FloodNavigator

Supporting urban adaptation to climate change through disseminating crowd-sourced flood data

www.floodnavigator.com

University of California, Berkeley, School of Information

Master's of Information Management and Systems

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Frances Brittingham, Cameron Kurtz, Leslie Noye, Maya Schoucair

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Advisor: Professor John Chuang

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Introduction

FloodNavigator is a community-driven platform for sharing and viewing real-time flood conditions. Initially developed for Accra, Ghana, where flooding is a daily problem, FloodNavigator empowers users to make safer decisions. By leveraging widespread mobile use and predictive models, our platform supports the city's adaptation to increased flooding from climate change.

The vision for FloodNavigator came from the lived experience of our co-founder and teammate, Leslie Noye, who grew up in Accra, Ghana, and dealt with the challenges of flooding every day of the rainy season. Through customer discovery interviews, scientific literature review, and a flood tech landscape analysis, we built a deep understanding of the nature of flooding in Accra, how it impacts people's daily lives, the tools they currently use to manage these challenges, and the gaps in the existing available resources. With this information, we honed in on our innovation. Design inspiration research, participatory design workshops, and usability testing fed an iterative, agile development process, from problem definition to MVP. This report documents our process for building a tool to democratize flooding information in Accra, Ghana that is simple, reliable, and accessible.

Problem Statement and Target Audience

While visiting my family in Accra, Ghana, I — Leslie Noye, co-founder of FloodNavigator — experienced what residents face during the rainy season. Each day brought rain, and with it, flooded roads. When my mom needed to go to the store, she called her friends living along the way to check if the roads were clear. If the rain persisted, my mom sent me down the hill on foot to assess the rising water level and gauge if we needed to prepare our home. On my second trip down the hill, I wondered aloud to my neighbor making the same trek, “Why don’t we have an app for this?”

I made developing an information tool to address flooding in Accra my mission of my School of Information education and recruited an incredible team to make it happen.

Flooding in Accra - Literature Review

Floods disrupt daily life across Accra. A 2021 study found that, due to flooding, 87% of residents experienced mobility disruptions, over half could not leave their neighborhoods for one or more days, and 20% saw water enter their homes (Andreasen et al., 2022). Emergency response services also struggle to navigate flooded roads, limiting their ability to assist those in need (Yao Kofie et. al., 2024). As can be seen in the photos below, flooding in Ghana can completely submerge vehicles.

(Flooding in Ghana, 2019, credits: Graphic Online Ghana)

(Flooding in Ghana, 2024, credits: RainbowRadioOnline)

The economic impacts are also significant. Flooding decreases labor productivity, disrupts supply chains, and damages business infrastructure (Danquah et al., 2024). For example, in a 2021 survey conducted in Accra, 25% of respondents reported being unable to “procure supplies for a business from bulk goods markets in central Accra” in the past year (Andreasen et. al., 2022). Between 2013 and 2023, flooding in Ghana caused economic losses of approximately $1.7 billion (Asamoah, 2023). While the full impact of urban flash floods on Accra is still being assessed, it is evident that adapting to increased flooding is essential for sustaining economic growth and resilience.

Rapid urbanization and climate change have intensified urban flooding in Accra and other West African cities. Accra’s population surged from 1.5 million in 2000 to 5.7 million in 2021 (GSS, 2021), and the city's daytime population can double as commuters flow in for work. Growth has far outpaced infrastructural investment, leading to insufficient waste management and drainage

networks (Amoako et al., 2014). Existing gutters double as trash receptacles, clogging them and causing streets to flood after moderate rainfall. According to University of Ghana hydrologist, Dr. Albert Allotey, because trash clogs are unpredictable, hydrology models alone cannot predict flooding in Accra. Accra already sees 170 days of rain annually (World Weather Online, 2024), and the Intergovernmental Panel on Climate Change (IPCC) warns of heavier rainfall due to climate change, exacerbating an already dire situation (IPCC, 2022). Moving forward, Accra's ability to respond to flooding intensified by population growth and climate change requires robust and accurate flood data to guide infrastructure development and flood mitigation strategies.

While the Ghanaian government and the World Bank have invested in early warning systems for significant river flooding events, little has been done for the urban flash floods that the industry calls “nuisance floods” or “pluvial floods”. Nuisance floods occur because rainfall exceeds the drainage capacity. While they are generally not catastrophic, they meaningfully disrupt lives in Accra. River flood warning systems are imperative for helping people prepare for major flood events but do not address the infrastructural issues that prevent people from getting around when it rains. Unfortunately, many past projects funded by the World Bank and other developmental agencies have ended without implementation or fallen into disrepair due to a lack of maintenance.

Until more robust investments are made in flood mitigation, the burden of adapting to flash flooding falls on individuals and their local communities. FloodNavigator’s goal is to lessen this burden by providing accurate, reliable, and consistent information on flooding. As one of our interview participants put it: when it comes to our tool, we must ensure that we “don’t let it quit working.”

Understanding The System of Accra's Flooding Problem

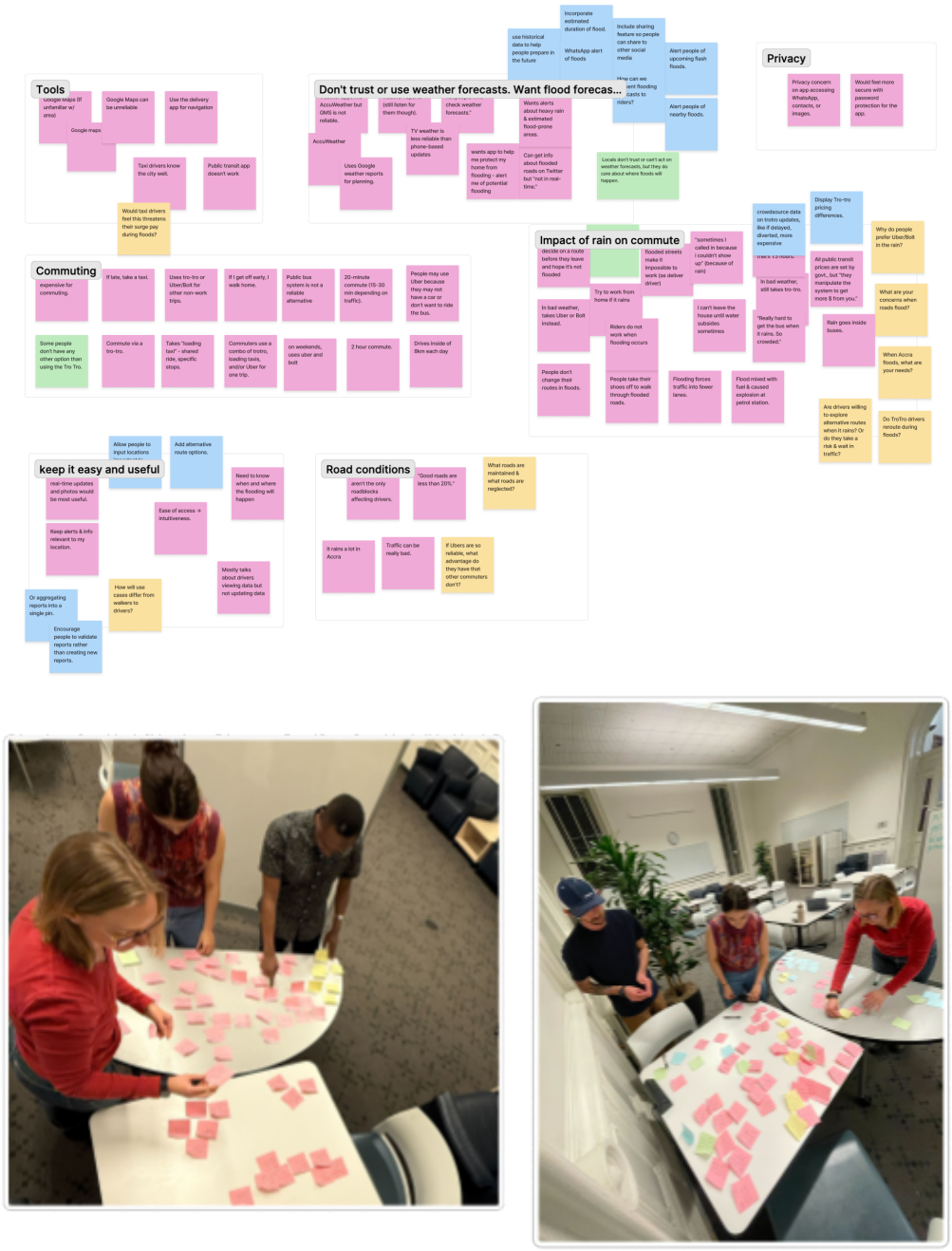
To identify, design, and build an innovation to help people in Accra adapt to daily flooding, we knew we needed to start by building a deep understanding of how flooding impacts people. We looked to our systems thinking toolkit to guide us and started by mapping the stakeholders of this system:

