International Journal of Disaster Risk Reduction 123 (2025) 105518

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Land-use analysis using infrastructure representations and high-resolution flood inundation mapping techniques

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ARTICLE INFO

Keywords:
Flood risk management
Land use analysis
Topographic flood models
HAND
GeoFlood

ABSTRACT

In the face of climate change and population growth in coastal regions, land-use analysis efforts are more challenging than ever. Land-use decision-makers in coastal communities are burdened with the difficult choices of where to place new homes versus other assets. While there has been an increased focus on hazard mitigation and disaster resilience in the field of planning, evidence points towards continued development in risk-prone areas including flood zones. Residential development within flood zones specifically continues to be a major issue. To help counter this trend, this study introduces a novel land-use analysis method, coupling topographic flood inundation mapping techniques with digital elevation model (DEM) adaptations. This *Topographic Model Scenario Generation* workflow can be used by planners early in the land-use decision making process and provides an alternative to high-computational hydraulic models. The analysis also includes the identification of strengths and weaknesses of topographic models' recognition of built infrastructure assets, adding to a limited body of knowledge addressing recommended uses of such models. Levees and canals prove particularly functional in this context while detention ponds less so, likely due to a lack of total water mass accountability. Finally, we provide a functional demonstration in Southeast Texas to illustrate the workflow's ability to create multiple infrastructure scenarios and visualize their effects across different flood events.

1. Introduction

Climate change and population relocations combine to create a region of increased risk to natural hazards along coastlines. Due to these increased risks, coastal areas are placing an increased focus on how their land is zoned, developed, and used. Land-use decision-makers in these communities are burdened with the difficult and often seemingly impossible choice of where to place new homes

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https://doi.org/10.1016/j.ijdrr.2025.105518
Received 8 October 2024; Received in revised form 22 April 2025; Accepted 22 April 2025
Available online 23 April 2025

versus other assets. Additionally, the land-use decision space is a crowded arena that includes many stakeholders with frequently conflicting priorities.

Recent studies define as many as eleven factors that influence land-use decisions within a community, including social factors (i.e. political, demographic, and economic) and physical factors (i.e. infrastructure and environment) [1]. The latter are also known as the built environment and natural environment. The built and natural environments closely overlap within coastal zones and can work harmoniously to mitigate risk or fight one another to exacerbate issues. These issues range from 'coastal squeeze' impacts on natural habitats, to the failure of the two environments to protect inhabitants as designed [2]. The term coastal squeeze represents the encroachment of coastal habitats from rising sea levels on one side and the built environment on the other. This squeeze can prevent coastal habitats from surviving and functioning properly, which in turn, can reduce their ability to act as a barrier to the built environment [2]. Further complicating this relationship, unlike in past decades, the natural environment can no longer be treated as stable when designing the built environment, as time scales for built systems are increasing outlasting stable natural systems [3,4]. De-coupling, and retreating from coastal areas is one tempting option to mitigate risk, but many social factors create push-back to those types of solutions [5].

Navigating land-use decisions requires understanding risks—none of which are more important to a coastal community than flooding. Flooding accounts for $5 billion in damages annually in the United States alone and climate scientists and hydrologists agree the severity of floods is expected to increase over the coming decades [6]. Coastal communities are often near rivers and low-relief topography, which when combined with tropical storm events can lead to multiple types of flooding, including fluvial (river floods), pluvial (rain-related flash floods), and coastal (ocean storm surge).

More acutely, flooding risks affect land-use decisions in two primary ways. Firstly, construction resulting from land-use decisions can impact floodplains. Urbanization, for example, often results in large increases in impervious land parcels, causing infrastructure solutions to struggle to direct water away from homes and community assets effectively. This topic of land-use change's effects on floodplains is widely studied (including in our focus area of Southeast Texas) and therefore will not be the primary focus of this research effort [7–10].

Secondly, land-use decisions should prioritize avoidance of new construction within flood zones, to protect the new assets themselves. Although seemingly intuitive, contemporary studies point towards large amounts of development within floodplains in the United States in recent years. A 2024 study of residential properties in North Carolina found that for every home 'bought out' of floodplains to reduce risk, ten homes were constructed within floodplains [11]. A nationwide study showed population growth within 100-year floodplains out-paced population growth outside floodplains from 2000 to 2016, continuing a trend present in the previous decade [12]. This already astounding amount of development within known-risk areas does not take into account new climate projections, which predict an increase in the size of floodplains, adding even more residents to higher-risk zones. This trend is not unique to the United States, as multiple studies point toward development in known-flood risk areas around the globe ([13–16]).

Previous research explored the planning efforts aimed at reversing these trends. Shi et al. surveyed 156 US cities in 2015 and found that sixty percent of responding cities had plans for climate adaptation, but fewer than ten percent had begun any implementation of those plans [17]. In 2016, Butler et al. completed a study of 17 coastal communities in Florida and showed that rather than taking major mitigation actions, most are taking a 'low-regrets' approach to adaptation, which was deemed not nearly enough to protect them from expected future events. An example of a low-regrets approach is including adaptation strategies in city plans, but not changing zoning ordinances to require the new plans to be enforceable. However, one key outcome of Butler's study showed communities with the most extensive natural hazard planning efforts often fit into two categories: 1) experienced a recent hazard event or 2) had 'confidence in planning intelligence' [3]. Increasing 'confidence in planning intelligence' may provide planners with what they need to bolster the resilience of their communities, rather than waiting for a disastrous event to motivate resilient planning after the fact. To better understand how to increase a planner's ability to provide confidence in planning intelligence, a review of the tools planners rely on to do their work is beneficial.

