Hazards in Hawai'i

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Abstract

As the world erupts, floods, and finds ways to change under our feet, hazardous events pose a threat to human life and properties, creating vulnerability in affected communities. Unfortunately, some communities do not have the proper hazard education resources that allows users to gain hazard awareness. When an event occurs, these communities are left unprepared and overwhelmed with feelings of panic, fear, and worry, hoping to find a sense of safety when a hazardous event occurs. Understanding the surrounding hazards allows individuals to be prepared for these events, making them feel safer as they can acknowledge what the event means, how to respond based on personal risk, and how to recover. By using GIS applications, preexisting hazard awareness resources, hazard assessment datasets, and historical hazardous event records provided by the Hawai'i GIS Program and the United States Geological Survey, the project created will be a web application that community members of the Hawaiian Islands to insert a location onto a map and learn about their local hazards. The hazard assessments included will showcase their locations' projected susceptibility to flooding, tsunamis, fires, and volcanic lava flows in the future. As a result of using this platform, the community will increase their knowledge to create hazard awareness and be useful to future urban developments. Helping the communities further prepare for their local hazardous events moving forward, allowing for greater resilience through hazard impact recovery.

1. Introduction

Many regions throughout the world are not affected solely by one hazard, but by multiple hazards that can act simultaneously and/or consecutively upon one another (Skilodimou *et al.* 2019). Communities in multi-hazardous regions often live with the thought of a hazardous event occurring as something so normal, one of their life's blissful afterthoughts. On the occasional chance that a hazardous event does occur, there is a lack of preparedness for mitigation and remediation due to their lack of community hazard awareness. Resources are drained and the need for emergency assistance is immediate when there is no known plan to action towards finding safety.

Located within the Pacific Ocean above a hotspot plume, the eight Hawaiian Islands are at a great risk for a multi-hazardous event. Each island can be affected by land driven hazards such as volcanic lava flows, earthquakes, and landslides (Heliker, 1990), while also being susceptible to coastal driven hazards such as tsunamis, flooding, storms, erosion, and sea level changes (Fletcher III *et a*l. 2002).

For my capstone project, I have created a multi-hazard web application that analyzes projected zoning and risks to hazards throughout the Hawaiian Islands. Floods, tsunamis, fires, and volcanic lava flows are just a few of the hazards present throughout the Hawaiian Islands but are those that will be represented within my multi-hazard capstone project, which can be found at sadng.github.io/23Capstone. The hazard data was all retrieved as shapefiles from the Hawai'i GIS Program (2017), the State of Hawai'i Office of Planning and Sustainable Development (2023) and the United States Geological Survey (USGS) (2023). As an additional representation of hazards, each web map has a real-time USGS data feed of all earthquakes that have occurred in the last 30 days (2023), allowing users to see earthquake data, if any is available.

The research questions motivating the creation of my capstone project are 'What hazards in Hawai'i (historical and projected) are found in a mapping environment?' And 'Have there been any web mapping approaches found helpful in hazard recovery?' Answering these research questions through my capstone project allows all the represented Hawai'i hazard datasets to be put into one spatial environment, allowing users to find the resources they need in one database location. Additionally, with the hope of having users from the local community and those just visiting, it can be used as a general education resource. Being educated in your surrounding hazards allows you to prepare for any event possible.

Multi-hazard maps allow for the advancement of hazard awareness and improve processes hazard management, mitigation, and resilience (Pourghasemi *et al.* 2020). By creating my multi-hazard capstone project through GIS applications, users will be able to insert a location onto a map and learn about the represented hazards. After users click a specified location, a popup containing the applicable hazard assessment will showcase the hazard zoning and projected susceptibility, increasing their personal hazard knowledge. This allows them to be better aware of their multi-hazardous environment, increasing their preparedness for the event of one or multiple hazards to occur. Furthermore, allowing for better community resilience throughout the impact recovery process.

2. Literature Review

To further development of my capstone project, assessing similar projects previously created allows for a greater understanding of what does and does not work in the geospatial community, how communities and hazard data are represented, current multi-hazard resources, and so much more. Through my literature review, these resources will be broken up into the following sections: participatory mapping, hazard communication in mapping, and hazard, with the subgroups hazard mitigation and contemporary hazards. These sections are created in motivation to answering my research questions, 'what approaches in teaching hazard preparedness have been found helpful in hazard recovery?' and 'what hazards are in Hawai'i that are found in a mapping environment?'