We quickly realized that flooding in Accra impacts everyone and we need to narrow our focus, so we honed in on those we anticipated were most acutely impacted by flooding: people who drive in Accra for a living and people who commute to and through Accra for work. To round out our understanding of the complex nature of this system, we also spoke with an engineer working on a World Bank-funded project to create a flood alert system for major flooding events in Accra (Greater Accra Resiliency and Integrated Development Project), as well as two hydrologists involved with a project for modeling flooding in Accra.

We spoke with 15 people to get a better understanding of flooding in Accra:

- 5 people who commute through Accra for work
- 4 rideshare drivers + 1 food delivery driver
- 2 hydrologists working on modeling flooding in Accra
- 1 engineer with Greater Accra Resiliency and Integrated Development Project

After conducting these interviews, we analyzed the interviews through an affinity mapping exercise:



Through this exercise, we uncovered 3 important insights:

1. Residents of the Greater Accra Metropolitan Area are desperate for notifications of nearby floods. They don't trust weather forecasts, so they don't want forecasts from us - they want real-time information.
    a. With real-time flooding information, they feel they would be able to protect themselves and their property.
2. Flooding is not just disruptive to people who are driving. It's also disruptive for people on foot, on public transport, and working at roadside businesses.

    a. We realized that we aren't just building for drivers. In fact, drivers have to navigate with the apps built by or integrated with the companies they work for. They want this information but not a new navigation tool.
3. Today, information about flooding is disseminated through word-of-mouth, WhatsApp groups, social media platforms, and over the radio. These information flows are decentralized and delayed, making them unreliable.

Our Target Audiences

By getting to know the system that flooding in Accra impacts, we narrowed in on our target audiences for our innovation:

1. Residents of flood-prone areas of Accra
2. People who commute to and through flood-prone areas of Accra
3. Drivers who can pick their own route (excludes public transportation drivers)

These three personas have similar needs and motivations:

Needs:	Motivations:
Are there floods nearby? Are there floods on my way? Will there be floods later? **Do I need to change my plans to stay safe?**	Safety of self, loved ones, and property Continuing life safely with and around floods (adaptation)

By clarifying who we are hoping to help, and identifying their needs and motivations, our mission became clear:

FloodNavigator's mission is to improve mobility, safety, and economic resilience in flood-prone regions by disseminating real-time, crowdsourced data about flooding.

The Flood Tech Landscape: Gaps and Lessons

Before designing an intervention for our users to help them adapt to and build resilience to flooding in Accra, we sought to understand the existing tools for flooding, as we did not want to reinvent the wheel. As flooding is one of the world's most costly natural disasters, many organizations are working to forecast, model, and respond to its impacts. Yet, real-time alerts of flash floods designed for residents — especially in the Global South — are rare across this landscape.

Our research into dozens of tools (most relevant listed in the table below) revealed three significant gaps:

- **Sustainability is a core challenge:** Promising projects like FloodCitiSense, Urban Risk Labs, and World Bank-funded Flash ACCRA have ended due to limited funding (Column 2).
- **Most tools are not built with—or accountable to—the communities they serve:** Waze is the only tool whose primary goal is to provide data directly to residents (Columns 3 & 4).
- **Zero tools provide real-time alerts** for nuisance (pluvial) flooding (Column 5).

We spoke directly with the teams behind the tools marked ✅ and surfaced three key lessons for success:

1. **Community involvement** in design drives higher adoption and better crowdsourced data.
2. **Partnerships with trusted local actors** are essential for scale and impact.
3. **Grants and government funding alone are insufficient** for long-term sustainability.

FloodNavigator is the only tool co-designed with Accra residents, built to deliver **real-time flood alerts** that empower communities to make **safer, faster** decisions during pluvial floods.

	Available & maintained	Community-centered design	Data openly available to residents	Provides flood alerts/ warnings	Located in Ghana
FloodNavigator 🌟					Accra, Ghana
Flash ACCRA ✅	Never released				Accra, Ghana (lasted less than 1 year)
Petabencana			Primarily partners		Indonesia, Philippines
Urban Risk Labs ✅	Some areas		Primarily partners		Thailand, Japan, India, US
Waze ✅					Minimal market penetration in Ghana
FloodCitiSense ✅			Primarily AI model		Belgium
ISeeChange ✅		For locality GTM strategy	Flood + other climate data		United States
Haas Alert System / Intellisense Systems				through Waze only	United States
FloodNet NYC					NYC, United States

	Available & maintained	Community-centered design	Data openly available to residents	Provides flood alerts/ warnings	Located in Ghana
FloodMapp NowCast✅			Only if locality has paid		Partners with city planning and emergency response organizations in US

(Excludes tools that do not provide real-time information or do not track *pluvial* flash floods, including FirstStreet, Fathom, Google Flood Hub, Floodtech, Floodwatch.io, Flood Alert SMART Project, My Flood Risk Accra, and more.)

From our interviews with residents in Accra, we know that many Ghanaians rely on word-of-mouth for information regarding floods, usually communicated via WhatsApp or phone calls. However, this flow of information is typically confined to one's network of family and friends, limiting the volume and reach of information. Some Ghanaians use X and other social media platforms to get flood updates, but noted that information posted to social media was often not done in real-time, making it less reliable. These strategies are stopgaps—not purpose-built for the problem, but temporary fixes in place of a long-term, effective, and scalable solution.

