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20 YEARS

TSUNAMI THAILAND

WHITE PAPER

This white paper, based on tsunami research in Thailand funded by TSRI and NRCT, highlights ongoing concerns about future major earthquakes, despite the long recurrence interval of tsunamis like the 2004 event. Such earthquakes could originate from different subduction zones than in the past. Coastal areas like Khao Lak and Patong, with growing populations, face increased tsunami risks. To address this, the research has developed hazard and evacuation route maps to enhance public preparedness. An Agent-Based Modeling and Simulation has been also developed to analyze and improve evacuation efficiency.

Digital Content

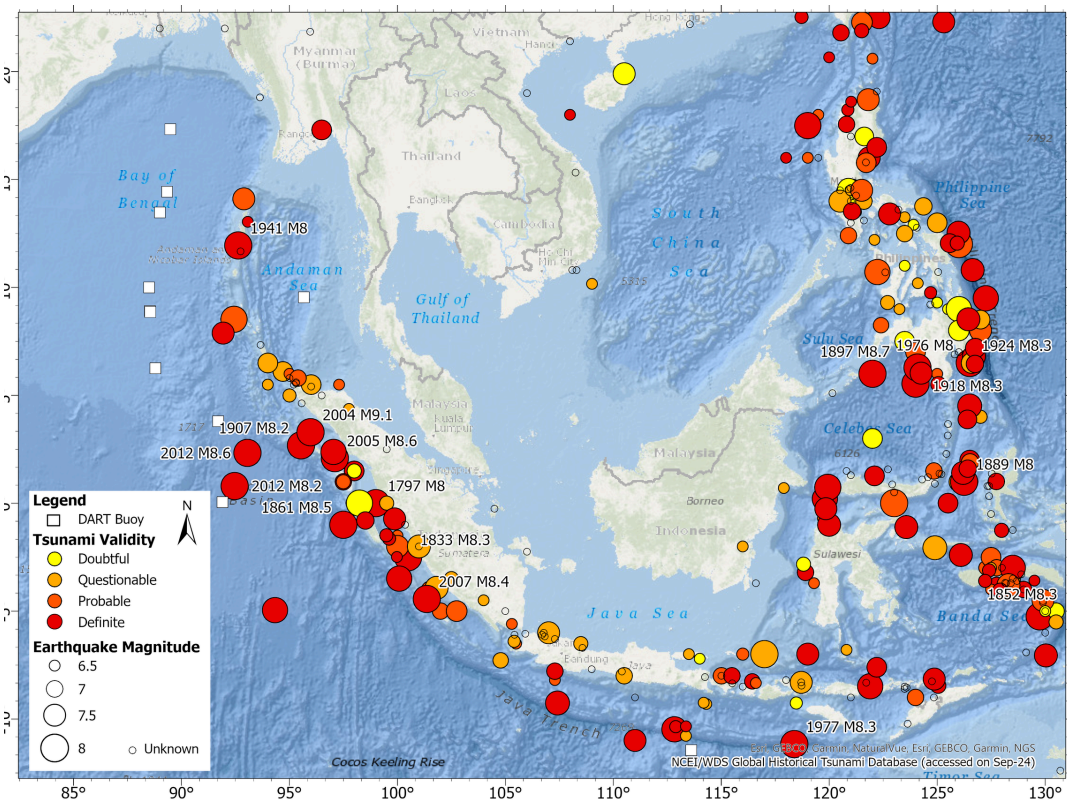
Background

Tsunami

The word tsunami comes from the Japanese “津波” and means "harbor wave," which refers to waves that crash onto the coast. Tsunamis are long waves that travel across the ocean and differ from normal ocean waves because they have a much longer wavelength. These waves are usually caused by sudden movements of the sea floor, usually by submarine earthquakes. In the deep sea, tsunamis are difficult to detect due to their low wave height. However, as they approach shallow coastal waters, they slow down, their wavelengths shorten, and their wave heights increase. When the waves reach the coast, they can reach several meters in height. For this reason, tsunamis are often referred to as "giant waves."

Historical Record

The historical tsunami database from the National Centers for Environmental Information (NCEI) in the United States has recorded over 2,800 tsunami events. These events are categorized into four main types: definite tsunamis (red), probable tsunamis (dark orange), questionable tsunamis (orange), and doubtful tsunamis (yellow). Interestingly, many events in the database date back over 1,000 years. This highlights the long recurrence interval of tsunamis but also underscores their persistent threat, which should not be overlooked.