When concerned with flood hazards, the simplest and most common tools for planners are flood inundation maps. Basic inundation maps are provided to communities nationwide by the Federal Emergency Management Agency (FEMA) and show 100-year, and 500-year flood risk zones. FEMA's maps are extremely useful but are not immune to issues. One major shortfall is the static nature of the maps, as there is no ability to project the impact of land use change or infrastructure designs onto the existing maps. This is a concern because scenario generation, over static maps, can inform land-use decisions by providing visualizations that assist planners in understanding and communicating risk to stakeholders [3]. These scenarios can also be utilized to inform additional risk-communication techniques including education through art, a recently utilized strategy to impact disaster risk reduction.

Hydraulic flood models serve as another tool and can provide not only an up-to-date version of a static 100-year flood map but depending on the architecture of the model, can also predict and visualize any number of flood events and scenarios [18]. This capability allows planners to predict the impacts of new flood-mitigation infrastructure, future land-use changes, and climate projections, and adjust their community plans accordingly. However, hydraulic models, particularly locally tailored hydraulic models, are out of reach for many communities due to their computational intensity and technical complexity [19].

A third option, which is the focus of this research effort, is using topographic models for land-use planning, specifically when concerned with flood risk mitigation. Topographic flood models use far-less computational intensity compared to hydraulic models and the framework presented in the following sections provides a novel method for using such models to complete flood mitigation scenario generation. Accordingly, this study asks and investigates the following research question:

Are topographic based flood models an effective tool for scenario generation and land-use planning?

Across the United States, and more specifically in coastal communities, residential development persists in flood-prone areas. This issue is often due to poor land-use decision-making, which can, in part, be attributed to a lack of accurate or accessible tools. Therefore, the objective of this research is to improve the outcomes of future land-use decisions by introducing a method of land-use analysis using topography-based flood inundation maps. The next sections will detail recent works related to this topic, present the research approach, and provide a functional demonstration in Southeast Texas to assist with the explanation of methods.

2. Related works

2.1. Land use decision-making tools

The primary tools used by planners in land-use decision-making include geographic information systems (GIS), analytic models, and visualization and communication software systems [20]. GIS specifically provide a critical resource for community planners as 70–80 % of their efforts involve spatial-related data [21]. To use GIS effectively for land use planning, four elements are required: computer hardware, computer software, geographic data, and technical staff [20]. These systems serve a variety of purposes across the planning portfolio but are particularly useful in land-use analysis and decision-making due to their ability to overlay and visualize the built and natural environments within a community.

An increasing present-day motivation for land-use analysis is hazard mitigation, and in coastal areas is often focused on flood mitigation specifically [22]. The most common and widely used GIS tools in flood mitigation planning are flood inundation maps. FEMA creates inundation maps, known as Flood Insurance Rate Maps (FIRMs) that are required to be reviewed by FEMA every five years [23]. However, even with those fairly regular reviews, 10 % of FIRMs are over thirty years old and 77 % are over five years old [24]. Rapid land use change and a shifting climate are testing the accuracy of FIRMs nationwide, compelling many communities to look for additional opportunities to create, update, and analyze their local inundation maps.

2.2. Flood inundation map development

The models used to develop flood inundation maps fall into three primary categories: empirical (or statistical) models, hydraulic (or physical) models, and topographic (or simplified conceptual) models. The practice of developing inundation maps has seen major gains since the 1970s, and yet still requires additional research to improve their accuracy and attainability [25]. In 2017, Teng et al. completed a review of the main methods for flood inundation mapping, concluding each of the three provide merit under the right conditions [26]. Similarly, and more recently, Jafarzadegan et al. completed a detailed review of recent advancements in flood modeling in 2023 and in regards to inundation mapping listed a major challenge as selection of model type. Furthermore, they cited a lack of studies showing the effectiveness of topographic-based methods to predict flood-extent as a reason those types of models are not often used in practice [27]. A broad overview of the capabilities from each of the three model types is included in Table 1, calling attention to the need to investigate whether topographic models can accompany hydraulic models as a valid technique for flood-mitigation infrastructure scenario generation.

2.3. Topographic flood inundation mapping method (GeoFlood)

GeoFlood, first released in 2018, is a terrain analysis workflow and toolset capable of creating high-resolution flood inundation maps at a low computational cost [40]. The GeoFlood workflow retraces the National Hydrography Dataset Medium Resolution (NHD MR) river flowlines and converts National Water Model flowrate forecasts to flood inundation extent and depth on lidar terrain with synthetic rating curves and the Height Above Nearest Drainage (HAND) method [40–43]. We provide a brief overview of the GeoFlood workflow here (Fig. 1). For a complete description of GeoFlood, as well as validation during Hurricane Harvey, see Refs. [40,44–47].

2.4. Using flood inundation maps for infrastructure site selection and design

Planners are charged with guiding the development of their community to a better future, and increasingly a major component of that planning requires a focus on disaster resilience. However, many local mitigation plans fail to direct new community growth

Table 1
Models for flood inundation map development and analysis.

Flood Model Type	Inputs	Relative Computational Expense	Suitable for Infrastructure Scenario Generation	Examples
Empirical/ Statistical	Historical flood observations	Dependent on use	No	Remote sensing imagery [28], Sensor data [29]
Hydraulic/ Physical	Physical equations, multiple input forcings including: DEM, river discharge, precipitation, soil type, land use, etc.	High	Yes	HEC-RAS [30], Flood Modeller Pro [31], LISFLOOD-FP [32], ADCIRC [33], GeoCLAW [34]
Topographic/ Simplified	Simplified equations and physical concepts, multiple input forcings including: DEM, river discharge, precipitation, soil type, land use, etc.	Low	**Unknown**	GeoFlood [35], TOPFIM [36], REFLEX [37], RFSM [38], GFPLAIN [39]