Iterative Design & Development of FloodNavigator

Unified by our mission and motivated by the lack of adequate existing solutions, we started planning, designing, and building FloodNavigator.

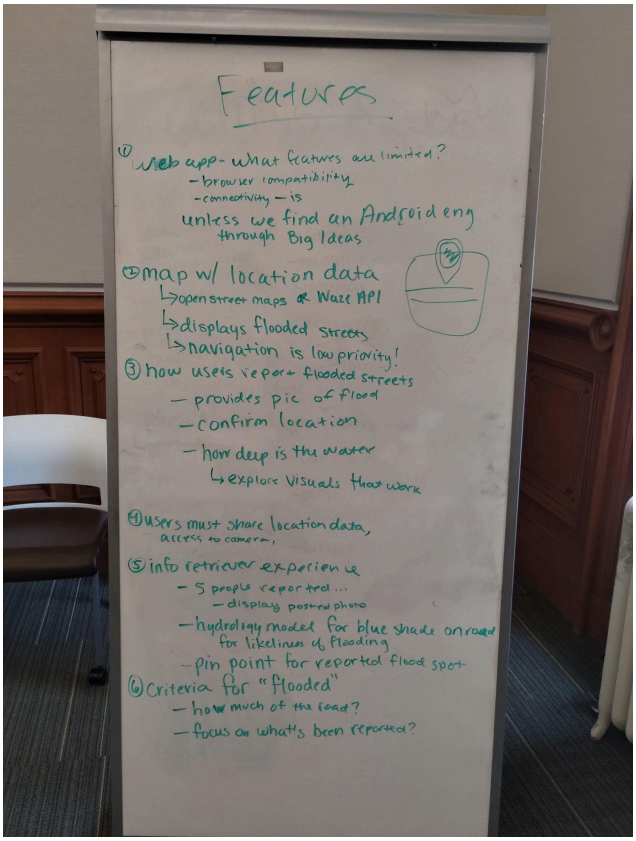
> *How might we help communities in Accra, Ghana share accurate flooding updates in order to keep each other safe and informed?*

Prioritization and Roadmapping

Our method for prioritization began with making our constraints explicit:

- We must be able to research, design, and build in 4 months (acknowledging that some research had been completed the prior semester).
- We will not tell people whether or not the water level is safe to drive or walk through. We will provide information that will allow them to make an informed decision.
- We are not providing turn-by-turn navigation instructions - just information so people can update their paths accordingly.

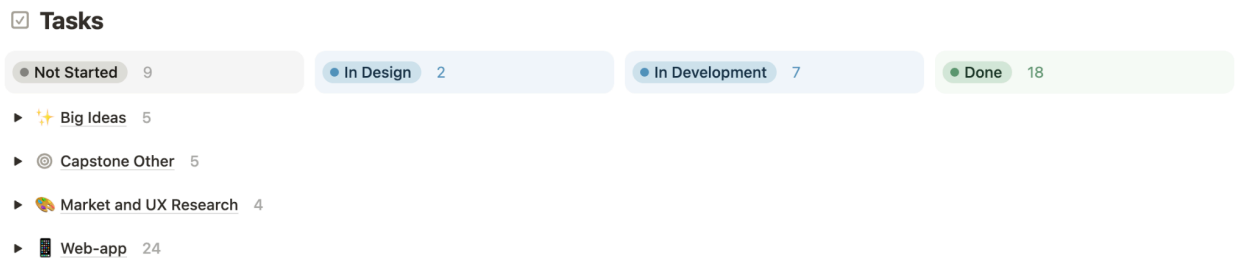
Given our constraints, we listed the features and open questions we have.



We envisioned an app where people could report flooding they've encountered. These reports would populate a map and notify everyone nearby. Several open questions remained:

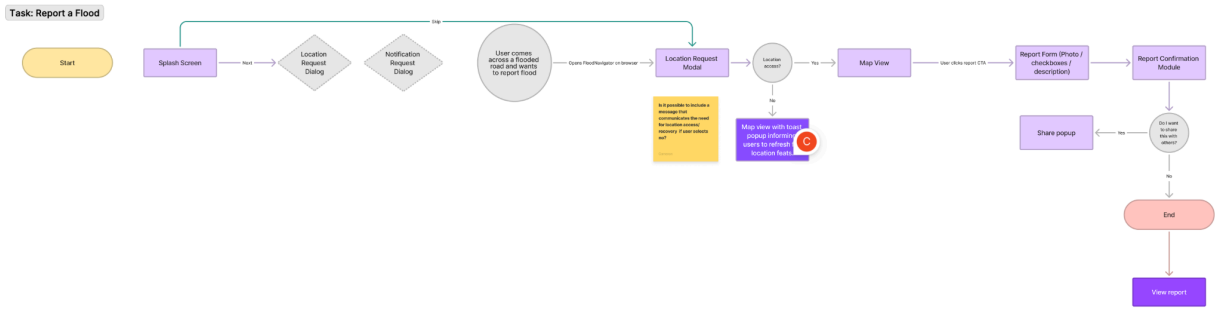
- Is this a research and design project or will we develop a tool?
- Can we build a mobile app? A web-app?
- How will we visually display flooded streets and the extent of the floods?
- How will users convey the depth of the water for a flood they encounter?
- Are people in Accra comfortable sharing their location with an app?
- Can we incorporate a hydrology model, sensors, or other measures to ensure reliability?
- How much water must be present for someone to call the road "flooded"?
- How do we promote safety for all users?

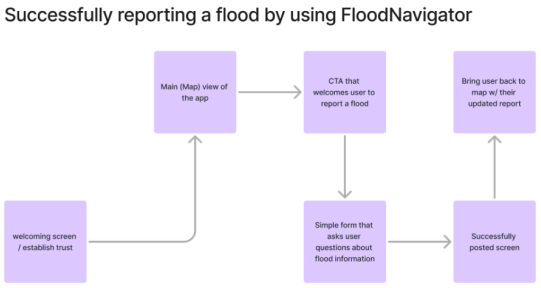
With our open questions and ideal list of features, we developed a product roadmap for design and development, as well as project plans for research, our Big Ideas application, and other Capstone deliverables:

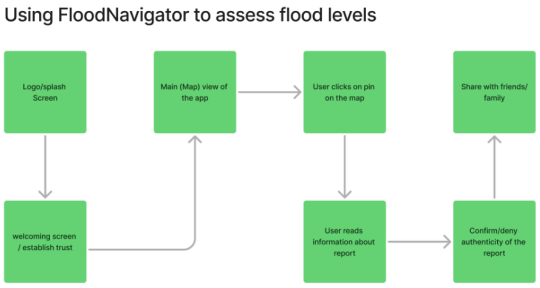


Sketches through User Flow and Comparative Design

We began by drafting the user journey:







We looked at existing apps, especially those used by people in Accra, for design inspiration, heuristics, and best practices, including Google Maps, Uber, Bolt, Waze, Snapchat, Citizen, Urban Risk Map, and WatchDuty.