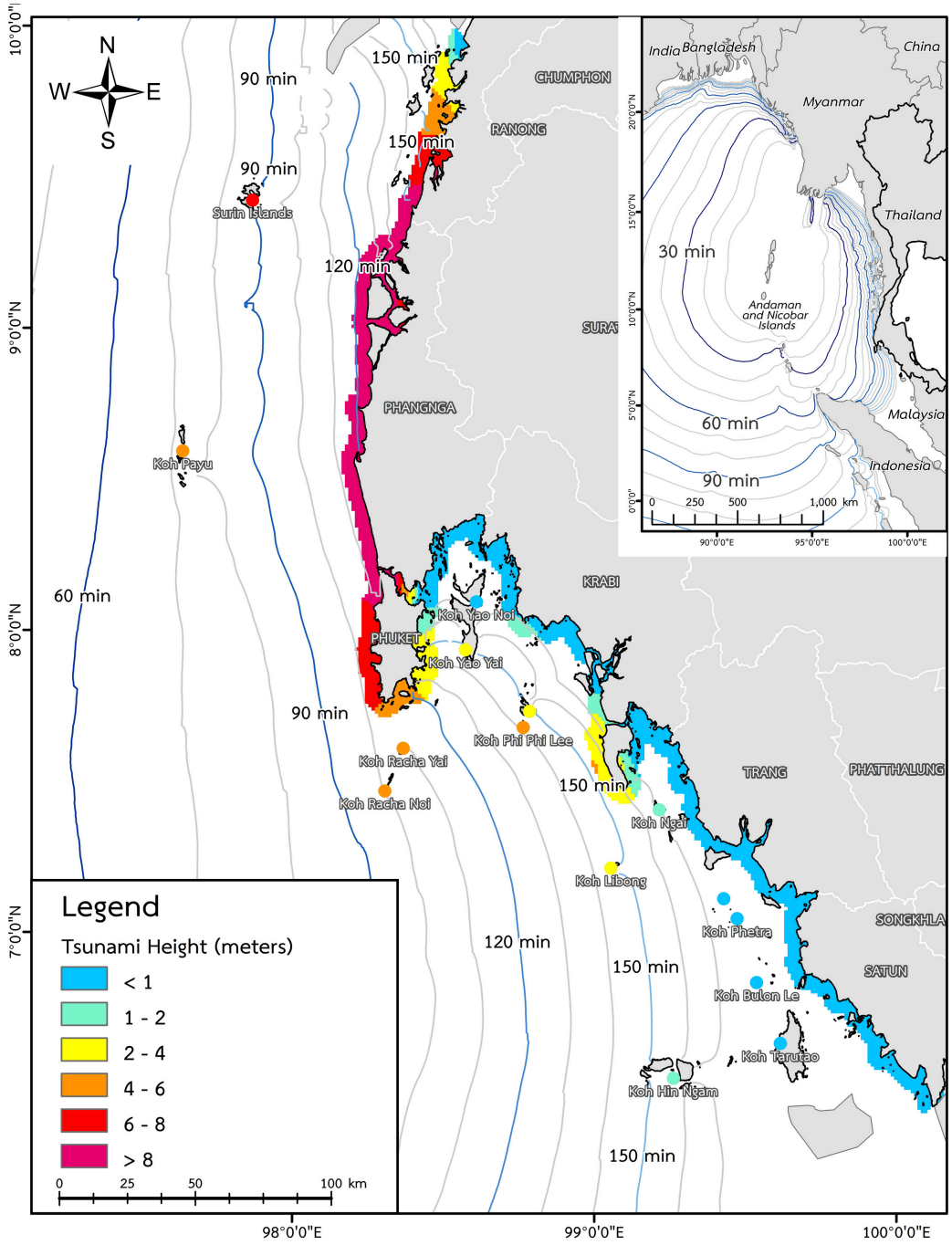


Significant Tsunami Events (More Than 1,000 Deaths)

Date	Magnitude	Epicenter	Country	Tsunami (m)	Death
16 Feb 1861	8.5	Southwest Sumatra	Indonesia	7	1,105
4 Jan 1907	8.2	Northwest Sumatra	Indonesia	15	2,188
16 Aug 1976	8	Moro Gulf	Philippines	9	6,800
26 Dec 2004	9.1	Off West Coast of Sumatra	Indonesia	51	227,899
28 Sep 2018	7.5	Sulawesi	Indonesia	11	4,340

Tsunami Hazard and Risk

The 2004 Indian Ocean tsunami was triggered by the massive release of energy from tectonic plate movements. Although such events have a recurrence interval of several hundred years, concerns remain about the potential for future major earthquakes, particularly from subduction zones different from those in the past. These could generate tsunamis as severe as, or nearly as devastating as, the 2004 event. Therefore, continuous monitoring and the preparation of effective evacuation measures are crucial to mitigate risks and protect lives.