Hazard mitigation highlights the ways hazard warnings and current hazard awareness resources are present throughout the Hawaiian Islands. As my capstone project will present a multi-hazardous map, it is necessary to understand what hazards, historical and projected, should be represented and how they have been previously represented. Previous representations will showcase ways data has been implemented in specific designs curated for community members, who may not have prior hazard knowledge, topics further addressed in the sections, hazard communications in mapping and contemporary hazards. To ensure true representation of the Hawaiian Islands in a spatial environment, the contribution of local knowledge and history becomes crucial. The working process, connections, and ethics required for community contributions is further discussed through participatory mapping.

2.1 Hazards

When discussing natural hazards of the Hawaiian Islands, they are divided by those that are land driven and coastal driven. Land driven hazards deal with volcanic and seismic influences, such as lava flows, earthquakes, and volcanic smog (vog) (Heliker, 1990). As the islands are created by an active hotspot plume among the Hawaiian-Emperor seamount chain

(Tarduno 2003), majority of the active occurring hazards are those that are volcanically influenced, which only is a large concern to those located on Hawai'i Island. The hotspot plume has continually been moving southward, currently located towards the southeastern flank of Hawai'i Island. Coastal driven hazards are a concern to all islands, these hazards are those pertaining to tsunamis, stream flooding, high waves, storms, tidal erosional, and sea level changes (Fletcher III *et a*l. 2002). As the concern towards all hazards continues to fluctuate based on occurring events, below I'll be discussing efforts to mitigate hazard effects on communities and the state of contemporary hazards.

2.1.1 Community Mitigation

With or without any warning, the Hawaiian Islands are at risk to hazardous events. From earthquakes to tsunamis to volcanic eruptions and more, the Hawai'i Emergency Management Agency was formed to develop and implement early warning measures/systems to protect the people of Hawai'i (State of Hawai'i, n.d.). An implementation of their early warning efforts was found in Hilo, Hawai'i, following the potentially destructive tsunami on February 27th, 2010. Through research it was found that the effective methods of informing the people of Hilo, Hawai'i were new technology (social media), pre-existing community networks, and the most effective being news media outlets (radio stations), (Sutton *et al.* 2011).

Hawai'i Island is divided into hazard zones determined by an area's risk severity to lava flows on a scale from 1 to 9 (Heliker, 1990). This lava flow hazard zone mapping system is still adapted today, but when looking at the two maps you can identify the current day map has made the hazard zones more specifically distinguished (USGS & Wright, 1992). By mapping the risk levels of hazards, the community can understand the chances that a hazardous event could affect their lives, but also shape their approach in urban development. When construction is set to occur, hazard analysis is critical to the development process to understand whether the land areas specific risks require the construction to include mitigation measures that fall within safety standards (Hwang 2005).

2.1.2 Contemporary

The Island of Hawai'i is composed of five shield volcanoes, including the most active volcanoes, Kilauea, and Mauna Loa (Bladt *et al.* 2019). With an ongoing eruption at the Kilauea volcano and the recent Mauna Loa eruption, the people of Hawai'i are amazed by the beauty but can also be affected by the volcanic risks. Lava and access to lava is currently contained, ensuring that exposed lava flow is not an accessible risk, but with lava flows in the past, closing off viewpoint access has not always been achievable. In 2018, access to Kilauea's Lower East Rift Zone was at community reach due to its 107-day fissure eruption that destroyed Leilani Estates, a community in the Puna District on the Island of Hawai'i (Williams *et al.* 2020).

As magma reaches the surface, lava releases noxious sulfur dioxide gas and other air pollutants that can alter the atmosphere, water quality, and create vog (Elias & Sutton 2017). Vog affects individuals differently, but they are known to cause sore throats, produce headaches, induce breathing difficulties, etc. (Elias & Sutton 2017) As vog is not always recognizable in plain view, public resources allow for the people of Hawai'i to understand the flow of vog through the VMAP vog forecast website (Businger *et al.* 2015).

Being in the middle of the Pacific Ocean, hazards of flooding due to sea-level rise, storms, tsunamis and more continue to put communities at risk. This is addressed in the Federal Emergency Management Agency (FEMA) mapping system that states all hazard zones excluding the tidal erosional zone in Hawai'i are associated with the National Flood Insurance Program (Hwang 2005). This means that any property within the tidal erosional zone is not eligible for coverage within the insurance program as the property owners understand the higher risk in losing their assets to any form of flooding event.