Our takeaways from this analysis:

1. Geospatial Pins
    a. Amongst all competitors, geospatial pins were the most common form of displaying all reports. One common solution to overcrowding information is clustered points.
        i. Best for: Displaying individual user reports without overwhelming the map.
        ii. How it works: Crowdsourced reports are clustered into icons (e.g., “5 reports” on a specific street) that expand when zoomed in.
    b. Recommendation: Use geospatial pins with clustering to prevent map overcrowding while ensuring visibility of all reports.
    c. Implementation:
        i. Cluster reports into a single icon (e.g., “5 reports” on a street) that expands upon zooming in.
        ii. Differentiate reports using clear iconography and color coding.
    d. Example: Waze, SnapMap, Google FloodHub.
2. Simple Map UI
    a. Most competitors used a simple UI navigation for maps. This will be essential for users to be able to navigate across the app quickly and efficiently.
    b. Recommendation: Keep the map interface minimalistic and easy to navigate for quick usability.
    c. Implementation:
        i. Prioritize intuitive map controls (zoom, filter, and search).
        ii. Maintain an intuitive layout that allows users to report and access flood data quickly.
3. Iconography
    a. For map pins, iconography was commonly used as a way to communicate different levels and types of information. For example, Google FloodHub uses different hues to communicate various levels of flood severity.
    b. Recommendation: Use distinct icons and color variations to indicate different levels of flooding.
    c. Implementation:
        i. Adapt a similar approach to Google FloodHub’s design of using hue variations for flood severity.
        ii. Ensure icons are universally understandable, even without text labels.
4. Water Level Data Visualization
    a. Some apps included illustrations to visualize the water levels. This needs to use simple language and visuals for users to understand at a glance information. Possibility to include granular information for more specific / detailed information.
    b. Recommendation: Provide both simplified and detailed views of flood severity.
    c. Implementation:
        i. Use easy-to-read visuals to show flood depth at a glance.
        ii. Offer an option to expand for granular information, catering to both general users and professionals.
5. Language Toggle

    a. A language selector is easily visible to allow users to quickly change the language of the app. This is essential for user groups who are not english-native speakers
    b. Recommendation: Include an easily visible language toggle for non-English speakers.
    c. Implementation:
        i. Place the language switcher prominently on the home screen or settings.
        ii. Support multiple languages relevant to the region (e.g., English, Akan, Ga, etc.).
6. Reporting
    a. The information architecture for apps that use reporting features include 4 or less pages (typically location confirmation > water depth > photo > description)
    b. Recommendation: Design a simple, step-by-step reporting system with minimal friction.
    c. Implementation: Ensure users can quickly submit reports without unnecessary complexity. Limit the reporting flow to 4 steps:
        i. Confirm location (GPS or manual selection).
        ii. Report water depth (predefined categories or input field).
        iii. Upload a photo (optional but encouraged).
        iv. Add a description (short, structured input).

At this point, we thought we knew what to do, so we started sketching FloodNavigator's UI and building low-fidelity wireframes. But, with every screen came more and more open questions.

What information do people want to know about a flood? What information are people realistically able to collect? What do they value in an app providing flooding information? And so many more…

Low Fi to Mid Fi through Participatory Design

Given our open questions, we felt that the best way to uncover the answers would be through a participatory design workshop.

Our Research Goal:

Learn how people in Accra describe floods, what information they want to know about floods when they occur, and what they value in resources and solutions for the issues that flooding may cause. These learnings will inform the design of FloodNavigator's flood reporting form, as well as how the information from reports of floods are displayed to viewers. We want to learn from anyone who has experienced flooding in Accra.

Our Assumptions (aka Hypotheses):

- We believe that accurate flood reporting metrics in FloodNavigator will improve real-time decision-making and route planning for commuters and drivers in Accra because reliable, community-sourced data will help them avoid flooded streets and reduce travel disruptions.

- The way people in Accra describe floods (e.g., using landmarks, water depth relative to the body, or traffic impact) will shape how we design the reporting form because local terminology and mental models will determine what is intuitive and easy to report, increasing usability and accuracy of reports.

Participants:

Three first-year graduate students at UC Berkeley from Ghana who previously worked in Accra.

Activities and Insights:

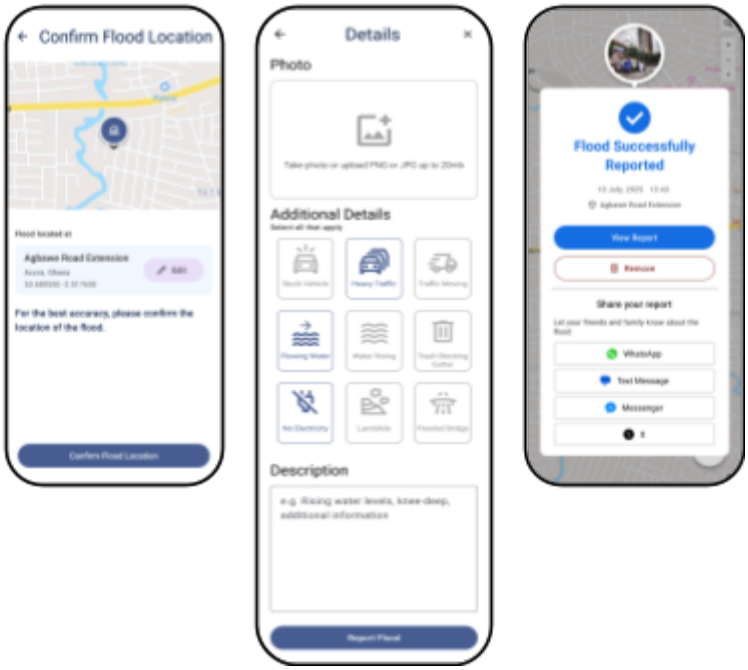
Activity:	Description:	Insights:
Critical Incident Sketching	Participants sketched or wrote about a past flooding experience, and then shared reflections on feelings, impacts, and key details with each other.	● Flood severity is subjective and also depends on the road that isn't visible. ● A road is either flooded or it's not. You can either see the road or you can't. ● Flooding is frequent and disruptive, even with light rain ● Roads have potholes that aren't visible in the rain. Sometimes they are very muddy. When they are flooded, you can't know if they are safe to pass.
Designing Solutions - Crazy 8s	Participants brainstormed solutions to the challenges caused by flooding in quick 1-minute sketches and then shared ideas with the group.	● To solve for flooding, keep trash out of the gutters and don't build in waterways ● Text everyone to warn them about flooding and integrate with Whatsapp ● Educate the public about the harms of throwing trash in the sewer, while also giving them an alternative place to put it
Values Sorting	From a list of 35 potential values, the participants selected the 3 they believed to be most important for FloodNavigator to embody.	● Accessible ● Reliable ● Simple/Usable
UI Analysis	Show the participants screenshots of the current UI of the map with flood reports on it. Ask them to tell us what they would want to see about a flood when they tap on a flood report.	● Video and images ● The name of the area, the way the locals refer to it ● Traffic situation ● "I don't want to check. The app should know my location and tell me."