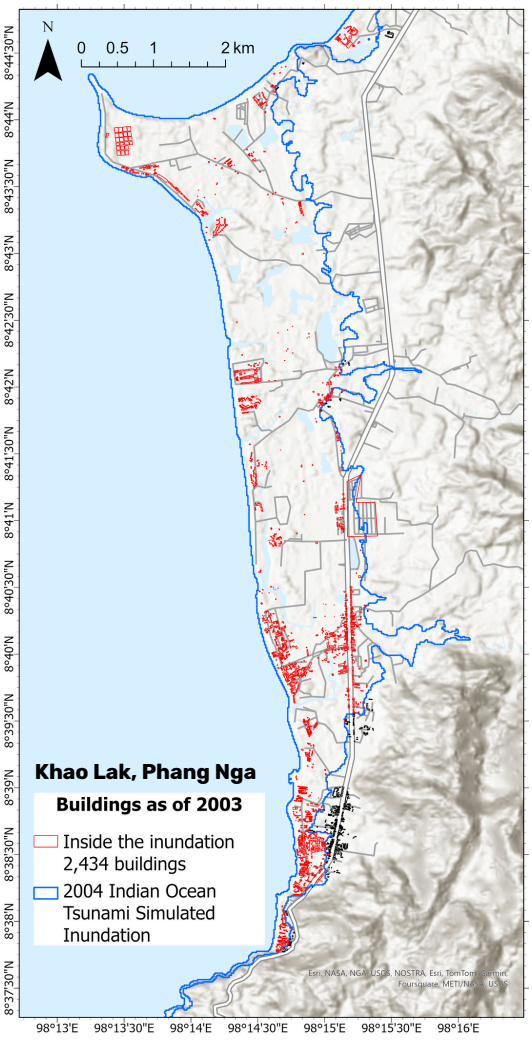


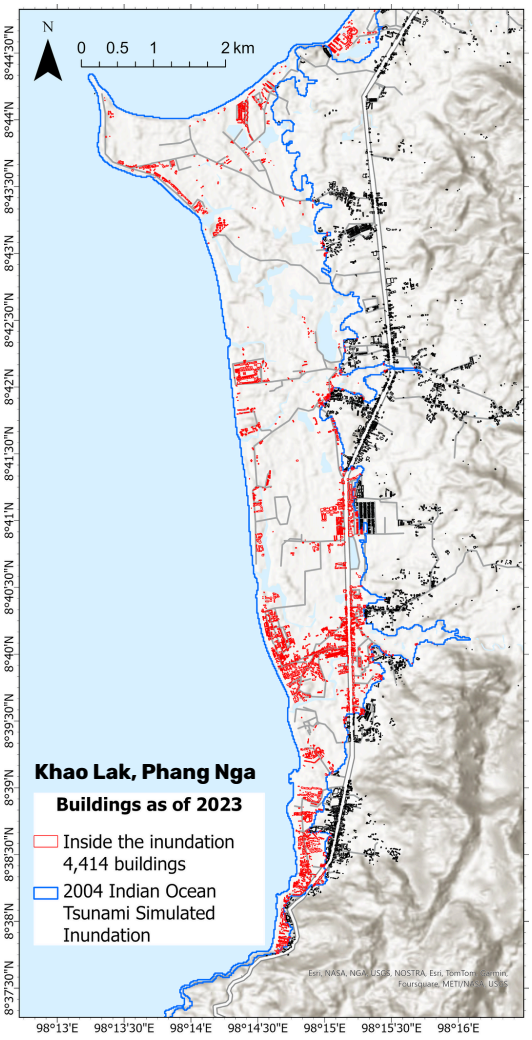
Simulation of Tsunami Heights and Arrival Times from M9.0 Earthquake near the Andaman-Nicobar Islands

