Team AdverCity

Matt, Cindy, Emily, Aditi, Vikram, Johan

The Team

Dynamics and Roles

Matt, United States

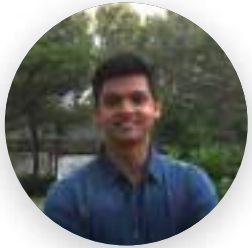
Infrastructure research, team lead

Cindy, Canada

Data Analytics, Educational Plans, Research

Emily, United States

Educational Plans, Research, Writing



Vikram, India

Machine Learning, Data Analysis

Johan, United States

Waste Management, Research, Design

Aditi, India

Seawall Research, Design

Defining the Problem

Sea Level Rise

Over the next few decades, the entire world will experience sea level rise. This will **exacerbate storms, weaken coastal cities, harm fisheries, and cause numerous other problems.** However, Jakarta, Indonesia will experience more severe sea-level rise than most of the world because of its unique under-sea geography and gulf-stream water pressure that gets trapped by the cluster of land masses.

Devastating tsunamis hit Sulawesi and Sula Strait in 2018, killing thousands and revealing several weaknesses of disaster management institutions in the country. These disasters paralyzed the economy while the mass migration of tsunami victims to Jakarta has raised concerns in Indonesia's most populous city. Sea-level rise could increase flooding and tsunami risk in a city already struggling with congestion, urban planning, and hygiene/health.

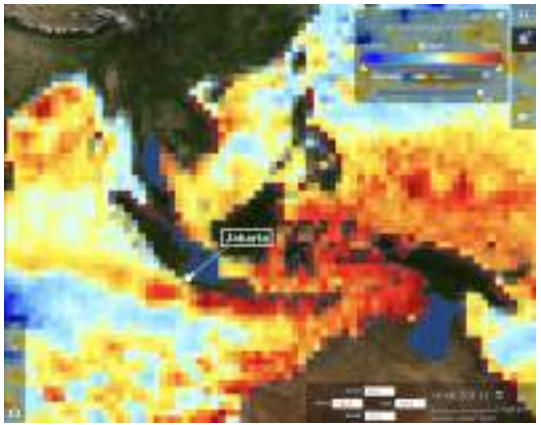


Figure 1: Abnormally high sea rise around the Jakarta area will exacerbate future storms

Defining the Problem

Infrastructure

Jakarta is sinking because:

1. Sea-level rise is consuming the coastlines
2. Storms are disintegrating the city's foundation and overwhelming the current drainage solutions
3. The people of Jakarta are taking drinking water from the aquifer below the city, causing the land to fall with the dwindling aquifer level

Therefore, we need to solve **all three** of these problems to keep the **populous** and **economically-crucial** city **thriving**.

Defining the Problem

Education: A Two-Pronged Concern

Public Awareness

Tsunami/flood warning systems are often damaged in natural disasters, and with communications down, community awareness is crucial to public safety. As an island nation with uncoordinated governmental education, information dissemination is extremely difficult. Few are aware of the devastating effects of sea level rise or how to handle natural disasters.

Climate Data Knowledge

In Indonesia, there is little coordination and analysis of climate data and reliable weather forecasts to the local population. As a result, farmers and fishermen often have little awareness of projected climate trends and are unable to implement effective adaptation strategies.

Therefore, we need to **educate** and **intensify the awareness** of sea-level rise in Jakarta while also gathering **critical climate data**.

Our Hypothesis

Primary Hypothesis: Building natural and innovative sea-walls will fortify the city, its inhabitants, and its thriving economy.

Secondary Hypothesis: Improving access to climate-related data will reduce the impact of natural disasters on local populations by allowing them to better understand and adapt to climate trends.

Our Plan

Problem: Jakarta is flooding because of coastline erosion and unsustainable flood-protection solutions. The population is poorly education on the situation

Seawalls: A living seawall and an innovative artificial one, when combines, will effectively quell sea surges in the city.

Drainage: Redesigning drains with one-way valves and using waste buildup as compost will clear the city of the flood.

Education: Building a machine-learning model to better understand local sea-level rise & increase public awareness

Effects:

Flooding is controlled and reduced in the long-term.

People will know how to react to floods.

We can better predict floods.