2.2 Hazards Communications in Mapping

Hazard communications through mapping should provide the same amount of informational depth as hazard communications outside of the mapping environment. The hazard information communicated are not shared as risk warnings that imply impending hazardous events but are shared to be ways to create accurate emergency response methods and develop the communities understanding of the hazardous risks (Viscusi & Zeckhauser 1996). To create effective hazard communication, many factors should be implemented such as being clear, providing various sources of support for more information, using different ways to communicate, providing multilingual content, and so much more (Mileti *et al.* 2004).

Although the hazards may be understood by those creating the hazard maps, they are often not understood by those in the community due to factors of aesthetics (Thompson *et al.* 2015). As an example, aesthetics of data plays a large role on the way that users engage with volcanic hazard maps because when determining a color scheme to a hazard map, designers often convey the message of hazard distribution through the red-yellow-blue color scheme, representing hazard risks that are highly present, to those that are low and not presently existent (Thompson *et al.* 2015). Used in the Hawai'i lava flow hazard map (USGS & Wright 1992) is a red-yellow-green color scheme which is similarly common as it follows the association that most individuals have with a stoplight, stop, slow, and go. It is likely you will not see hazard maps with a color scheme of purple-blue and/or pink-green-blue, simply because they are not common colors associated with one another on a safety scale. Colors influence the users understanding of the map, so choosing an appropriate color scheme is very important in the design process itself.

Interactivity and creativity in any map are also aesthetic factors to consider when determining user engagement. As tourism is present throughout Hawai'i, effective methods of hazard communication must be implemented to ensure that non-residents understand the measures to take when a hazardous event may occur. But often, knowing what tourist spots to go to is more important than understanding the hazardous risks presented in their lives by going there. The interactive platform, GeoPDF provides information on the relationship between tourist locations and hazard zones, while also providing additional information such as emergency measures on Hawai'i Island (the Big Island) (Cervantes 2009). Providing levels of interactivity allows users to take only the information they want from your map, but also provides a way for them to understand it in their own means. Through GeoPDF users have the options to turn on and off layers of data so they can see only what they want, whether that is just tourist spot recommendations, hazard zones, or both, and mark points with their own applicable information (Cervantes 2009).

Base map design is also an important factor with aesthetic understanding and data representation. When choosing a base map, you want to highlight the data you are using effectively in the location environment you are working in. Research results showed that when looking at a volcanic hazard map, respondents were only able to locate and orient the map when looking at an aerial base map, rather than a contour map (Haynes *et at.* 2007). As the islands have an interesting and constantly changing cartography, contour maps often do not represent the niche landforms and lava flows known to the community. While moving forward in the design process of my capstone project, I will provide an aerial base map view to allow community members to orient themselves with the landform surroundings they are familiar with.

2.3 Participatory Mapping

Maps made for communities are best made when communities contribute to the creation. Participatory mapping is a method of identifying place values (Brown *et al.* 2020) by incorporating local knowledge and community participation to develop spatial information, an approach created to fill the gaps of current geographic information (Levine & Feinholz 2015). Approaching communities can create controversy, communities can be misrepresented and mislead by the purpose of the project. Participatory map datasets act as a basis to make informed decisions (Brown *et al.* 2020), a way to further spatial data-based decision making (Levine & Feinholz 2015). Which initiates the ethics-based predevelopment process necessary for proper participatory mapping, which includes understanding the purpose and use of data, and ethics when it comes to approaching the specific communities for data collection. A major example of applying participatory mapping are maps representing indigenous communities, as their history and lifestyle may not be properly represented by those creating a geospatial environment (Chambers 2006). This makes it possible for you to represent the communities correctly and include them in the spatial decisions made to affect their lives.

Data collection through participatory mapping methods can create very limited datasets. Looking back at the ethics of participatory mapping, developers must understand that to collect the data required, you are taking people's time and raising expectations that their participation will make an impact (Chambers 2006). Collecting data locally can also be used against people or benefit those who were not meant to be benefited, causing tensions in communities which can cause distrusting relationships with the dataset you are creating (Chambers 2006). But alike to any limitation or controversy, you can learn more about what data throughout the community should and/or shouldn't be represented, what additional data is necessary, what other ethics applications should be applied, etc.