Design changes:

- Do not ask the user to provide the depth of the flood. Focus on collecting photos or videos.
- Collect details on clogged gutters as this may be helpful data for government agencies.
- Information on muddy roads could be valuable since people can get stuck in them.
- Reporting a flood should be simple and fast - make it as few steps as possible.

Before:

After:



Mid Fi to Hi Fi through Usability testing

Coming out of the participatory design workshop, we felt better about the new iteration of FloodNavigator. Given our participants' emphasis on usability and simplicity, we knew it was time to run a usability test on the current designs.

Through usability testing, we aimed to assess overall feelings and perceptions of the prototype, as well as uncover any aspects of the designs that are confusing or misinterpreted by our participants, in order to improve the overall experience.

Our Research Questions:

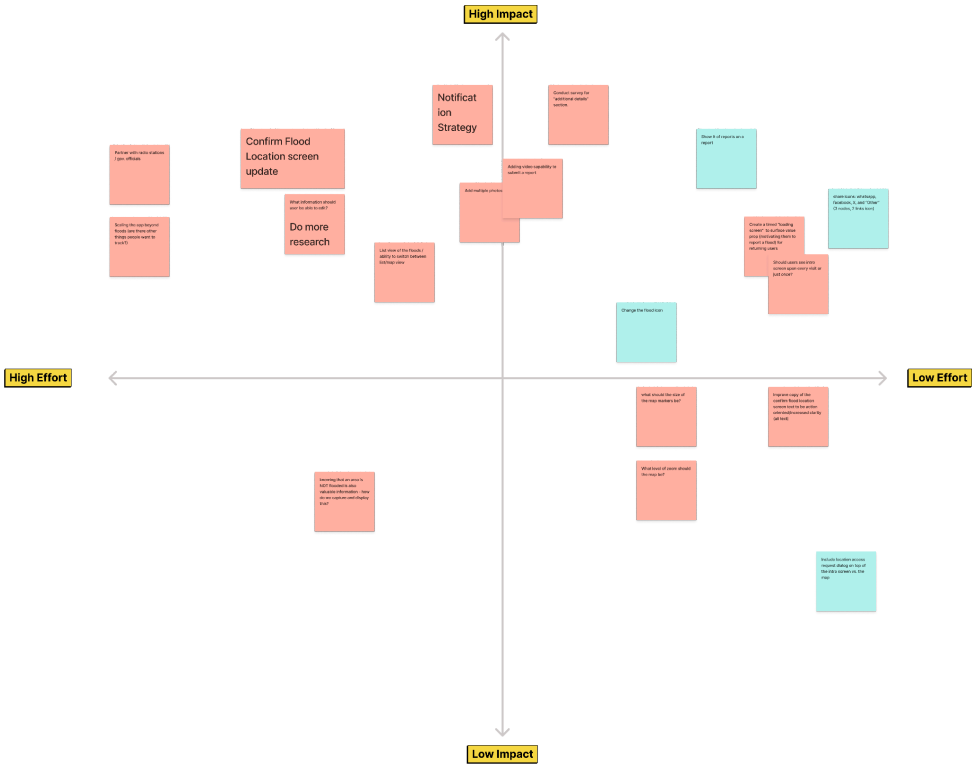
- How do local Ghanaians feel about using this app to report a flood?
- Is the user flow short enough for users?
- What aspects are confusing or misinterpreted?

Our participants:

Four graduate students at UC Berkeley from Ghana who previously worked in Accra. There was no overlap in participants from the participatory design workshop. Due to time zones and technical constraints, we were not able to conduct this usability test with people currently in Ghana.

Results:

Based on the four interviews, we listed usability concerns that we wanted to address and then prioritized them through an Impact vs Effort prioritization matrix:



Design changes:

- Improve the pin that demarcates a flood on the map to make it more obvious that it is a pin of a flood
- Update the share options to Whatsapp, X, Facebook, and Other
- Add number of comments on a report
- Design an onboarding experience to briefly introduce the user to the app
- Include a list view of nearby floods, in addition to the map view

Addressing Privacy and Safety Concerns

In the process of designing the FloodNavigator MVP, we made user privacy and safety a top priority. We knew that for an app that relied on users sharing their locations, it would be critical to build trust with our audience. This sentiment was echoed in user interviews. Multiple interviewees mentioned often turning off location services on their devices due to a fear of being hacked and/or having their personal information stolen. In particular, they expressed concern over the government accessing their data as well as companies that may later sell their data to malicious actors.

Thus, in addition to embedding security in every aspect of our app's technological infrastructure (see *Technological Decisions and Development* for more), we also made key design decisions to prioritize user privacy and safety. These decisions were guided by the principles of the Privacy by Design (PID) framework (Cavoukian, 2011). In line with Principle 1 of the framework, we wanted to be "proactive not reactive; preventative not remedial."

Anonymity:

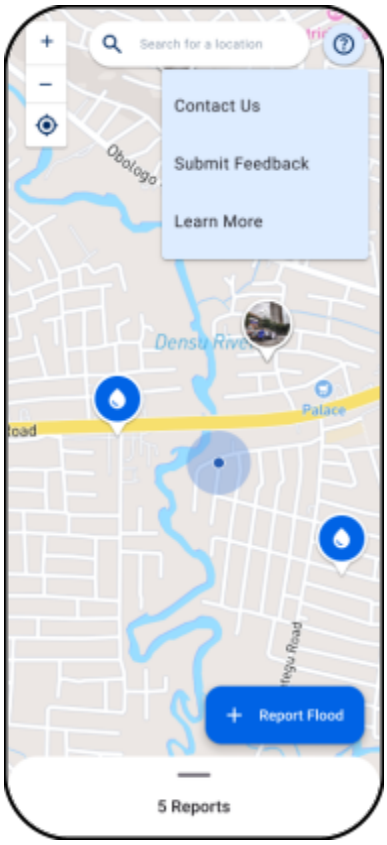
In accordance with Principle 2 of the PID framework, "privacy as the default setting," all user reports are anonymous by default. Reports are not tied to a public profile or any personal identifiers, as can be seen in the example report on the right. This ensures that individuals cannot be tied to or located by their reports, which is of particular importance when considering the safety of individuals in vulnerable situations. This decision was directly driven by user feedback - when asked if they would prefer to post flood reports anonymously or with a public profile, more than half of interviewees stated that they would prefer the former.

Data Minimization:

When users report a flood on FloodNavigator, they are not asked to create an account or provide any personal information. In fact, they are not asked to do this at any point when using the app. We only collect information that is strictly necessary for the flood report, specifically time and location. Though users have the option to include a photo and description of the flood, those are completely optional. By minimizing the data we collect from our users, not only do we reduce the risk of harm, we also lower the barriers to participation. Users in a rush or who simply do not want to go through the process of creating an account need not do so to use FloodNavigator, helping us to maximize the spread of real-time information for all.