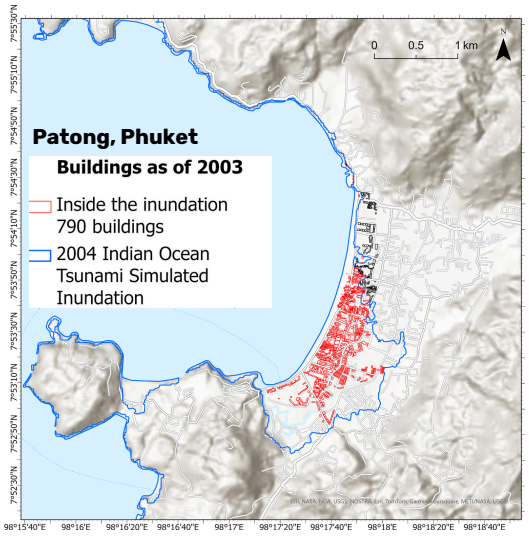
This map illustrates the tsunami risk from a potential 9.0 magnitude earthquake near the Andaman-Nicobar Islands. It uses a color gradient to depict wave heights, ranging from less than 1 meter (light blue) to over 8 meters (dark pink). Contour lines with numerical labels indicate the estimated time for the tsunami waves to reach various locations. For Phang Nga and Phuket, tsunami waves are expected to arrive within 90-120 minutes after the earthquake, highlighting the critical importance of early warning systems and well-prepared evacuation plans.

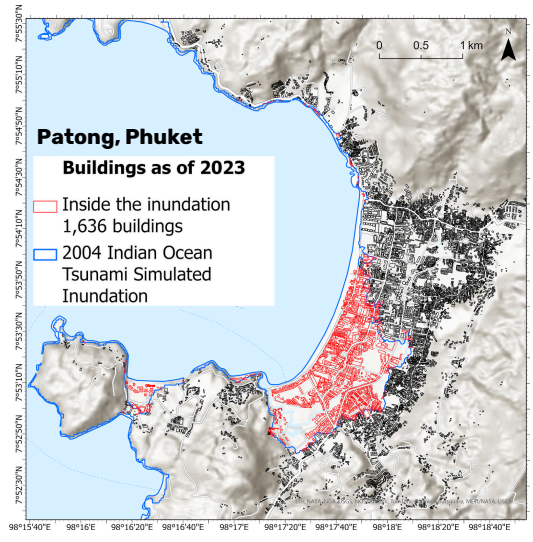
Population Growth

Coastal areas previously affected by the past tsunami have experienced significant growth in infrastructure and population, driven primarily by tourism. This figure shows the increase in population and buildings in Khao Lak, Phang Nga Province, and Patong, Phuket Province, between 2003 and 2023. The number of buildings in tsunami-affected areas has nearly doubled during this period. Such expansion has heightened the risk of potential future tsunamis. The impacts of these risks extend beyond tourists to include business owners, employees in restaurants, hotels, and shops located in these coastal areas.