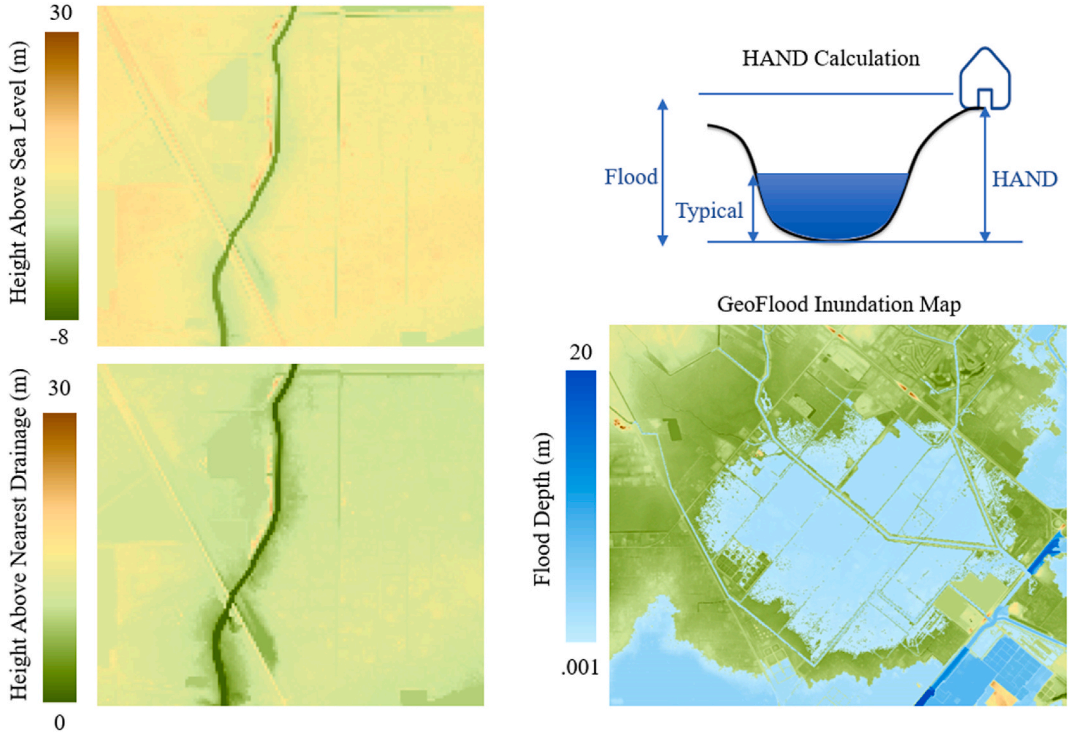

Fig. 1. HAND and GeoFlood. The left side displays a digital elevation model (DEM) above a HAND raster of the same study area. The HAND raster is derived by normalizing the DEM to the river network. The value of a pixel in the HAND raster is calculated as the height of that pixel above the river channel pixel to which it drains. GeoFlood, shown on the right, leverages the HAND method, as well as terrain analysis operations, to efficiently generate high-resolution fluvial flood inundation maps.

towards lower-risk areas or manage redevelopment to reduce future risk. This type of planning, when combined with forces of sea level rise and increased hurricane severity, will increase loss of life and property along coastal areas [48]. To improve the level of flood-resilience included in planning, accessible and accurate flood inundation maps are essential. Although a valuable resource to start with, FEMA's inundation maps have accuracy and currency issues, which has contributed to communities being slow to take on climate adaptive planning [19,49]. We use GeoFlood's workflow in a new way to address this problem, which leads us to the following hypothesis: The combination of terrain analysis-based flood models and targeted changes of high-resolution bare-earth spatial data is a valid way to represent modifications to the built environment and can provide an efficient tool for land-use decision makers concerned with flood mitigation planning.

3. Research approach

First, we completed a preliminary analysis to investigate the strengths and weaknesses of the methods. We choose the region of Southeast Texas due to its known flooding risks and representative nature to the rest of the Gulf Coast. This area is prone to risk from

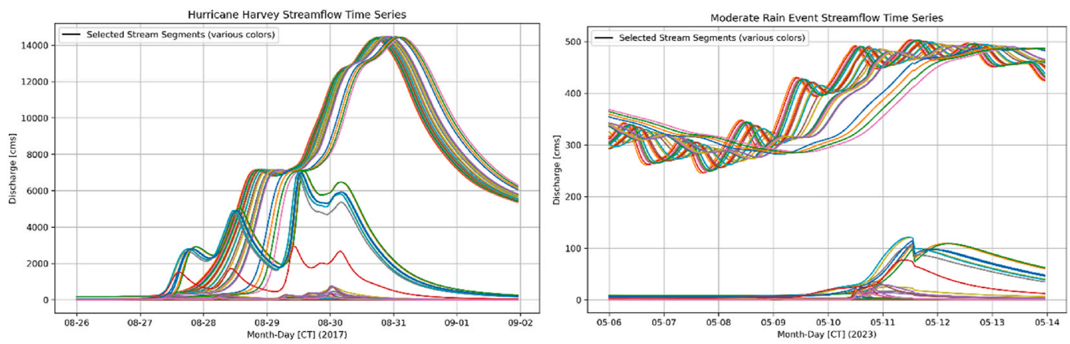

Fig. 2. Streamflow for 87 river segments surrounding Port Arthur, TX during a major and moderate rain event.

hurricanes and its relatively low-slope and low-elevation topographic features increase the risk of large floods. We retrieved streamflow data from 87 NHD MR segments during two past flood events: Hurricane Harvey (Aug. 26-Sep. 1, 2017) and a more recent rain event (May 6–13, 2023) [50–52]. The segments selected run through the catchment areas in and surrounding our area of interest. The catchment area analyzed totaled 382 square kilometers, and the two rain datasets selected represent an extreme event and a moderate event respectively (Fig. 2).

The analysis tested these two flood events across 15 modifications of the built environment. We created terrain modifications by using GIS software to modify pixels of a DEM—the novelty of these methods are these adjustments to the DEM (levees were represented by raising pixel values, canals and detention ponds by lowering pixel values). The specific pixels changed were chosen based on both existing infrastructure systems and proposed locations of new infrastructure systems. The change of each pixel was based on realistic values for infrastructure systems. For example, 20 m levees were not modeled as that is not a realistic height for levees in this study region (i.e., the highest documented levee in the region is 6 m high). We simulated the flood events iteratively over different versions of these built environment modifications to gain an understanding of how the topographic model was (or was not) affected by the infrastructure representations. The resulting inundation maps showed varying levels of impacts from the modifications, and the primary take-aways from the preliminary analysis are listed in Table 2. These take-aways guided the scenario generation development in the functional demonstration section, and should be followed for future uses of these methods.

