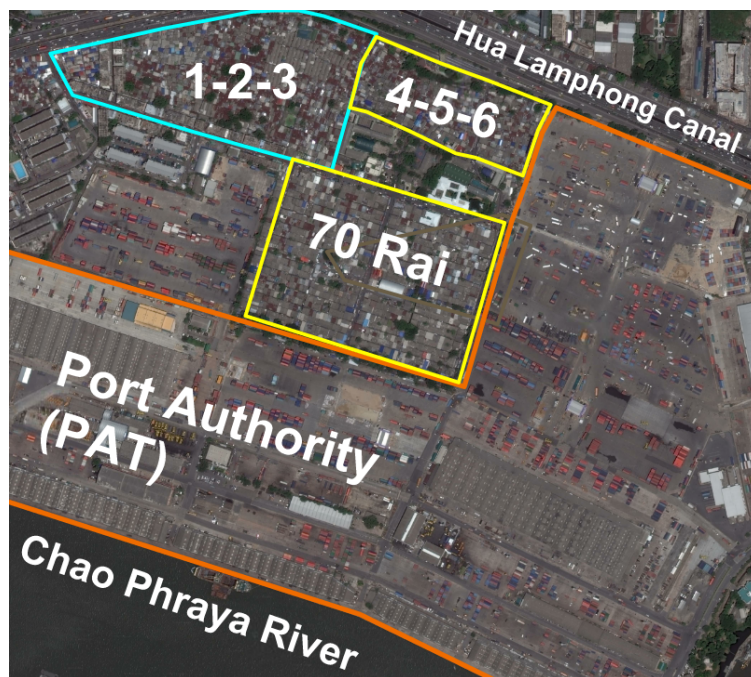


# Executive Summary

## Introduction and Background

One quarter of the world's urban population lives in slums, the most deprived and isolated form of informal settlement, where occupants have no right to the land. Often, slum residents suffer disproportionately to natural disasters because the only affordable land is located in highly undesirable areas. This relationship between poverty, location, and the environment is referred to as “environmental justice” (Habitat iii, 2016). The most common and pervasive problems in slum communities often include improper sanitation, lack of infrastructure for drainage and waste removal, lack of adequate housing, and increased exposure to environmental threats such as flooding, monsoons, and volatile weather (Informal Settlements, 2015).

Our project focused specifically on the Khlong Toei slum in Bangkok, Thailand. The slum is made up of three communities: Locks 1-2-3, Locks 4-5-6, and 70 Rai.



**Figure A: Aerial Road Map of Khlong Toei**

Located on a plot of land owned by the Port Authority of Thailand (PAT), the community is built over swampland and thus experiences frequent floods, especially during the Southwest and Northeast monsoons (Drakakis-Smith, 2012). Standing water resulting from such flooding acts as a breeding ground for mosquitoes and causes many health problems for the community (Pii Fay, personal communication, 12 January 2017). The sponsor we worked with during our project was the Duang Prateep Foundation (DPF), a non-profit organization that aims to address five overarching issues in the slum: education, health, social services, human development, and emergency funding (Murray, 2007). One of the best ways to assist the DPF in helping the community is to provide tangible information the DPF can use to convey the flooding problem to key stakeholders.

## Goal, Objectives, and Methodology

The goal of our project was to convey vulnerabilities to flooding within the Khlong Toei slum of Bangkok, Thailand in order to enable the DPF to bring about change, which will ultimately mitigate the effects of flooding within the community. In order to accomplish this goal, we divided our research into four objectives:

1. Analyze the physical attributes of the slum in order to understand the vulnerability to flooding in Khlong Toei.

In order to gain understanding of Khlong Toei's current state of flooding, we visited the slum, performed interviews with Khlong Toei residents, community leaders, and Duang Prateep Foundation officials, and took measurements within the slum's walkways. The attributes we recorded were the elevation, trash buildup in drains, water flow, depth of the drains, and depth of standing water.

2. Investigate the social factors that are inhibiting progress towards flooding solutions.

Our group interviewed many of the key stakeholders whose roles play into the mitigation of flooding in Khlong Toei. We first spoke with the Kru Prateep (leader of the DPF), and community leaders to begin to understand the relationship between different parties which affect flooding in the slum. Later on we interviewed representatives from the PAT, Pavarich Meebangsai of the Khlong Toei District Department of Drainage and Sewage, and Dr. Sapon Pornchokchai, a local researcher of slums to figure out what is preventing the community from solving the flooding problem.