On the island of Ambae, Vanuatu, participatory mapping research was conducted to create hazard maps to ensure that the indigenous populations trusted the datasets but were also capable of understanding the way they were digitized to ensure the map was used (Haynes *et at.* 2007). Another example of participatory mapping is through the Hawai'i Coastal Uses Mapping Project where they created a map that digitized locations of human recreation as it effects and relates to coral reef management (Levine & Feinholz 2015). These projects of participatory mapping evaluate methods of community engagement and map understanding throughout island communities. Additionally ensuring that throughout the process of creating my multi-hazard capstone map, that it is trusted, understood, and used by the Hawaiian communities at the same depth as hazard maps throughout Vanuatu.

Through analyzing the hazards that effect the Hawaiian Islands as a whole, I've identified the historical and projected hazards will be represented throughout my capstone project and how each hazard type present pose concerns to how they're addressed throughout the communities. Recognizing approaches and designs in effective hazard communications in mapping environments allows me to move forward in designing my map in a way that is appliable to the communities and is designed in a way to further develop the understanding of hazards. By creating an understanding of participatory mapping, I'm offered insight on how dataset creation is approached to include communities that the multi-hazard map data will represent.

3. Description of Application / Intervention

Uploaded as a repository on GitHub, my user interface has been created as a website with five individual web pages. On the home page, users can familiarize themselves with relevant capstone documents and information such as my abstract, my capstone proposal, and my final capstone paper. As they continue through the homepage, they can refer to my database resources, and each specific dataset references for shapefiles used to create my capstone.

Above is a navigation menu connecting users to the webpages of the four represented islands, Oahu, Hawai'i Island, Kauai, and Maui. When you open any of these four pages, users will be welcomed to see a Leaflet web map interface with the capacity to zoom in and out, change your base map, and go back to previous extents, users also can interact with the map itself. Overlaying the base map is a transparent red mask which can be seen in figure 1 below, showcasing where data is present. By clicking on the map at any of the locations where data is present, users will generate a popup as seen in figure 2 below.

Figure 1 (above). Island of Hawai'i Leaflet interface (Nguyen 2023).

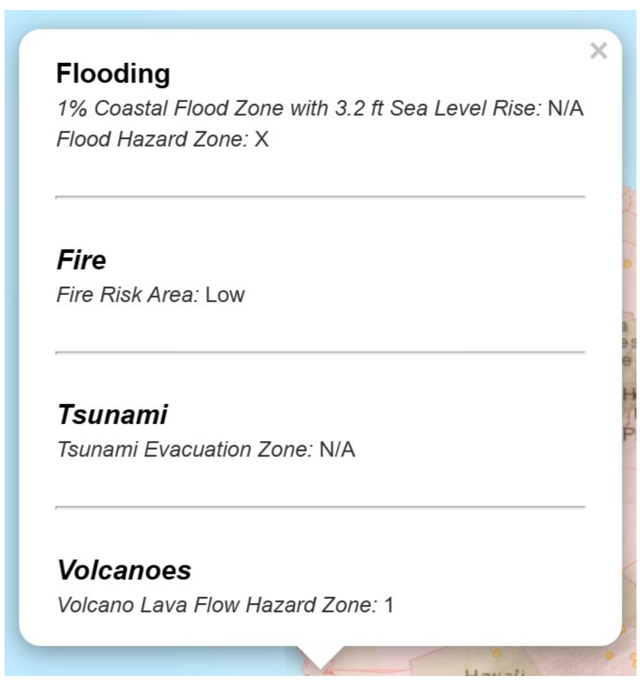

Figure 2. Popup interface taken from the Island of Hawai'i (Nguyen 2023).

Popups are generated based on the user clicked locations applicable dataset. These popups are organized to generate data by flooding, fire, tsunamis, and when applicable, volcanic lava flows. Represented by smaller orange circles are epicentres, generated by the USGS real time data feed showcasing 30-days' worth of earthquakes (2023). These earthquakes have a corresponding popup, as seen in figure 3 that showcase their magnitude and their location as they generate in real-time. For better user visibility, popups can also be moved to the side for the location and its surroundings to not be blocked if desired.