Following this initial analysis, we constructed an approach to use these methods for presentation and visualization that aims to assist land-use planners in understanding and communicating flooding risks to their communities. The approach we term *Topographic Model Scenario Generation* encompasses four steps: data compilation, built environment validation, built environment modification, and land use analysis (Fig. 3). The following functional demonstration section will assist with clarification of the approach, but a brief overview of each step is included as follows:

Step 1. Data compilation will look slightly different for each planner, based on their community's available datasets. However, this approach purposefully requires minimal data inputs, to ensure usability in communities with a wide variety of resources and existing datasets. The two required inputs are DEMs and flow values for surrounding rivers. In the United States, there are several online resources with downloadable DEMs and the National Water Model provides a large amount of river flow data [50,53]. Outside the United States, streamflow data comes in many forms, many of which are freely available for download [54]. Besides these two required inputs, any additional data will help validate the existing built environment and inform suggested modifications to the built environment. These additional datasets will range widely but some examples include past flood extent information and local community input.

Step 2. Validation of the built environment is necessary to provide planners with confidence in their analysis. As discussed earlier, when planners provide their communities with confidence in planning intelligence, they are better equipped to implement adaptive and resilient planning actions [3]. To complete validation, run the GeoFlood workflow (or similar topographic model) using an existing DEM and river flow information. If there are areas of concern once the initial flood model is completed, some adjustments to the DEM may be necessary. This can be completed by directly changing the value of pixels at locations of existing infrastructure systems. The examples provided in the functional demonstration will assist with understanding this process.

Step 3. Modifications to the built environment represent the infrastructure design portion of the approach, but unlike with hydraulic models, this step does not require a detailed understanding of infrastructure design. During the development of hydraulic models, an expert (often a hydraulic engineer) must complete the basic designs of any infrastructure systems to inform the model accordingly. Conversely, this approach uses the simple method of DEM pixel value changes to represent new infrastructure systems. As with the validation step, the functional demonstration will assist with further explanation.

Step 4. The final step is land-use analysis which can take many shapes. The example presented in the functional demonstration will provide a glance at the possibilities, but each planner will bring their requirements and desires to this step of the process. The overall workflow allows this final step to be flexible and tailored to a community's needs.

4. Functional demonstration

To demonstrate the usefulness of this workflow, we performed a land-use analysis in Southeast Texas using these methods. We chose this region because of its representative nature of communities in the coastal region and due to the researcher team's ability to gain insight from local technical professionals. Through discussions with local drainage district experts, and community representatives, we further narrowed in on the Montrose neighborhood for our land-use analysis (Fig. 4). This neighborhood is adjacent to and supported by a large detention pond, and also experienced major flooding during Hurricane Harvey in 2017. The rest of this section

Table 2
Keys to successful DEM modification to impact topographic flood models.

Infrastructure Type	Takeaways for DEM Modification
LEVEES	Assign width equal or greater to 2 pixels
DETENTION PONDS	Pair with levee for greater impact on flood extent
CANALS	Primary target for initial DEM corrections to adjust canal elevation from water surface to channel depth

Note: Downstream impacts are underrepresented for all.

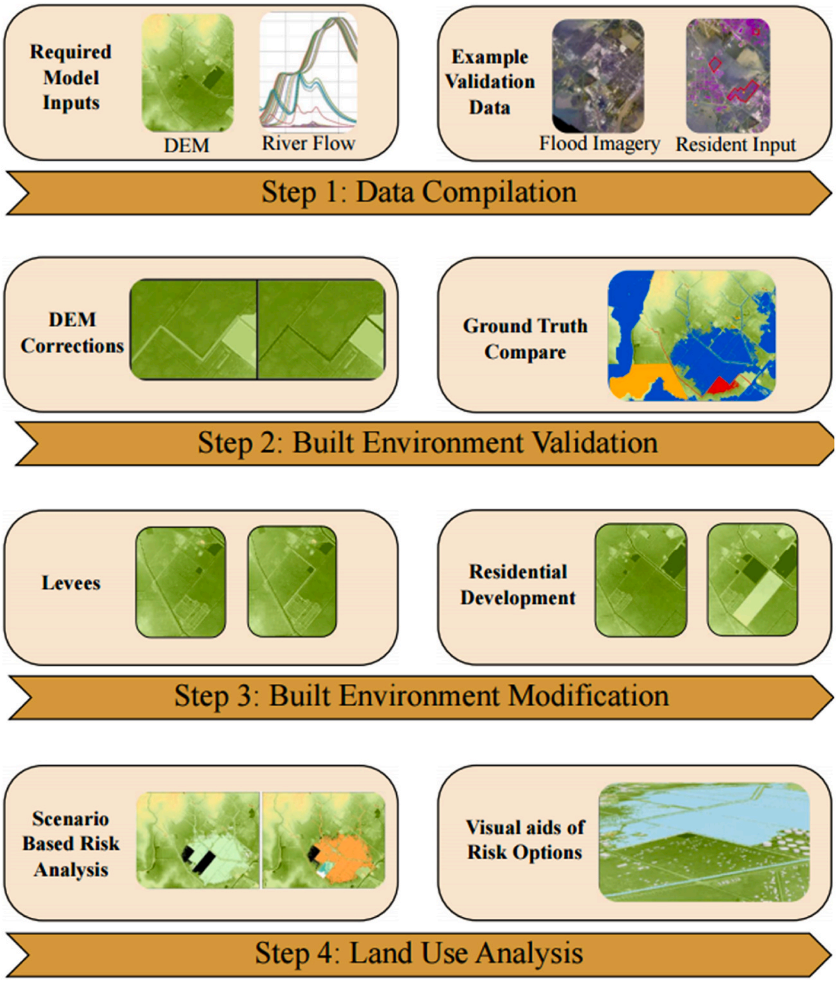

Fig. 3. Topographic model scenario generation.

will step through the four stages of the topographic model scenario generation process and conclude with land-use analysis products for the study area.