User Control:
FloodNavigator is designed to give users full autonomy in their level of engagement. When users open the app, they will be asked to share their location in order to automatically center their mapview and report a flood. However, this is entirely optional. If users decide to decline to share their location, they are still able to use FloodNavigator to view reports. They are able to use the search bar to manually navigate the map to view flood reports in any location they desire. This ensures that, in accordance with Principle 4 of the PID framework, "full functionality – positive-sum, not zero-sum," users can still benefit from the real-time, crowdsourced data without compromising their personal preferences with regards to privacy.

Transparency & Communication:
In accordance with Principle 6 of the PID framework, "visibility and transparency," we use clear, plain-language to communicate our data practices to our users. For example, when prompted to share location data, users will be informed that the data will only be used to orient their mapview and to include in their report. We will provide this and additional details about our data practices on our website. Additionally, we've made it very easy for users to contact us and submit feedback (as seen in the image to the right) if they have any questions or concerns about the privacy or security of their data. These efforts are part of our broader goal to foster trust with our users through transparency and open communication.



Future Enhancements:
We recognize that dominant frameworks for data privacy and security follow Western-centric schools of thought, which often overlook the local knowledge that shape data practices in African communities (Abebe et al., 2021). Thus, as we continue to engage directly with users in Ghana this summer (see *Our Next Steps* for more), we plan to develop a robust data governance framework and privacy policy for FloodNavigator that incorporate culturally relevant understandings of privacy and security.

Addressing Reliability Concerns

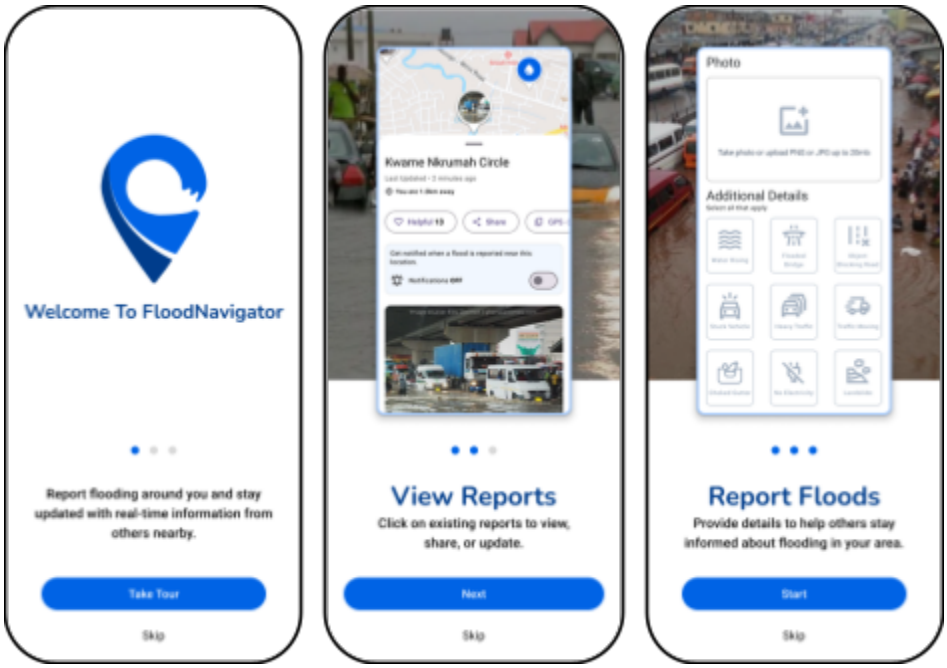
Despite its many benefits, crowdsourced data does come with the risk of inaccurate information. While we provide disclaimers that we cannot verify the definitive veracity of every flood report, we currently include community-based moderation tools to promote data integrity. Users can "report" others' flood reports if they believe the information is fraudulent or inappropriate in any way. Once flagged, reports will temporarily be removed from the map pending review by our team. In addition to adding information to an existing report to enhance its accuracy, users also have the option to "mark flood as cleared" if a flood reported prior has cleared. Users can also mark a report as "helpful." These collaborative features help to keep the map up-to-date with real-time conditions.

As we begin to gather more flood data over time, we will develop a model to calculate confidence scores for each report. The scores for each report will be generated using a combination of data: hydrology modelling, user engagement with the report, historical flood reports, and past and current weather data. Again, in order to maintain trust with our users who have expressed a prioritization of reliability, we will provide clear disclaimers that these scores are merely predictions. We will also offer users the option to opt out of seeing the confidence scoring feature.

The Final Designs

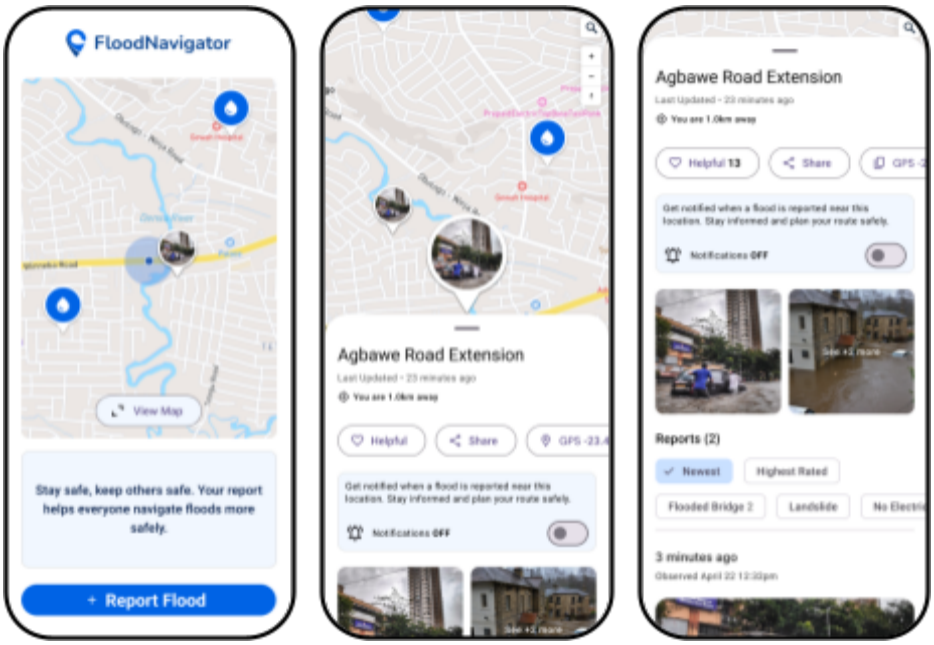
A final round of iteration based on the insights we gathered through usability testing led us to finalize the designs of FloodNavigator.