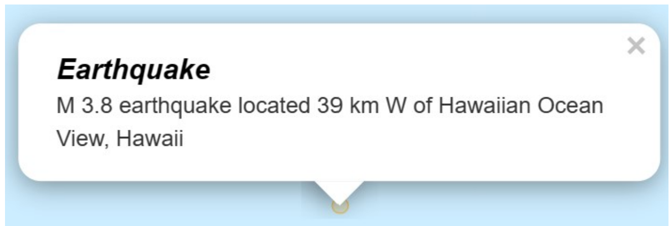

Figure 3. Popup interface for real-time earthquakes (Nguyen 2023).

4. Methods

To complete my multi-hazard capstone project, I've completed tasks in a three-section split over the timespan of seven months. Design drafting is a planning and proposal development process that started in February 2023, and due to be completed within March 2023. The data period will conduct data collection and editing, as well as data implementation into the created design interface, spanning from March 2023 to June 2023. Lastly is the evaluation stage where the conduction of user-interface testing, data analyzation and formal writeups from July 2023 to August 2023.

4.1 Design Drafting

The design drafting process has been completed throughout this proposal writing process but was a crucial part in my assessment of previously created resources and how my multi-hazard capstone project should be created moving forward. The resources assessed are those that similarly focus on hazard analyzations, connecting with the community to develop maps, and have taken place throughout the Hawaiian Islands. Through this process I've taken notes within a literature review on the found preexisting projects, allowing me to understand the implementation of participatory mapping when addressing community contributions, hazard communications in maps, and hazards throughout the Hawaiian Islands and how they are presently approached for hazard mitigation processes. I've additionally created a methods section which has created a timeline to discuss the process in which I have been creating my capstone project design features.

The code was created using HTML, JavaScript, and CSS environments, assisted by ArcGIS Pro tools, Map Shaper to create GeoJSON files, and leaflet to properly create a web application. With many islands and hazards being projected, the design must include cohesive functionality and knowledgeable design. Implementing design methods found in previously created hazard maps, the capstone map follows a red color scheme to properly identify regions represented in the application. Red at a transparent capacity allows for users to see across all three provided base maps, that there is data present in particular locations. The ability to change base maps was implemented for the user's personal preference but also generated with an aerial map so lava flows and current urban features can be easily identified.

4.2 Data

The focus of data within my capstone project will be to collect datasets and conduct any editing that is found necessary. To find datasets that represent the Hawaiian Islands floods, tsunamis, fires, and volcanic lava flows, I've retrieved my data from the Hawai'i Statewide GIS Program (2017), the State of Hawai'i Office of Planning and Sustainable Development (2023), and the United States Geological Survey Earthquake Hazards Program (2023) databases to collect datasets pertaining to natural hazards and their corresponding future projected hazardous events.

Datasets from the Hawai'i GIS Program (2017) were broken up to represent one island's jurisdiction at a time. For the multi-hazard capstone project, only four islands will be analyzed due to data availability, and representation. All GIS data layers have been collected in a shapefile format to represent the islands of Oahu, Kauai, Hawai'i Island, and Maui. From the Hawai'i GIS Program (2017) database, I collected each islands applicable dataset of 1% Coastal Flood Zone with 3.2 ft Sea Level Rise (2017), Parcels (2023), Flood Hazard Areas (DFIRM) (2021), Fire Risk Areas (2021), and the Volcano Lava Flow Hazard Zones (2021).

Through the State of Hawai'i Office of Planning and Sustainable Development (2023), I collected the GIS shapefile of Tsunami Evacuation Zones (2013). As a real-time data feed, I implemented the United States Geological Survey Earthquake Hazards Program (2023), GeoJSON for All Earthquakes in the Past 30 Days (2023).

Table 1. Attributes created through spatial joining parcels with hazards.

Attribute Label	Origin	Applicable Attributes
TSU	Tsunami Evacuation Zones	Evacuation Zone Extreme Evacuation Zone Safe Zone
FHADFIRM	Flood Hazard Areas (DFIRM)	A AE AH AO D Open Water VE X
FRA	Fire Risk Areas	Low Medium High
T1PCFZ3	1% Coastal Flood Zone with 3.2 ft Sea Level Rise	A CA V
LAVA	Volcano Lava Flow Hazard Zones	1 2 3 4 6 8 9

After collecting their datasets, reprojection was conducted to ensure that the datasets are in WGS84 to fit within the Leaflet mapping environment. Using the parcel layers, I conducted a spatial join in ArcGIS Pro to create an attribute table of the applicable hazard data relevant to each represented parcel. In table 1 above, you can see how each hazardous dataset was represented in the parcels spatial joined attribute table, and their applicable results. Parcels with all matching hazard attributes were then merged, to lessen the need for data storage. This effort additionally allowed for the parcels not to lose their original delineations, keeping the working parcel lines present. These final shapefiles were then exported as GeoJSON files using Map Shaper and implemented into our JavaScript environment. By conducting the attributes through individual island parcels, I was able to ensure that I had one largely representing data source for each island, reducing my need for data storage and it allowed for my interactive leaflet popups to pull results from one location.