4.1. Data compilation

The DEM used for our analysis is from the *Texas Natural Resources Information System (TNRIS) Lidar DEM: Jefferson, Liberty and Chambers, TX (East)* which included a 1-m resolution of the study region, and the National Water Model provided streamflow data [50, 55,56].

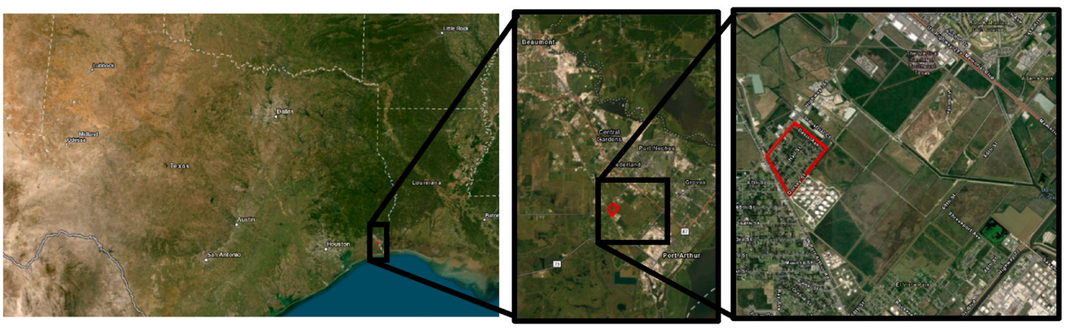

Fig. 4. Functional demonstration area: Southeast Texas - city of Port Arthur - neighborhood of Montrose.

To assist with validation of the model and land-use analysis, additional data sources included priority flooding sites from our local experts, high water marks and imagery from Hurricane Harvey, and residential building data (Fig. 5) [57,58].

4.2. Validate built environment

GeoFlood has been validated with observed flood depth and extent during Hurricane Harvey. [40]. However, modifying the DEM input to the model allows for further enhancement of the accuracy of the initial GeoFlood inundation map. Changes to the inundation extent and depths of individual pixels can be achieved to include removal of pixels deemed false positives and additions of pixels deemed false negatives. Specific DEM correction techniques include edits to canals and levees, guiding the model to correctly recognize built infrastructure items (Fig. 6).

4.3. Modify built environment

The Montrose neighborhood is a residential zone that covers just under one square kilometer and hosts 114 residential structures [58]. As seen on historical imagery (Fig. 5), and confirmed by our local experts, Montrose experienced major flooding during Hurricane Harvey but does not flood regularly. The Halbouty detention pond covers approximately two square kilometers of land, just east and across a canal from Montrose. The local drainage team is in the design phase of an expansion to the detention pond to the Montrose-side of the canal. There is interest in modeling the impacts of this expansion on mitigating flooding in Montrose. Other stakeholders are interested in expanding the number of homes in the local area. One location being considered for new homes overlaps with the land targeted for the Halbouty pump station's expansion. Finally, a levee may be helpful to protect Montrose itself, but it is important to note many communities downstream from Montrose struggle with flooding as well, and therefore simply pushing the water downstream may not suffice.

Using the updated DEM from the validation process, the built environment can be modified to generate scenarios for land-use analysis. Pixels in the DEM can be adjusted to represent infrastructure items in specific locations (Fig. 7). The detention pond expansion was modeled by matching the elevation of the existing detention pond for a large number of pixels in the targeted area provided from community members. This pond expansion was connected to the adjacent canal in two locations by decreasing the value of pixels between the two infrastructure systems. A levee was placed between the neighborhood to be protected and the canals and ponds creating the flooding risks. This levee was 2 m high and per the key takeaways (Table 2) two pixels wide. This specific DEM's resolution was 10 m, resulting in a 20 m wide levee. The neighborhood's location matched a portion of the detention pond expansion, but pixel values were raised rather than lowered to represent fill due to development.

4.4. Land use analysis

To support this land-use analysis, we analyzed inundation maps for the six scenarios and included two levels of flooding events for