3. Develop visualization tools displaying both notable contributors to flooding and areas that are most vulnerable to flooding.

After gathering substantial data regarding the physical infrastructure present in the slum, we used a software called QGIS to generate maps of the community depicting the most susceptible areas to flooding based off of the attributes described in Objective 1. Visualizing this data and overlaying maps allowed us to see many trends and correlations affecting flooding that were not immediately obvious.

4. Identify feasible solutions to be implemented by the DPF in conjunction with the Port Authority of Thailand and the Khlong Toei District Office for long-term flooding mitigation in the Khlong Toei slum.

In order to further help the DPF explain flooding in the slum to stakeholders, we developed an action plan timeline outlining our recommendations for the DPF. We prioritized recommendations that could feasibly be implemented before the monsoon season in May, and also provided long-term strategies.

## Results and Findings

After analyzing the data we collected, we were able to organize our findings into three different categories: the current state of drainage in Khlong Toei, the major contributors to flooding,

and the relationships between key stakeholders. We have highlighted the key findings in each of these areas below.

Finding: Failing drainage systems lead to flooding in Khlong Toei.

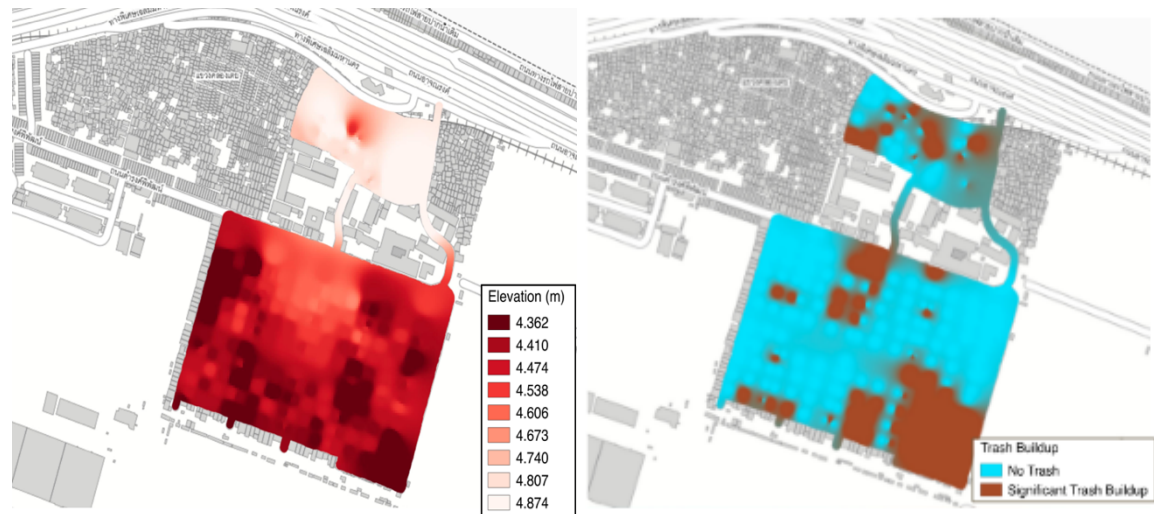
From our interviews and first-hand inspection, we found that water located in the drainage trenches situated along the sides of the walkways is predominantly stagnant and is pooling due to clogging. During periods of intense rainfall, rainwater adds to the volume of this standing water and flooding occurs. Shown below is an example of one of the clogged drainage trenches preventing water flow in the Khlong Toei slum.



**Figure B: Trash Buildup in the Drains Preventing Water Flow**

Finding: Lower lying areas in Khlong Toei are more susceptible to flooding because water flow brings trash and sediment, which clogs the drains.

We found that the areas of lower elevation in the slum tend to be where trash builds up. This is because as water flows toward locations of lower elevation, it brings with it trash and sediment which clog the drains. This decreases the effective depth of the drains and makes these areas more likely to flood when it rains. Seen below are maps of both the elevation as well as the trash buildup in both 70 Rai and Locks 4-5.



**Figure C: Map of Elevation (Left) and Areas of Trash Buildup (Right)**

Finding: The water from Khlong Toei cannot be released to the Chao Phraya River due to the water quality.

We collected water from 70 Rai and submitted it to the Environmental Research Institute at Chulalongkorn University. We compared the results with the acceptable water quality based on the Pollution Control Department of Thailand and found the water quality in the southeast corner of 70 Rai does not meet the standard, and therefore cannot be released directly into the Chao Phraya River. Until the water quality is improved, the drainage infrastructure problem leading to flooding will continue to persist in Khlong Toei.