4.3 Evaluation

The final analysis included testing the user-interface of the multi-hazard capstone project design, finalizing the data analysis and the projects written report. With the number of islands being represented in my capstone, I broke down my final interface to have individual web map pages for each island. Using an individual interface allowed me to analyze the availability and functionality of hazard GIS data for each island individually. Through the completion of my capstone project, the interface of multi-hazard mapping will allow the Hawaiian communities a chance to expand their understanding of local hazards, historical and projected, establishing knowledge towards hazard preparedness.

5. Discussion

Through this capstone, I was motivated by the research questions ‘What hazards in Hawai’i (historical and projected) are found in a mapping environment?’ And ‘Have there been any web mapping approaches found helpful in hazard recovery?’ As I created this capstone, I got to understand the efforts and effectiveness that come from multi-hazard mapping, and the ways that hazards are approached on the Islands of Hawai’i.

Successfully I was able to create a GitHub repository that allowed for users to find Hawaiian hazard data in one spatial environment. Additionally, I was able to create a web application that can teach users a specified locations hazard zones and projections. This tool can be used to expand hazard awareness and education, allowing for helpful hazard recovery.

Unfortunately, I did not get the opportunity to answer all components of my research questions. Originally, my capstone was focused on showcasing both the historical and projected hazard susceptibility to every location on the four represented Hawaiian Islands, Oahu, Hawai’i Island, Kauai, and Maui. By implementing features of the past, present, and the future, the capstone would have highlighted the pattern of the island’s past risks and future risk assessments. With the need to be informed and prepare for the future, the Hawai’i GIS Program (2017) and the State of Hawai’i Office of Planning and Sustainable Development (2023) provided me risk assessment and zoning region shapefiles to further be implemented to represent projected hazards.

The only dataset relevant to historical hazardous events that represented all four islands in this capstone at the time of data collection were Tsunami Wave Heights, a dataset created in 1976 provided by the State of Hawai’i Office of Planning and Sustainable Development to highlight the highest wave height due to a tsunami across 5 years (1946, 1952, 1957, 1960, and 1964). Although it is past historical data, there is a large gap of tsunami wave height data dating from 1964 to present day, 58 years unrepresented.

As mentioned previously, there is no dataset that showcases what regions were affected by tsunami, and even flooding events. These wave height datasets are simply a number in feet, as a single data point among the coastline of the islands. Through further research across tsunami information published by the Federal Emergency Management Agency (FEMA) (2023), it is not possible to know how far inland a tsunami wave is capable of effecting communities because waves are anticipated to travel 20 to 30 miles per hour with a wave height of 10 to 100 feet high. Though this sounds extreme, the inland topography and infrastructure can allow the tsunami waves to further travel, causing severe damage, and/or slow the travel, limiting the communities effected by the hazardous event.

As for volcanics, the United States Geological Survey (USGS) Science Base Catalog (2023) has shapefile datasets displaying volcanic lava flows as early as 1790 to 2018 for the Kilauea Volcano, on the Island of Hawai'i. More recently at the 2023 Esri User Conference in San Diego, California, I was also able to find lava flow datasets for the Mauna Loa Volcano, also on the Island of Hawai'i. This dataset is located for public use on ArcGIS Online (C.D. 2022) and supported by the Mauna Loa Story Map created by McCabe (2022).

The volcanic lava flows of these two active volcanoes represent majority of the current day risks, as they are the two volcanics currently above the surface that have recently erupted, but only representing two of the many volcanic structures across the islands did not satisfy the history of the volcanics across the Hawaiian Islands. Currently within the Island of Hawai'i web page, users can understand what volcanic lava flow risk zone (Hawai'i Statewide GIS Program 2021) their location is in, as those ratings are currently applicable and regularly evaluated. Oahu, Kauai, and Maui do not have volcanic lava flow risk zones showcased on their web map applications because there is no active lava flow risk on their islands, as the hot spot has traveled too far Southeast from their volcanic structures.