Research Methods

Finding Information

Text-Based Research

We obtained our research from a variety of publications, from local news sources, to US-based scientific primary articles. We wanted to ensure that our research encompassed and fairly represented the people of Jakarta while still being scientifically accurate. Without this holistic research, the plan would be useless and unrepresentative.

Outreach-Based Research

We reached out to an extremely diverse group of experts. This included Jakarta-based groups like their version of the Red Cross, national water management institutions, and researchers/scientists. These experts gave us feedback that helped us shape our project. Once revised, their insights reinforced our plan, giving us additional confidence.

Infrastructure
Seawalls

Our infrastructure solution addresses the most prevalent issues mentioned earlier in the presentation. Our priorities were to make it sustainable, accessible, maintenance-free, and could integrate into the city. The model is a combination of artificial walls using porous concrete which can absorb and withstand salt water in key areas integrated with small 'habitat' pools, genetically-modified mangroves to provide a natural, sustainable barrier further on the coastline and irregular natural boulders in order to ensure a gentle slope which would absorb & reflect incoming wave energy.

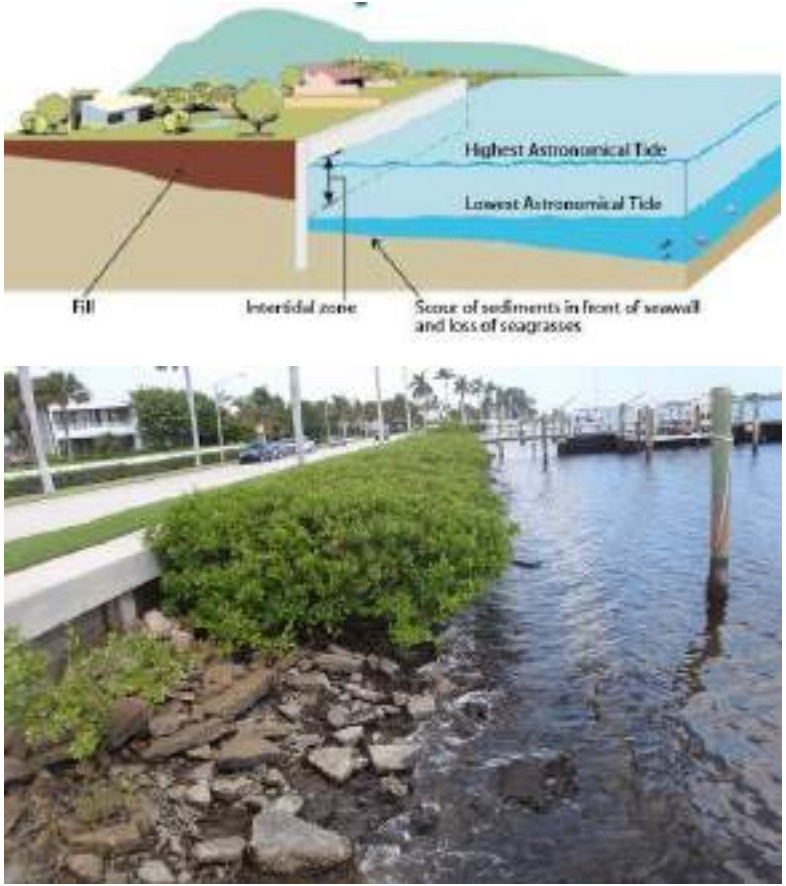


Figure 2: An example of a living shoreline in Florida to protect the busy, economically-crucial road from rising tides

Infrastructure

Waste Management & Drains

Accumulation of wastes elevates sea levels, as certain parts of the drain and sewage systems are clogged by trash. In the event of a storm, water gets collected until it gushes out to the urban areas of the city.

To counter this problem we proposed to redesign drains by using polymer concrete instead of concrete material for construction and one-way valves as well as pumps for channeling waste. Polymer concrete is much more durable, stable, and light when compared to its counterparts. The V-shape of the channels along with the in-built slope further facilitates the faster flow of water. We also plan to process waste materials as compost for plantation fields. Organic wastes are extracted and reprocessed to become organic fertilizers.