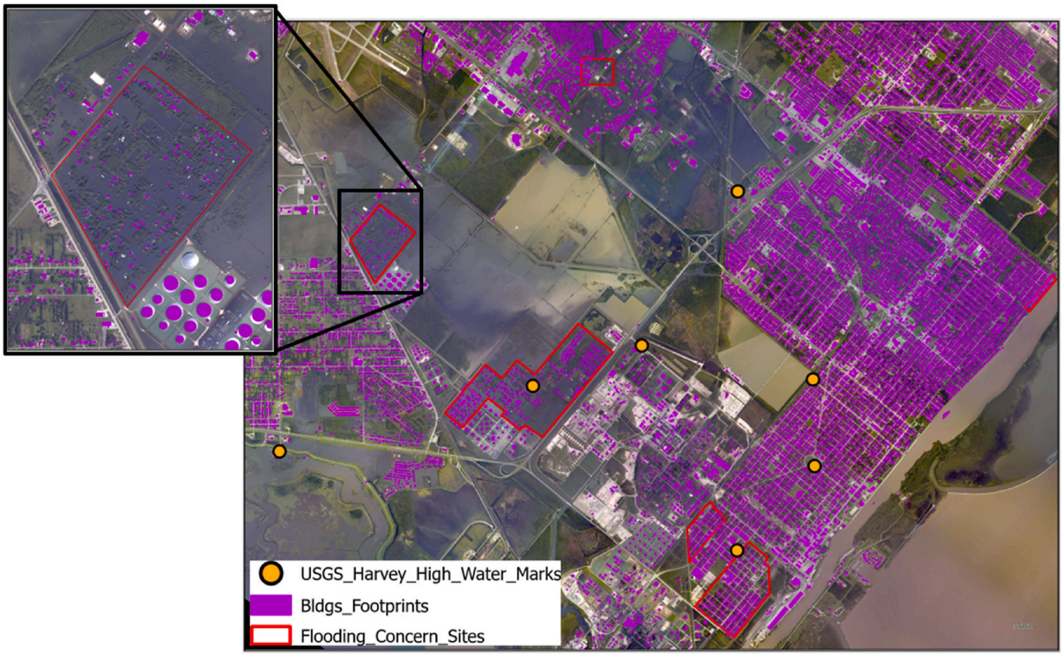

Fig. 5. Sites of flooding issues, flood imagery, high-water marks, and building footprints.

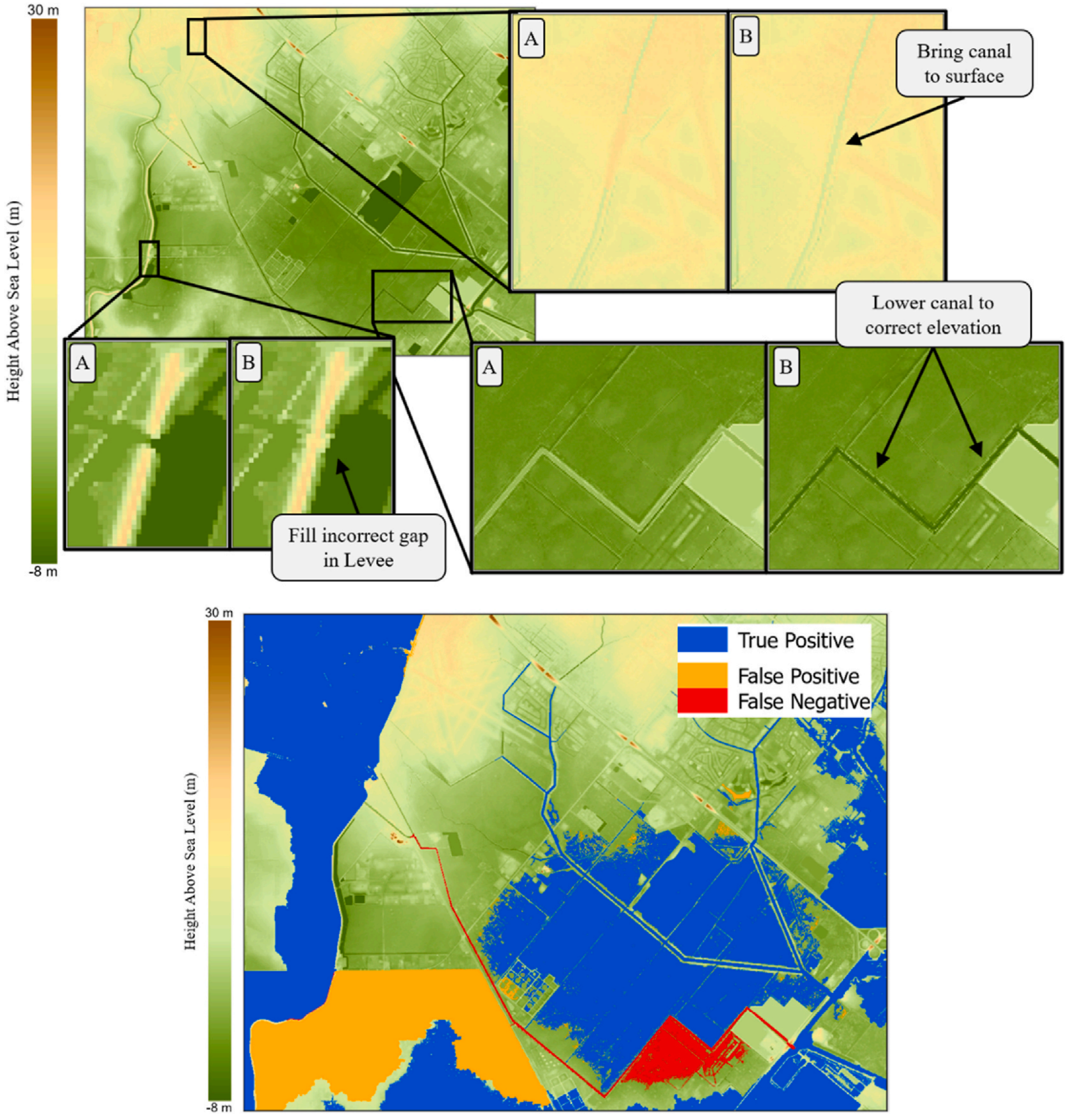

Fig. 6. Validation of DEM: 'A' shows initial & 'B' shows corrections. False positive flood inundation removed by correcting the DEM's representation of a levee, and false negative areas are accounted for by correcting the DEM's representation of a canal. Following corrections, the corrected inundation map more accurately represents how the community experienced flooding for Hurricane Harvey, as validated with high water marks, imagery, and discussions with community members.

each. The major flooding event used the fluvial input from the week of Hurricane Harvey and the quarter-major event cut those flows down by four (Fig. 8).

The inundation results for all six scenarios can be found in Table 3. All of the inundation results for the quarter event matched those of the corresponding major event scenarios. The levee proved to be required to ensure the Montrose neighborhood was protected from flooding and the extent and depth results provide an area for improvement and discussion.

Difference maps can be used to assist with the analysis and highlight changes in depths and extent between different scenarios (Fig. 9). Scenario 5M is the most robust and shows the expanded detention pond experiences increased depth of flood inundation and the Montrose neighborhood is shown to no longer experience flooding.

