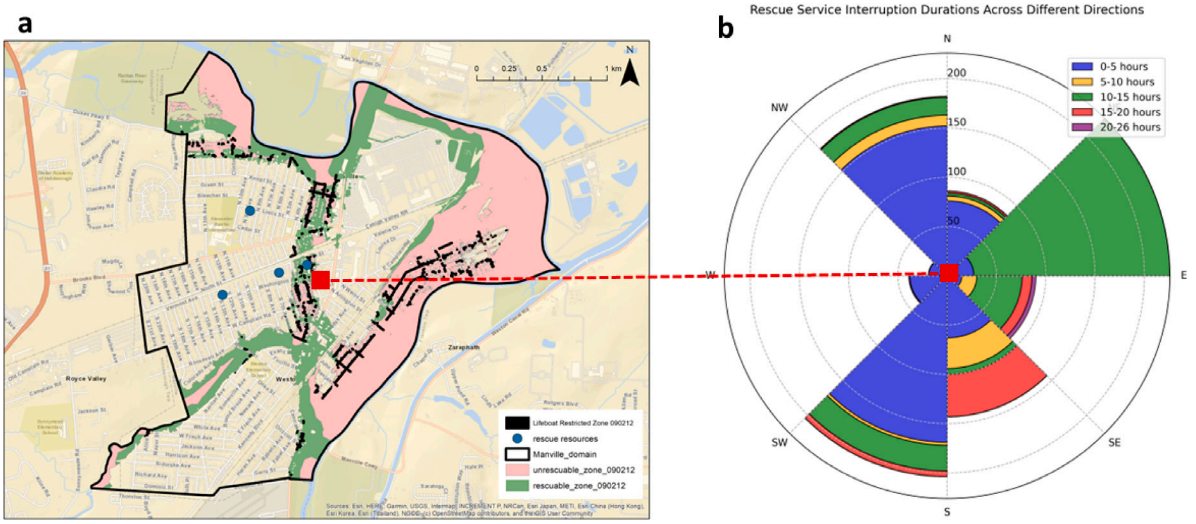

Fig. 7. (a) The inaccessible area and accessible area under the worst rescue condition (September 2nd 12:00 pm), the black areas represent the restricted zone for lifeboats due to overhead power lines. (b) the overview of rescue services interruption duration around Manville Township. The highlighted red square in both sub-figures indicates the central location used for analysis. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4. Discussion

Overhead power lines are critical but often disregarded urban features in the built environment in terms of emergency response and associated planning during flood events. For first responders lacking guidance or corresponding flood information support, recognizing the feasibility of safely navigating through overhead power lines is challenging unless in close proximity. The absence of this information can significantly hamper rescue operations and exacerbate the vulnerability of first responders and those requiring rescue. Historically, the effect of overhead power lines on emergency rescue operations has been overlooked due to computational limitations hindering the production of high-resolution flood information and 3-dimensional power line extraction. However, the scenario has shifted in recent years due to the advancements in computational capabilities and the increasing demands of early warning systems for inland flooding induced by greater frequency and intensity of extreme precipitation events under climate change in specific regions. A flood early warning system coupled with an operational building-scaled flood model with overhead power lines information will provide effective guidance for emergency response planners.

Aside from providing navigational guidance for first responders during rescue operations, another objective of a flood early warning system is to bolster the community's flood resilience. An effective early warning system would aid in identifying buildings that could lose access to rescue services prior to flood events. Without considering overhead power lines, all inundated buildings are purportedly reachable by lifeboats provided the water depth satisfies navigational requisites. However, the presence of the overhead power line networks in the built environment, coupled with safety-mandated clearance distances, renders a significant number of buildings inaccessible to lifeboat rescue operations. For those buildings without rescue services, early evacuation would be the only solution to avert isolation. The proposed early warning system possesses the capability to identify the buildings necessitating early evacuation. Furthermore, it facilitates the emergency response team in disseminating targeted evacuation alerts before events, thereby elevating the community's flood resilience. Also, the simulation of historical events by this flood warning system exposes vulnerable sub-communities that were at risk of flooding but with limited rescue accessibility. The Manville Township case study during Hurricane Ida illustrates that the eastern and southern parts of the municipality, particularly in the northeastern to the southern direction of the township, experience prolonged rescue service interruption durations. Armed with this information, the flood warning system offers substantial contributions to the planning process.