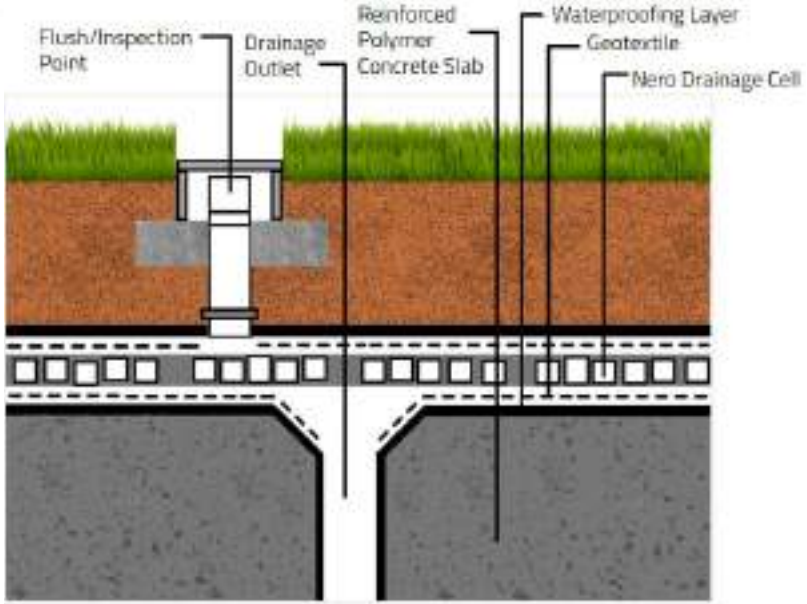


Figure 3: This diagram shows how the flood water would be efficiently drained from the city in a sustainable and implementable fashion.

Education

Public Awareness

Basis	Adaptation	Future
Between 2009-2011, the United Nations Development Program (UNDP) executed the Safer Communities Disaster Risk Reduction project in the district of Aceh Indonesia. Using $200 million in donations and involved the integration of disaster awareness/training modules for elementary, junior, and high school students.	Expanding upon the structures developed through the project in Aceh, we suggest that the government communicate the UNDP's high school level educational modules to local community members during an annual development plan called *musrembang.*	The success in training students in Aceh could be easily applied to a larger scale in Jakarta for little cost, as the educational materials have already been created.

Education
Public Awareness

Educational Model Specifics

Musrembang

- Annual community development meetings where residents collaborate with the government to provide input
- Open forum for the dissemination of information - specifically relating to current natural disaster threats

Government Considerations

(Based upon areas of improvement found by the UNDP)

- Must coordinate with local NGOs and international organizations to streamline efforts/funding
  - The Indonesian Red Cross implements similar trainings in Aceh as well - the government can harness volunteers from this program to defray costs
- Must take into account local religious authorities - tailor more effective messages/delivery
  - Indonesian society is highly superstitious and sometimes relies on faith-based knowledge as opposed to the sometimes unreliable government

Overall: We suggest implementing this feasible, cost-effective, and successful system of educational modules raising awareness of disasters heightened by sea-level rise and how to respond to them, taking into account social and religious structures already in place and lessons learned from past data.

Education
Database

In Indonesia, the analysis of climate data, reliable weather forecasts, and climate information, are still lacking significantly. For an early warning system to function, coordination and synchronization of disaster data for all relevant stakeholders, both national and local, must be achieved. The logical step forward is to implement a system in which stakeholders can interact, to better achieve their objectives at different administrative levels.

The **Indonesia Disaster Data and Information** (DIBI) is a database which shows disaster data since 1815. Current capacity constraints include:

- Ineffective dissemination of information
- Untrained operators
- Poor communication network
- Inability to analyze and apply climate information

As part of our short-term solution, rather than creating a new database which would require a significant amount of time and money, we will be working off of DIBI by restructuring data input on a district, provincial, and national-level, as well as identifying training strategies such as technical training, field schools and community learning centers.

Education
Database

Short Term Implementation:

Current education efforts in Indonesia include the Public Awareness, Training and Education Program on Climate Change initiative. The aim of this local radio program is to help farming and fishing communities increase awareness of climate change and to create higher adaptive capacity. A governmental budget of $1,206,872 has already been approved for this project. We will be incorporating our own educational material into this existing campaign to ensure that our solution will be delivered to Indonesian communities within the first 6 months of implementation, with minimal additional costs.

Long Term Implementation:

As part of our long-term solution, we have created a **machine learning algorithm** which is able to predict floods before they strike. This program will allow citizens and the government to better prepare for response, recovery, and prevention through methods such as implementing supporting infrastructure. Additionally, the access of this data to the local population will be crucial to long-term development and adaptation strategy in Indonesia.