Onboarding:

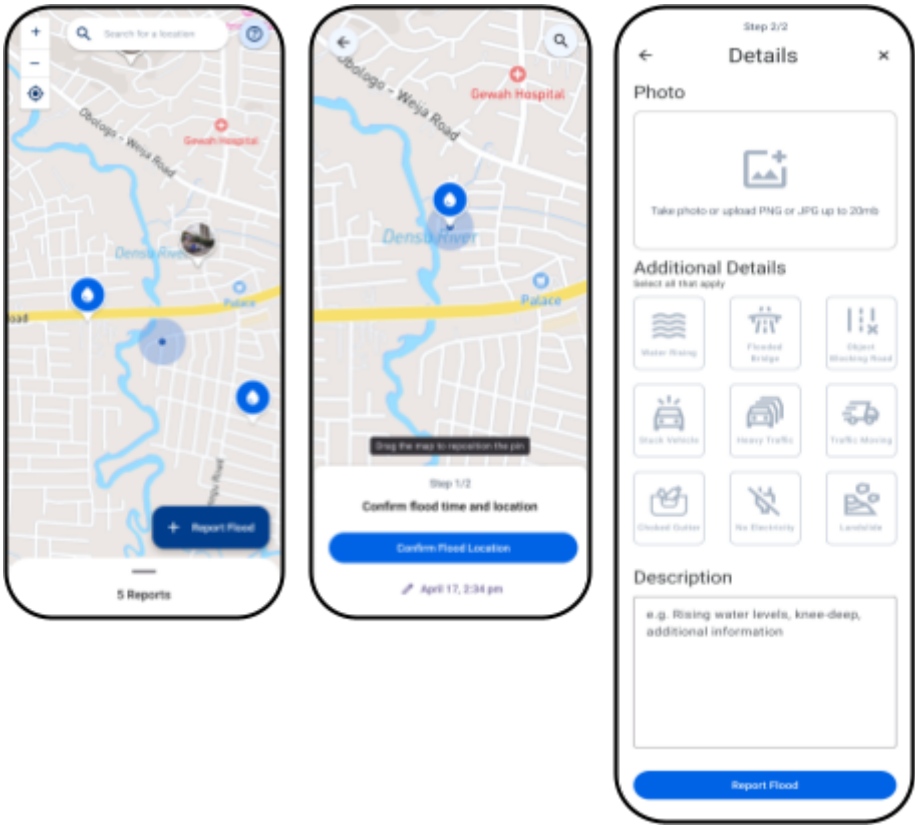


(Due to time constraints, this has been designed but has not yet been implemented.)

Viewing Flood Reports:



Making a Flood Report:



Technological Decisions and Development

Due to time constraints and the expertise on our team, we decided to develop a web app for our MVP. Our web app allows for cross-platform compatibility, meaning that users will have a consistent experience on FloodNavigator regardless of the device, operating system, or browser they use. However, since we know that over 80% of mobile users in Ghana utilize Android devices, we made technological decisions that would help FloodNavigator feel familiar and intuitive to our target audience (StatCounter Global Stats., n.d.).

Front-End Architecture

Development:

The front-end was built using **React** with the **Next.js** framework. We chose React for its robust library capabilities, performance-first approach, and reusable component architecture. To bring our designs to life in the MVP, we used **Material UI**. Since Material UI is the React version of Google's Material Design language, following this design system allowed us to closely mimic the Android device experience. For additional custom styling, we used **Tailwind CSS**. For the map itself, we used **Mapbox**, as it had a wide variety of custom templates for our map, offline functionality, and advanced data visualization tools we plan to take advantage of in the future.

Deployment:

The front-end is hosted on **Vercel**, which ensures HTTPS deployment for a secure connection. To provide additional data security measures for our users, we also implemented **VAPID** (Voluntary Application Server Identification) to ensure that all data is encrypted in transit.

Back-End Architecture

Development:

The back-end was built using **Django**, due to the framework's security as well as its pre-built components that made it much easier and faster to build our web app in the short amount of time we had. Additionally, Django is designed for scalability, meaning no significant infrastructure changes will be needed once FloodNavigator begins to scale and get more user traffic. We used **PostgreSQL** as our database to store our flood reports and containerized our app using **Docker** to ensure that it would run consistently across environments during the development process.

Deployment:

The back-end infrastructure is hosted on **DigitalOcean** and uses **NGINX** as the server. We used **Gunicorn** as the server to interface between our Django application and NGINX, acting as the "middleman" between the two. To provide data security for our users on the back-end, we incorporated multiple measures, including middleware, SSH key authentication for server access, and credential protection for the Django admin panel.

Derisking FloodNavigator

It was important to us to ensure we are building a tool that promotes a better, more resilient Accra without negative consequences. Through systems thinking and scenario planning, we considered the potential medium- and long-term consequences of FloodNavigator and designed mechanisms for mitigating negative impacts.

Digital Divide and Accessibility

We identified that requiring access to smartphones and mobile data could exacerbate existing inequalities, leaving out low-income residents or marginalized groups without such devices. This risk emerged through primary interviews with local commuters, secondary research on mobile access patterns in Accra, and horizon scanning that examined broader technology trends in the region. To mitigate this, we plan to integrate our system with offline channels, such as local FM radio and existing WhatsApp broadcast groups, ensuring that flood warnings and updates reach those without direct access to the app. Additionally, we aim to co-design the system with local community groups to tailor communication methods to the needs of different population segments.

Data Misuse and Privacy

We recognized that collecting geolocated flood reports raises concerns about surveillance, political misuse, or unintended exposure of sensitive locations. This risk was highlighted through scenario planning exercises, stakeholder consultations, and a review of academic literature on civic data collection in politically sensitive environments. To address this, we will design the system to allow anonymous reporting (as mentioned earlier) and ensure that any data shared externally is presented only in aggregated, non-identifiable form. Again, we also plan to implement robust data governance practices and openly communicate privacy safeguards to users to build trust.

Over-Reliance and System Failure

We acknowledged that communities could become overly dependent on the app, creating a dangerous single point of failure in times of crisis if the system were to go offline or malfunction. This risk became apparent through Four Futures scenario exercises, where we tested how our innovation would hold up in collapse or transformation scenarios, and through expert feedback on resilience strategies. To mitigate this, we are intentionally blending digital and non-digital strategies — combining app-based alerts with community-level public announcements, printed maps, and partnerships with local disaster response leaders. We are also exploring technical redundancies, such as integrating with government emergency channels, to avoid sole reliance on any one tool.

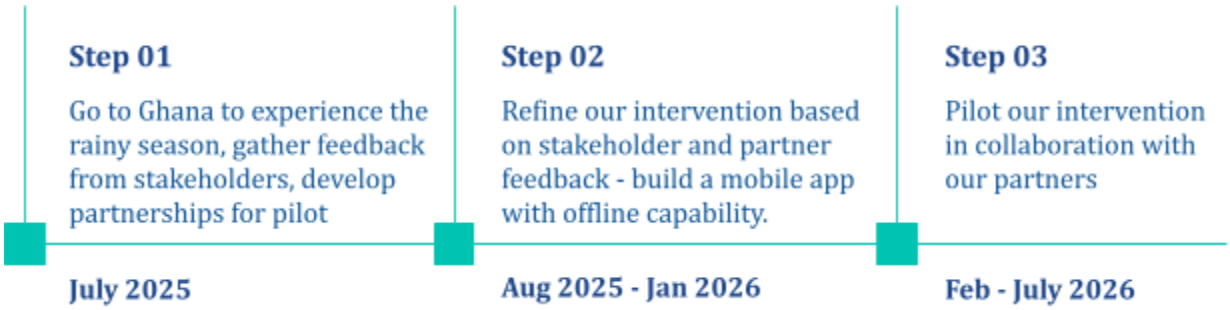
Financial Sustainability Risk

We recognized that relying solely on grant funding poses a significant risk to the long-term survival and impact of FloodNavigator. This insight emerged through our funding landscape analysis, scenario planning, and a review of similar civic technology initiatives that struggled to scale or maintain services after initial grants ended. To mitigate this risk, we have built income-generating

strategies directly into our model: we plan to offer local businesses the option to pay for map listings within the app and to sell aggregated, non-identifiable flood data insights to government agencies, insurers, and other stakeholders focused on urban resilience. These self-sustaining revenue streams are designed to reduce dependence on time-limited external funding, ensure continuous operation and improvement of the platform, and align our financial incentives with the broader social and economic benefits the system provides.