The consideration of flood velocity impacts on the viability of lifeboat navigation has been omitted in the current study. This choice aligns with the specific case under examination, which pertains to a riverine flood event characterized by a relatively gradual spread of flood waters. Throughout this event, the flood velocity remains notably restrained, with 95% of the inundated areas experiencing velocities slower than 0.52 m/s. It is important to emphasize that in scenarios such as flash flooding, characterized by rapid inundation, the incorporation of flood velocity becomes crucial for discussions concerning the feasibility of lifeboat navigation. For instance, delineating the spatial–temporal distribution of flood velocity during the spreading phase aids in identifying the optimal windows for executing rescue operations, based on near-reality flood conditions, rather than relying on experience and conjecture.Taking into account potential obstructions from urban features like trees, fences, or even flooded vehicles near the streets, the current study assumes that lifeboats will have constrained navigation within the existing road networks, utilizing a 60 m search radius. However, it remains a valuable endeavor to explore the possibility of identifying additional passageways for lifeboats beyond the established road network in future investigations. Additionally, this study did not integrate the urban drainage system due to limited access to relevant data. However, given its potential impact on flood duration and subsequent effects on the isolation duration, the drainage system should be considered in future studies. We believe identifying the vulnerability of sub-communities will contribute to flood resilience for communities facing challenges from climate change. This study primarily focuses on the impacts of overhead power lines on rescue operations using lifeboats. We recognize additional safety concerns posed by relatively low overhead power lines even during dry conditions. The concerns related to pedestrian and vehicle safety will be thoroughly investigated in our future studies, to better improve the resilience of communities. Additionally, to assess rescue service accessibility, social vulnerability indices will be integrated to identify vulnerable sub-communities more comprehensively.

5. Conclusion

This study is the first to integrate overhead power line information into the planning of emergency rescue operations during urban flood events. It carefully examines the substantial obstruction effect caused by overhead power lines on lifeboat-based rescue activities, and their impact on the spatial distribution of emergency response resources. Using a case study, we reconstruct the rescue conditions during a riverine flooding event using Manville Township during Hurricane Ida, to discuss the critical role of overhead power lines in rescue operations. To do this, a comprehensive emergency response framework is developed, integrating a 2-dimensional flood model, a physics-based human vulnerability model, the spatial distribution of overhead power lines, and a network analysis module. Applying this emergency response framework to Manville Township, New Jersey during Hurricane Ida vividly underscores the critical role of factoring in the overhead power lines' obstruction in the planning and execution of rescue activities. Results indicate that under the most challenging rescue conditions (September 2nd at 12:00 pm), 46% of impacted buildings are deemed non-rescuable and a substantial 67.7% of the vulnerable areas become inaccessible due to the obstruction of rescue routes by overhead power lines. These findings emphatically illustrate that without accounting for the impact of overhead power lines, rescue efficiency would be greatly compromised, concurrently amplifying the safety concerns for first responders. Furthermore, the township experienced a continuous span of 10 h, during which an average of 43.4% of the 991 impacted buildings encountered complete isolation and remained non-rescuable subsequent to the peak water level observed in the nearest river gauge. For residents of buildings that experience extended durations of inaccessibility, early evacuation emerges as the sole option to avoid the risks associated with isolation. This underscores the critical importance of conveying targeted and comprehensive flood warning messages to these communities. These messages are essential to ensure that residents opt for early evacuation instead of relying on rescue services.

This study also illustrates how the incorporation of overhead power lines in emergency rescue route planning allows for the identification of the most vulnerable sub-communities in terms of extended duration of isolation and non-rescuability. In the study area of Manville, NJ, these vulnerable sub-communities have been identified in high concentration in the northeastern to the southern regions of the municipality. The uneven spatial distribution of rescue resources highlights the need for future initiatives to enhance the flood resilience of these vulnerable sub-communities, taking into consideration the distribution of overhead power lines and the allocation of rescue resources.

CRediT authorship contribution statement

Yifan Wang: Data curation, Formal analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **Holly Josephs:** Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Zhixiong Duan:** Data curation. **Jie Gong:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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