Predicting Floods

- Sea level data can be used to predict floods in Indonesia
- Indonesia can be better prepared for floods if they are informed of possible floods before they strike
- Datasets of floods that occurred around the globe since 1993 from University of Colorado were used in combination with sea level datasets from AVISO

So, we created a machine learning algorithm...

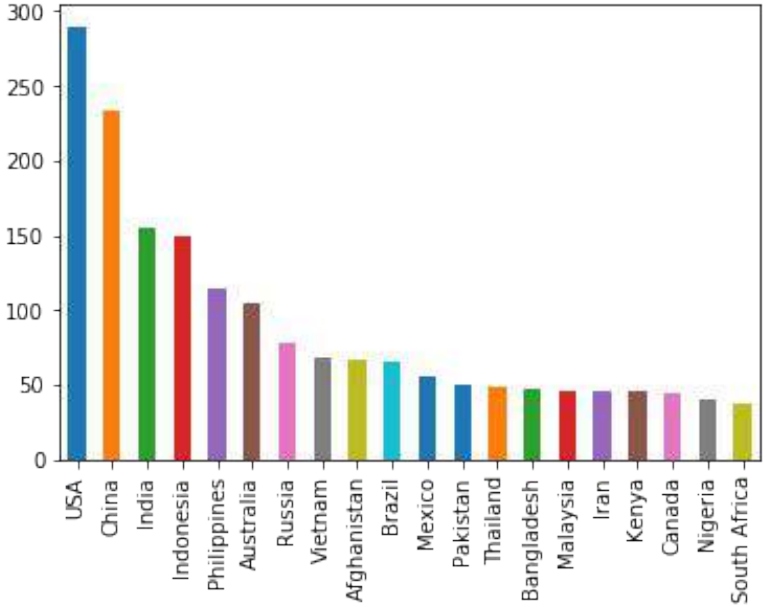
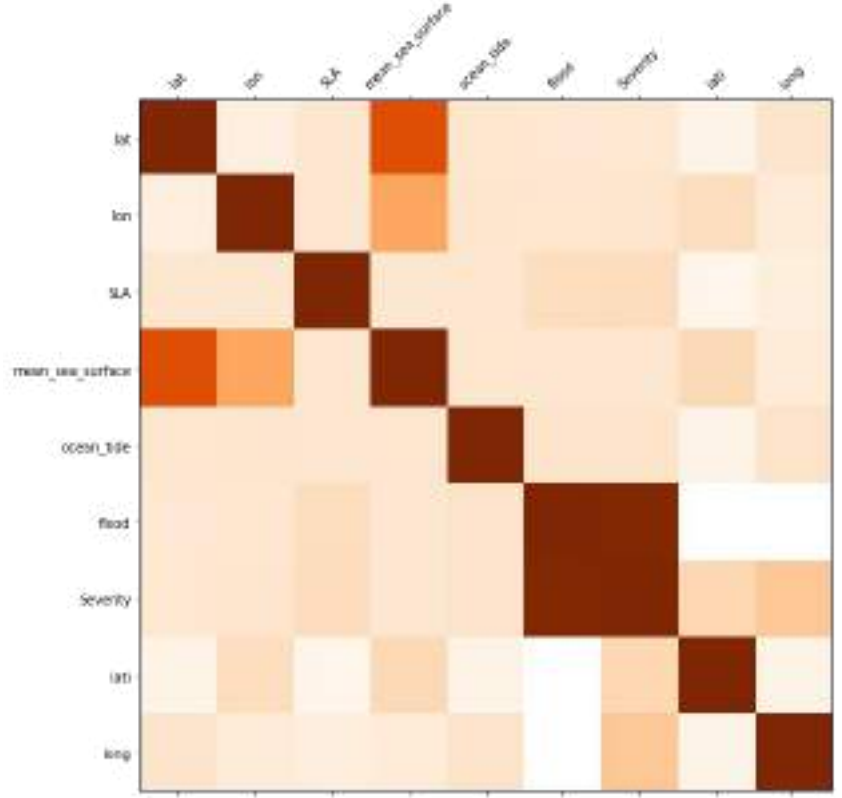


Table 1:

Indonesia is among the countries which experience the most number of floods

Machine Learning Model

- The correlation of variables in the dataset proved that floods had correlation with mean sea level, sea level anomalies, longitude and latitude.
- This made it possible for a decision tree based machine learning model to predict floods based on these factors with an accuracy of approximately **83%**.
- The machine learning model used a 20/80 test-train split.