Planners and decision makers may find different perspectives helpful to communicating the scenarios. By bringing in OpenStreetMap data, the no-change scenario can be visualized when compared to a levee and detention pond expansion scenario, with the Montrose neighborhood in question easily depicted by residents (Fig. 10) [59].

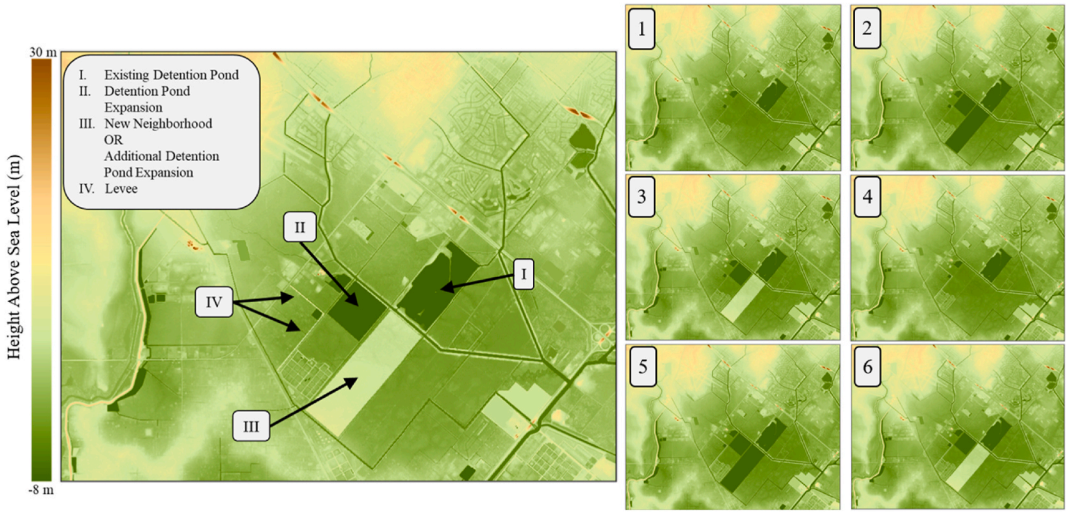

Fig. 7. Built environment modification scenarios. 1 - No change; 2 - detention pond expansion 3 - new neighborhood; 4 - new levee 5 - levee & detention pond expansion; 6 - levee & new neighborhood.

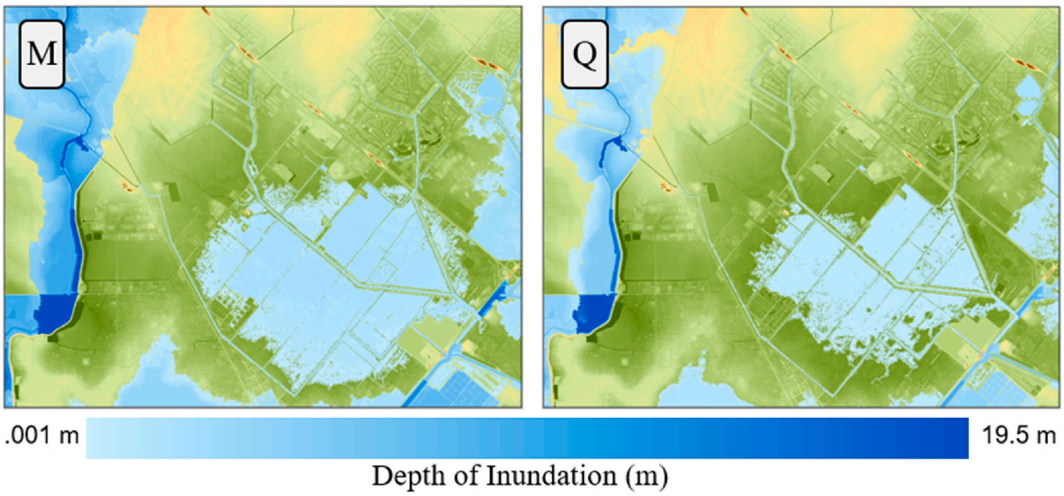

Fig. 8. Flooding event Baselines: M – major Event; Q - quarter event.

5. Discussion, limitations, and opportunities

5.1. Elevation changes as infrastructure representations

Representing infrastructure using modifications of a DEM proved useful and impactful when paired with topographic modeling methods. Specifically, the researchers showed levees, canals, detention ponds, and new developments can be represented by elevation adjustments to a DEM and impact the resulting flood inundation maps. These modifications provide an efficient approach for both correcting and modifying a DEM. Correction of a DEM may be necessary if an initial topographic model contains known flood inundation false negatives or false positives. Modification of the DEM allows for the development of many scenarios, leading to robust analysis possibilities. However, there are some lessons learned and recommendations for use of these methods (Table 2). Arguably the biggest shortfall points back to one main difference between topographic and hydraulic methods: capturing the mass movement of flood waters. This lack of capturing movement leads to under-represented changes in inundation depth and extent in areas downstream of the modifications.

5.2. Impacting land-use decision making

The *Topographic Model Scenario Generation* process laid out steps for a planner to use these techniques to complete land-use analysis.

Table 3
Built environment modifications – Montrose neighborhood.

Built Environment Modification	Storm Event (Scenario code)[b]	Inundation Results		
		Montrose Fully Protected from Flood	Flood Extent Change Outside Montrose[a]	Flood Depth Change Outside Montrose[a]
No Change	Major (1M) Quarter (1Q)	No	N/A	N/A
Detention Pond Expansion	Major (2M) Quarter (2Q)	No	Pond Only	Pond Only
New Neighborhood	Major (3M) Quarter (3Q)	No	New Neighborhood Only	Pond Only
Levee	Major (4M) Quarter (4Q)	Yes	No Change	No Change
Levee & Detention Pond Expansion	Major (5M) Quarter (5Q)	Yes	Pond Only	Pond Only
Levee & New Neighborhood	Major (6M) Quarter (6Q)	Yes	New Neighborhood Only	Pond Only

[a] Model limitation addressed in the discussion.
[b] All quarter event inundation results matched those of the corresponding major event.