Finding: Many residents of Khlong Toei lack motivation to improve their quality of living.

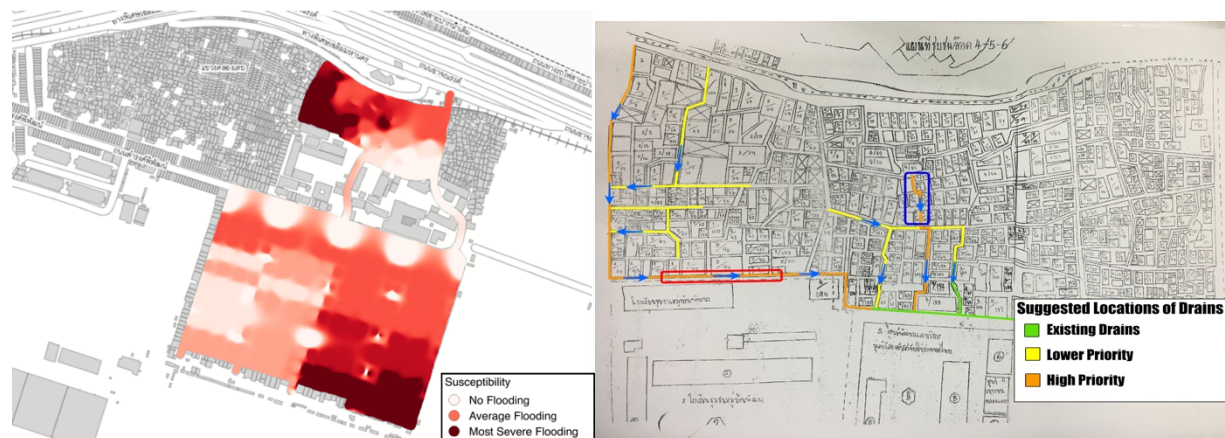
The residents believe they will be evicted in the near future and thus have very little motivation to improve their current living situation. Additionally, they do not own the land and believe action should be taken not by themselves, but by the landowner (the PAT). This attitude makes it very difficult for programs to gain traction and be sustained, as the residents have trouble committing to community efforts.

## Recommendations

Following from our findings, we outlined recommendations for key stakeholders in the Khlong Toei community to begin mitigating flooding. Below we have highlighted three of the most important.

Recommendation: Residents add new drainage channels to Locks 4-5

The residents of Khlong Toei installed a new pipe in the northern part of Locks 1-2-3, which connected to the Bangkok Metropolitan Drainage System and allowed water to flow directly into the canal to the north instead of all the way down through 70 Rai. We recommend the residents install similar additional drainage infrastructure in certain locations in Locks 4-5. The first map of Locks 4-5 shown below outlines in red the most susceptible areas to flooding in Locks 4-5, as well as the current formal drainage system in green. The second map lays out our recommended drainage system plan, which targets the most susceptible areas. Shown in orange are the most essential drains, while those in yellow are less necessary but would be useful with more time and resources. The blue arrows dictate water flow.



**Figure D: Map of Susceptibility (Left) and Suggested Drainage Plan (Right)**



Recommendation: Community leaders establish recurring drainage community cleaning days with Khlong Toei District.

The Khlong Toei District occasionally helps residents of the slum clean the drainage system by providing labor and materials. In the past, the District and community leaders struggled to schedule a time together because the residents are typically working their day jobs when the District is available. We are recommending both parties plan recurring community cleaning days on holidays such as Mother's day, Father's day, and certain national Buddhist holidays when both parties are available.

Recommendation: The DPF and community leaders establish waste management initiatives with the residents.

After finding that areas of trash buildup are strongly correlated with the most flood-prone areas in the slum, we recommend the DPF and community leaders initiate and lead the formation of waste management programs that incentivize the residents to clean using some sort of exchange reward. Successful programs in the past included "Garbage for Eggs" and "Trash for Toothpaste" where residents traded garbage for eggs or toothpaste, respectively.

## **Conclusion**

Flooding in Khlong Toei remains a serious problem that affects the daily lives and health of the residents of the community. To try to further the progress towards a sustainable, feasible solution our team constructed a collection of maps depicting many factors surrounding the state of flooding in Khlong Toei in order to help the DPF advocate for the slum to external stakeholders. Additionally, we devised an action plan consisting of a series of recommendations for the DPF to begin implementing before the monsoon season. We hope our recommendations, along with our deliverables, will help the DPF begin to mitigate flooding in the Khlong Toei slum.