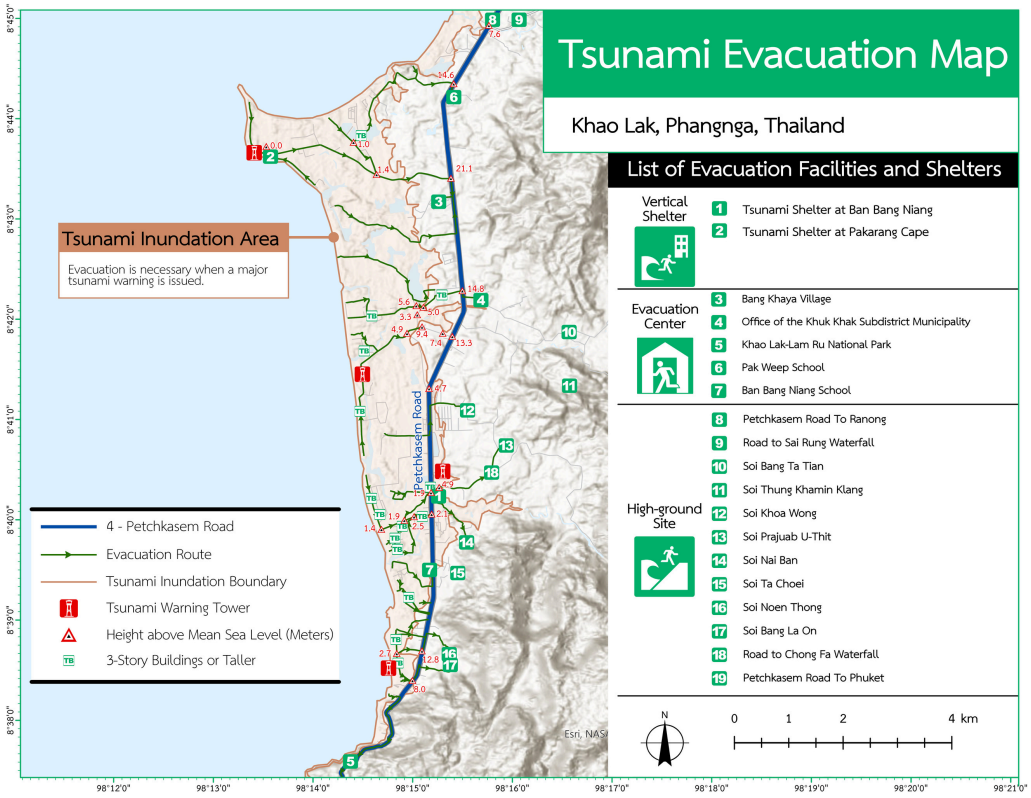


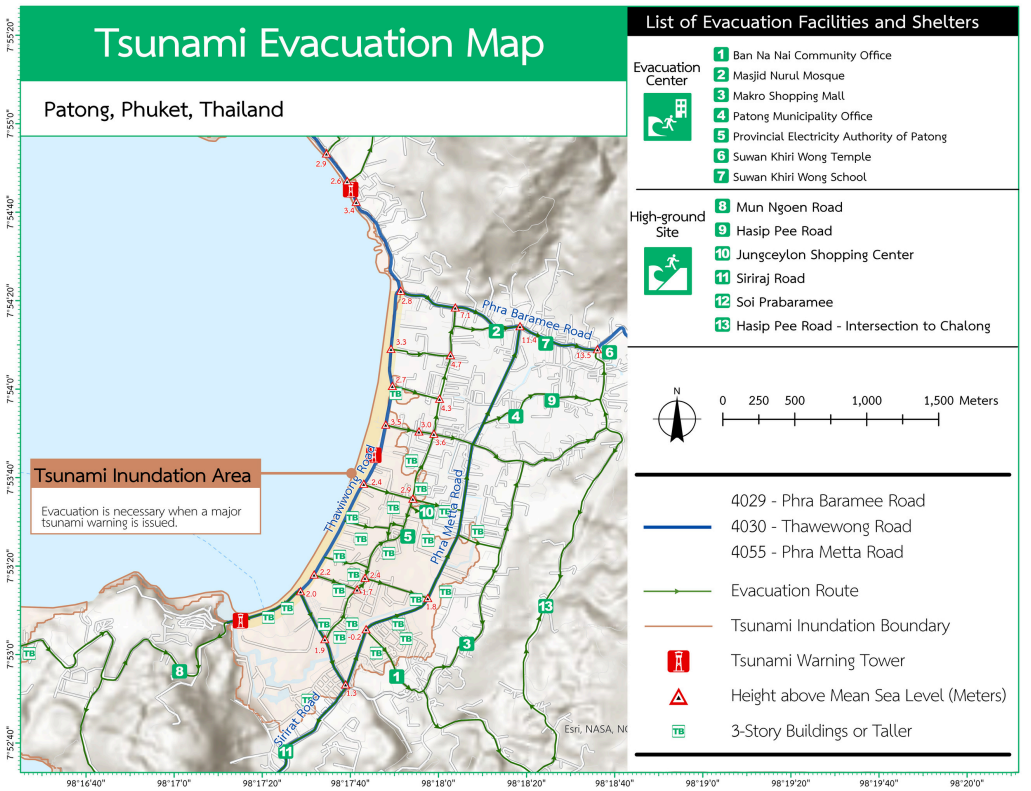


Evacuation Map

Tsunami Evacuation Route

The tsunami evacuation route map includes key information such as tsunami inundation areas, evacuation sites, road networks, evacuation routes, warning tower locations, elevation levels above sea level, and buildings with three or more stories, which could serve as alternative evacuation shelters in the future. This prototype map can be used to enhance the accuracy and update existing maps. However, alternative evacuation buildings must undergo safety analysis by engineers and consultation with relevant authorities. To maximize the effectiveness of the map, it is crucial to emphasize community involvement and support in the planning process.