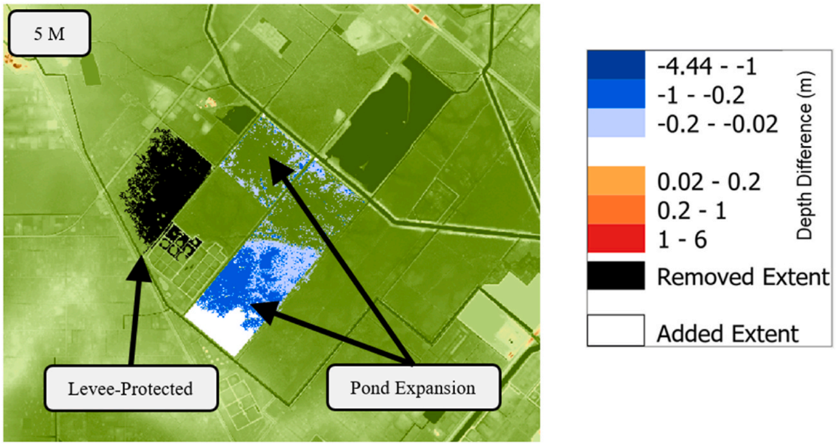

Fig. 9. Flood Extent and Depth Change for Scenario 5M (Levee and detention pond expansion).

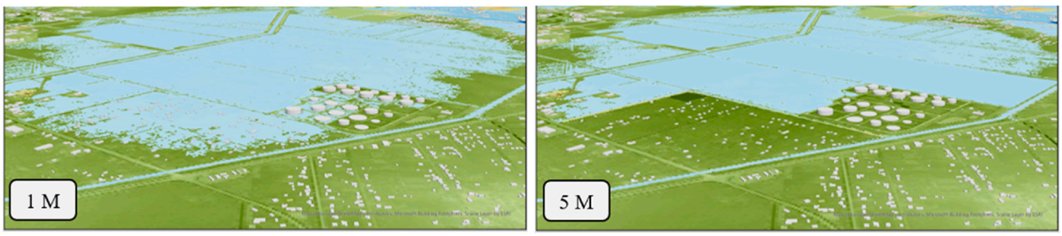

Fig. 10. Visualization Example for Scenarios 1M & 5M (97 structures protected from flood inundation); Map data OpenStreetMap contributors, Microsoft Building Footprints, Scene Layer by ESRI.

The functional demonstration provided an example of a real-world neighborhood in need of this type of scenario generation and showed how these methods can assist that community by providing visual products and impact analysis of different infrastructure solutions. The methods allow many scenarios to be developed with different combinations of built-environment modifications across multiple flood-events. Consistent with the known strengths of topographic methods, the scenario generation did not require large computational capacity to provide a substantial number of inundation maps for analysis. Early in a land-use discussion, these methods may indeed prove helpful in broadening the understanding of possible scenarios and the associated flood risks of different land-use decisions.

5.3. Future opportunities

The version of GeoFlood used in this study accounted for fluvial (riverine) flooding. However, future editions of GeoFlood will also include pluvial and coastal impacts [60,61]. These types of improvements to topographic flooding modeling techniques will improve the models themselves and in turn the ability to apply these methods to workflows including the *Topographic Model Scenario Generation* process presented here.

The specific procedure of identifying and detailing the DEM modifications in this study provides an opportunity for automation. We will enhance and streamline the methods presented in this study by developing these automation capabilities. If successful, this automation will greatly expedite the identification of 'pixels of interest' within a DEM—the pixels that are key to effect change in the resulting inundation map. Further automation will assist with sizing the optimal adjustment to each pixel—in infrastructure terms, this may represent the height of a levee or the depth of a canal.

This research accompanies a larger project in the Southeast Texas region that includes a large number of research efforts. One such effort includes development of an Advanced Terrestrial Simulator (ATS) hydraulic model for the region. The DEMs prepared and inundation maps created in this study will be used alongside additional infrastructure designs to enhance the ATS model. Results from the two models will be compared with the goal of not only assisting this specific community but also providing valuable information regarding the accuracy of different flood modeling techniques in general.

The literature reviewed during the writing of this study pointed toward gaps in attainable and understandable tools for planners when it comes to flood-mitigation planning. However, there is a need to further understand the datasets and data visualization types planners require most, to help bridge the interdisciplinary gap between these two fields [62]. Therefore, through future efforts, this research team intends to collect detailed information from planners directly to help gain and share that insight.

6. Conclusion

The combination of climate change and population relocation makes land-use decision making extremely challenging, particularly along coastal regions. However, as modeling techniques continue to improve, there is an opportunity to improve the tools available for land-use decision makers. Which flood model types to use under different circumstances is an open question that we attempt to help answer in this study. Our results show topographic flood models, when paired with DEM modifications, can provide a low-computational method for scenario generation. We provided lessons learned that point toward some shortfalls when using topographic models, but also showed through a functional demonstration that these methods can provide multiple flood inundation maps early in a land-use planning efforts. These methods represented an example of moving toward a cross-functional space where engineers are creating attainable and useable products for planners—to meet the true need rather than create the best product at an unrealistic cost. To address the current and future disaster mitigation challenges our communities face, more cross-functional research efforts are not only necessary but essential.

CRediT authorship contribution statement

Sean Murphy: Writing – original draft, Visualization, Investigation, Formal analysis, Conceptualization. **Mark Wang:** Writing – review & editing, Software. **Chih-Shen Cheng:** Writing – review & editing. **Paola Passalacqua:** Writing – review & editing. **Fernanda Leite:** Writing – review & editing, Supervision.

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.

Acknowledgements

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Biological and Environmental Research Program under Award Number DE-SC0023216. Any opinions, findings and conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the U.S. Department of Energy.

Data availability

Data will be made available on request.

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