6. Conclusion

An active hotspot plume moves slowly Southeast across the Pacific Ocean, creating what is known as the Hawaiian-Emperor Seamount Chain. Eight of the seamounts have surfaced above the Pacific Ocean and are known as the eight islands that make up the state of Hawai'i. With active volcanics and oceanic surroundings, the islands are susceptible to multi-hazardous events that can cause damage to the local communities. Land driven hazards that are seen to affect the surface of the eight islands are volcanic lava flows, earthquakes, and landslides (Heliker, 1990). Coastal driven hazards also affect the islands with sea level rise, flooding, tsunamis, coastal erosion, and storms (Fletcher III *et a*l. 2002).

Through my capstone, I've created a web map application that represents four Hawaiian Islands, Oahu, Hawai'i Island, Kauai, and Maui. These four islands out of the eight were chosen for this project due to their data availability. Data was retrieved from the Hawai'i Statewide GIS Program (2017), the State of Hawai'i Office of Planning and Sustainable Development (2023), and the United States Geological Survey Earthquake Hazards Program (2023). The specific shapefile datasets collected were 1% Coastal Flood Zone with 3.2 ft Sea Level Rise (2017), Parcels (2023), Flood Hazard Areas (DFIRM) (2021), Fire Risk Areas (2021), and the Volcano Lava Flow Hazard Zones (2021). Additional real-time USGS data is being retrieved through a GeoJSON feed, showcasing all earthquakes that have occurred in the last 30 days (2023).

Motivating my capstone are the research questions, 'What hazards in Hawai'i (historical and projected) are found in a mapping environment?' And 'Have there been any web mapping approaches found helpful in hazard recovery?' My capstone project puts all the represented Hawai'i hazard datasets to be put into one spatial environment, allowing users to find the resources they need in one database location. Additionally multi-hazard maps assist the advancement of hazard awareness and improve processes hazard management, mitigation, and resilience (Pourghasemi *et al.* 2020), my capstone can become a general education resource for users to become better educated about their surrounding hazards.

The web map the data was implemented into uses a Leaflet web mapping environment, implementing the opportunity for users to change their base maps, reorient to their previous viewpoints, and zoom in and out. For my popup interactions to work, datasets were separated by their islands parcels, allowing data to only generate from one large source. Additionally, this separation allowed for better data organization, and data storage capacity. Doing these edits through ArcGIS Pro, I used the spatial join tool to allow each parcel to pull their applicable hazard projections and zones. To further save data storage, attributes with all the same attributes were merged, to lessen the amount of individual parcels present.

To be implemented into the capstones HTML, CSS and JavaScript environment, the shapefiles were exported to GeoJSONs using Map Shaper. This allowed me to place the data into their corresponding Leaflet web maps, to be uploaded as a GitHub repository and shared as a website which can be found at sadng.github.io/23Capstone.

To also be implemented in the future, is data from the United States Geological Survey (USGS) Science Base Catalog (2023). This catalog provides volcanic lava flow shapefiles for the Island of Hawai'i's most active volcano, Kilauea. For this historical record to be implemented, creation of the 2020 to 2023 volcanic eruptions needs to be created to have an accurate representation of volcanic events from 1790 to present day. With the more recent volcanic lava flow from Mauna Loa, also on the Island of Hawai'i, I would like the opportunity to also quality check and use the flow polygons made public on ArcGIS Online (C.D. 2022). The implementation of historical hazards will allow users to understand a pattern in their hazardous risk, but also allows them to learn why the location they are in may have been built to look the way that it does today.

Moving forward, I would like the opportunity to expand my capstone project to the community through partnerships with large-scale organizations such as the Pacific Disaster Center, the United States Geological Survey, USGS Hawaiian Volcano Observatory, the Hawai'i GIS Program, the State of Hawai'i Office of Planning and Sustainable Development, and local higher education institutions, such as the University of Hawai'i System. Through partnering with these organizations, I will be able to connect with the hazard analysis community throughout the Hawaiian Islands to further deepen the datasets I am using, but also the data that I am sharing. Additionally, I will be able to connect with locals of the community through these organizations to fulfill my goal of bringing it to community events, classroom discussions, and more so that locals and visitors are more capable of learning their hazardous surroundings. Being more educated and aware of hazards allows for communities to become more resilient throughout the impact recovery process, mitigating the hazard damages that could affect their lives.

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