Solution Results

Expert and Industry Feedback

Richard Van Bruggen

Water Resources Consulting Services

"I can say the construction and expansion of sea walls is an expanding science that does provide a defense for urban areas threatened by sea level rise. **Developing new eco-friendly designs and environmentally rugged materials for the construction of sea walls is a smart endeavor and worth pursuing**. I don't know anything about the durability or practicality of the use of mangroves, but that idea sounds like one worth looking at with the guidance of an arborist and eco-systems scientist. Temporary storage areas for stormwater drainage in low lying areas is commonly done through the use of **one way flap valves**, to release flood water during lower tidal stages, and automatically triggered pump systems."

Jared Caspar

Coastal Flooding Researcher and Expert

"In terms of the living shorelines, research shows that it's better than using a wall because that defects wave energy to adjacent areas but doesn't absorb any of it. If you use **sustainable ecology** such as naturally occurring marshes, plants, corals, logs, and mangroves to provide soft barriers then it will mitigate some of the wave energy. **Porous concrete is good** internally, especially areas that are concave and water will pool. Yes, **I think this plan will be effective.**"

Solution Potential and Sustainability

Social Impacts

Potential to Make a Difference by including minority groups in our solution. We have made sure to include a diverse representation the population in our solution. For example, Indonesian fisherman have been unfairly targeted by recent legislation that has hurt their business. Conversely, our plan makes sure to include them. The natural sea wall will not interfere with their fishing and the mangroves will enrich biodiversity and strengthen their economy.

Other than fishermen, women disproportionately face underrepresentation in Indonesian society. *Musrembang* meetings allow women to gain critical access to disaster preparedness information not often available in their limited education.

Commitment to Sustainability by using eco-friendly designs and materials for the construction of sea walls.

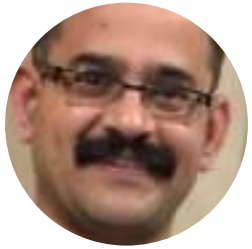
Our solution takes into consideration the long-term environmental impacts of a large scale sea wall project. The use of natural materials will mitigate some of the wave energy while preserving the fishing industry and marine wildlife.

We are improving biodiversity while protecting the prized shorelines of Jakarta. Shorelines across the world are vanishing, and we are proud to be rebuilding them with our solution.

Acknowledgements

Global STEM Alliance at The New York Academy of Sciences

Our most sincere thanks goes to the Global STEM Alliance and The New York Academy of Sciences for supporting a program that enables students from around the globe to put forward their best work and grow to become the next generation of STEM experts.



Our Mentor, Ganesh Nagarathnam

Our heartfelt gratitude goes to our wonderful mentor Ganesh, for guiding our approach with all his invaluable experiences, and associating us with some of the specialists from our project field. These connections have been vital in our solutions development.

All Experts Involved

Our earnest thanks goes to Richard Van Bruggen, Jared Caspar, and all other experts and advisors for their thoughtful and crucial feedback. These have been fundamental in our design process. We would also like to thank

References

- http://floodobservatory.colorado.edu/
- https://www.aviso.altimetry.fr/index.php?id=3047
- https://scikit-learn.org/stable/modules/tree.html
- https://gbdmagazine.com/2017/aco-uses-smart-design/
- https://www.nytimes.com/interactive/2017/12/21/world/asia/jakarta-sinking-climate.html
- https://www.nbcnews.com/mach/science/walls-won-t-save-our-cities-rising-seas-here-s-ncna786811
- http://www.id.undp.org/content/indonesia/en/home/operations/projects/crisis_prevention_and_recovery/safer-communities-through-disaster-risk-reduction-in-development.html
- https://www.undp.org/content/dam/indonesia/Project%20Docs/DRRA/11%20Report%20DRRA%20Project%20Evaluation%20Final.pdf
- https://www.devex.com/news/indonesia-disaster-reveals-community-preparedness-shortfalls-93634
- https://climateknowledgeportal.worldbank.org/country/indonesia/impacts-sea-level-rise
- https://www.redcross.org/content/dam/redcross/atg/PDF_s/Publications/Annual_Reports/TRP2YrReport.pdf