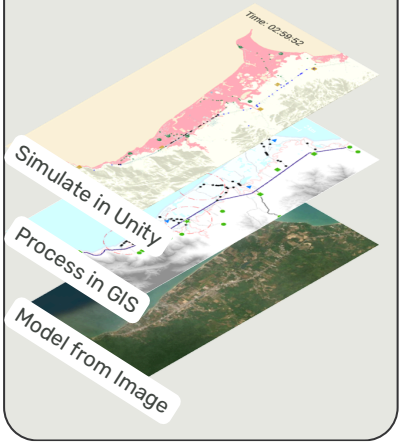


Tsunami Evacuation Simulation

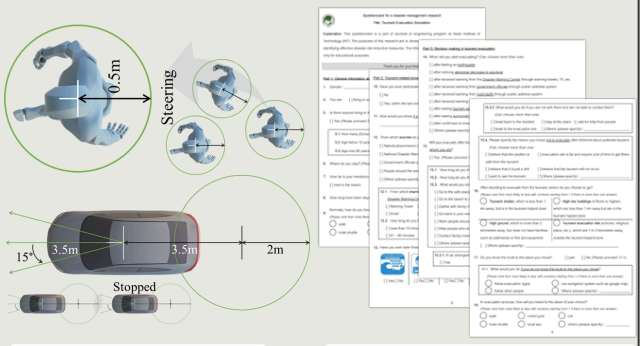
Agent-based Modeling and Simulation

The Agent-Based Modeling and Simulation (ABMS) for tsunami evacuation in Khao Lak was developed using Unity, a platform commonly used for game development. The model aims to: 1) Assess the strengths and weaknesses of current evacuation processes, 2) Explore potential improvements, and 3) Identify effective measures for evacuation. The model incorporates agents representing evacuees, categorized by residential status (locals or tourists) and evacuation method (on foot or by vehicle), each with unique behaviors. It also integrates environmental elements, such as warning towers, evacuation sites, gathering locations, road networks, evacuation route signs, and the tsunami wave. This simulation approach enables a comprehensive and in-depth analysis of evacuation efficiency under various scenarios, facilitating the development of more effective evacuation measures.

Environment Models

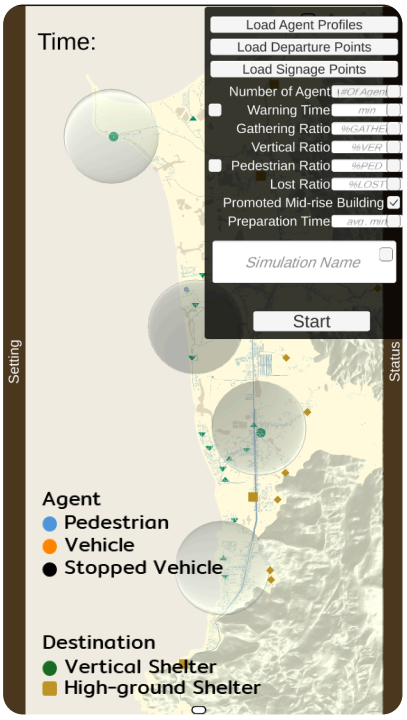


Agent Models



Model physical condition by mode of transportation

Model evacuation preferences from the questionnaire survey



Baseline Scenario: Khao Lak

Evacuation Measures:
64 Signs of Evacuation Route
4 Warning Towers

Evacuation Sites:
Inside Inundation
2 Vertical Shelters
14 Potential Vertical Shelters
(Existing RC Mid-Raise Building)
Outside Inundation Zone
5 Evacuation Centers
11 High-Ground Sites

Population: ~40k
Locals 60% Tourist 40%

Evacuation Preferences:
80% Spend some time before departure
80% Evacuate with the family
35% Evacuate to a vertical shelter
75% Evacuate by using a car
50% Know the nearest evacuation site

Research suggests evacuation efficiency can improve by using existing three-story reinforced concrete (RC) buildings as shelters, encouraging on-foot evacuation, and installing clear evacuation signs. Although these recommendations focus on the Khao Lak area, the tools and methods developed can also be applied to improve evacuation strategies in other coastal areas.