- Microinsurance: Offer payouts to vendors disrupted by flooding, verified through app data.
- Platform integrations: Partner with Uber, Bolt, and Yango to share data.
- Flood sensors: Lease affordable water-level sensors to businesses for hyper-local alerts.
- Peer-to-peer incentives: Enable users to reward helpful reports with micropayments with a small platform fee.
- Donations: Encourage in-app giving to support free access for all users.

Our Next Steps



Customer Discovery in Accra

Leaning In To Our Community-Centered Theory of Change:
Our theory of change is rooted in community partnership, cultural understanding, and a go-to-market strategy designed around social resilience. Research on flood communication in Accra shows community involvement strengthens engagement and motivates preparedness (Abunyewah et al., 2023). Inspired by this, as well as the need to develop a self-sustaining solution, our plan for the next year focuses on three core goals:

- Build a network of early adopters by forming partnerships with trusted community leaders and organizations
- Deploy MVP and gather feedback from our target audiences
- Explore revenue models that expand our social impact

Thus, in the Summer of 2025, we will travel to Ghana to kick off further research and partnership development. We will lead participatory design workshops and focus groups to ensure the app reflects the community's needs. These sessions not only guide product development but also build trust and foster a sense of ownership by showing partners that their input directly shapes FloodNavigator. By August, we will mobilize and train a network of “community ambassadors” who will document local flooding and promote FloodNavigator within their networks. Ambassadors will receive incentives to support adoption, especially in underrepresented neighborhoods.

Stakeholder engagements will also serve as forums for exploring potential revenue models that can enhance our social mission and ensure we can continue serving the community long-term. These are the revenue models we will gauge the viability of through conversations during our 2025 pilot that will inform further experimentation in 2026:

- Microinsurance: Offer payouts to vendors disrupted by flooding, verified through app data.
- Platform integrations: Partner with Uber, Bolt, and Yango to share data.
- Flood sensors: Lease affordable water-level sensors to businesses for hyper-local alerts.

- Peer-to-peer incentives: Enable users to reward helpful reports with micropayments with a small platform fee.
- Donations: Encourage in-app giving to support free access for all users.

Measuring Success:

Goals	Key Outcomes	Success Metrics
Build a network of early adopters through trusted leaders and organizations	1. Partner with trusted community leaders and organizations to pilot FloodNavigator 2. Establish community ambassador program	1. 5 community organizations committed to partnering ○ Reports and usage among 500 rideshare drivers and 200 market vendors 2. 30 community ambassadors across 3 neighborhoods
Explore revenue models that expand our social impact	1. Estimate impact of potential revenue models 2. Estimate expected income and timeline of potential revenue models	1. Qualitative understanding of impact formed through interviews, participatory design, and market research 2. Conduct 5 likeliness-to-pay interviews per revenue stream
Deploy MVP and gather feedback	1. Users of FloodNavigator find it simple 2. Users of FloodNavigator find it reliable 3. Users of FloodNavigator find it accessible	1. Features pass usability tests 2. Likert-style survey question scores above ⅘. 3. Likert-style survey question scores above ⅘.
	1. Users of FloodNavigator tell other people in their community about the app 2. During rains, people use FloodNavigator 3. People feel safer and more empowered with mobile access to flooding information	1. NPS score above 50; “How did you hear about us” poll shows 50% via word-of-mouth channels 2. Squarespace analytics show at least 1000 unique visits; during each rain, at least 5 pictures of floods are provided 3. Express feelings of safety, security, and empowerment in qualitative interviews and surveys

Our Long-Term Impact

Over time, FloodNavigator's crowdsourced reports—including photos, locations, and timestamps—will form a robust dataset that city planners can use to identify high-risk areas and prioritize flood mitigation. This data will also support strategic investments in drainage, waste management, emergency preparedness, and transportation infrastructure. This work is especially urgent, as research shows that socially vulnerable groups are often underrepresented in disaster response efforts—largely due to a lack of accurate, real-time information (Esparza et al., 2023).

While we are focused on Accra today, the challenges FloodNavigator addresses are shared by rapidly urbanizing cities across West Africa and the Global South. As climate change accelerates the frequency and severity of urban flooding, FloodNavigator's lightweight, community-driven model can be adapted and scaled to help other cities build resilience and adapt to the evolving climate.

Our Team

Leslie Noye—Visionary and Product Manager. Leslie is a Masters of Information Management and Systems candidate at UC Berkeley, where he focuses on leveraging technology for social impact. He lived in Accra, Ghana for 12 years before immigrating to the U.S. He graduated from the University of Southern California with a BA in Journalism. Leslie's career has taken him through roles in digital marketing strategy and product management at tech giants like Google and Yelp.

Frances Brittingham - Product, Market, and User Researcher. Frances is a Masters of Information Management and Systems candidate at UC Berkeley. She uses human-centered design and research skills to drive the customer discovery process for her ventures. She's a serial social entrepreneur who loves getting her hands dirty, building new technology, and getting it into the hands of users to learn how to make an even better product for them.

Cameron Kurtz - Product Designer. Cameron is a Masters of Information Management and Systems candidate at UC Berkeley. He earned his undergraduate degree in visual communication design at San Francisco State University. Cameron is passionate about transforming ambitious, impactful technology ideas into intuitive products with delightful user experiences that improve lives.

Delvin Marimo - Data and Software Engineer. Delvin is a Masters of Information Management and Systems candidate at UC Berkeley. He earned his undergraduate degree in Electrical Engineering where he utilized machine learning to train IoT devices. He is passionate about all things data and the use of technology to drive change for people living with disabilities. Delvin has experience in data and software engineering roles working for companies like Siemens and Amazon.

Victor Ngetich - Software and Machine Learning Engineer. Victor is a Mastercard Foundation Scholar and a Masters of Information Management and Systems candidate at UC Berkeley. His background is in computer science. He worked as a software engineer at Flux in Nairobi, Kenya, where he built a web platform for mapping the coverage and impact of water, sanitation, and hygiene facilities. He combines technical skills with strategic and entrepreneurial thinking to develop scalable technological solutions that create positive social change.

Maya Schoucair - Data and Policy Analyst. Maya is a Masters of Information Management and Systems candidate at UC Berkeley. She focuses on the intersection between data, policy, and behavioral science. Due to her upbringing in the Philippines, she's particularly interested in using novel big data sources to help people in developing countries. She hopes to help advance the use of such data to aid policymakers in making informed decisions.

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