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Floating Dock with Automatic Early Detection for Tidal Mitigation and Tidal Flooding with IOT-Based Instruments

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Abstract

Purpose: Coastal areas frequently face the threat of increasingly intense tidal and tidal flooding due to climate change and sea level rise. These conditions disrupt dock operations and endanger the safety of infrastructure and surrounding communities. To address these challenges, this research designed and developed a new system.

Method: An Internet of Things (IOT)-based Automatic Early Detection Floating Dock is an adaptive mitigation solution. The system is equipped with various sensors, including ultrasonic sensors, water pressure sensors, and a GPS module, to monitor sea level in real time.

Practical Applications: Collected data is automatically transmitted to an online monitoring platform using a wireless connection, enabling rapid analysis and early warnings to stakeholders. An adaptive floating mechanism allows the pier to automatically adjust its height according to changing water levels, ensuring its operational and safe operation.

Conclusion: System testing demonstrated that the tool can predict potential tidal flooding early and function stably in dynamic marine conditions. This innovation not only increases the resilience of dock infrastructure but also provides direct benefits for early warning systems in coastal areas. The application of this technology is expected to be part of a long-term adaptation strategy to the impacts of climate change in coastal areas.

Introduction

Tidal flooding is a recurring phenomenon in coastal regions, primarily driven by rising sea levels, lunar phase variations, geographic positioning, and extreme marine events such as storms and high waves. These factors collectively contribute to coastal erosion, which poses significant ecological and economic challenges (Falchi, 2024; Burns, 2025). The impacts extend beyond environmental degradation, affecting coastal communities whose livelihoods depend on fisheries and aquaculture. Persistent land loss in these areas is often attributed to a combination of natural processes and human-induced activities (Kang, 2025).

Natural drivers of land subsidence include fluvial sediment reduction, crustal loading, glacial isostatic adjustment, and gravitational compaction, all of which influence vertical land motion (Kang, 2025; Wang, 2025). However, anthropogenic factors such as resource extraction and hydrological alterations have been shown to accelerate these processes significantly (Shirzaei, 2021; Karegar, 2015). These changes not only exacerbate flooding risks but also disrupt the biogeochemical balance of coastal ecosystems, leading to long-term ecological consequences (Macías-Tapia, 2021; Raposa, 2016).

The Keputih area in Surabaya, situated along the Jagir River and Wonokromo Canal, exemplifies a region vulnerable to tidal flooding and soil erosion. This locality supports traditional fish farming and fishing activities, making it economically dependent on river access for production and distribution. Studies have demonstrated that infrastructure development and residential expansion in such areas intensify hydrological changes, further destabilizing land and increasing susceptibility to flooding (Shirzaei, 2021; Karegar, 2015). These conditions underscore the urgent need for adaptive strategies to safeguard both livelihoods and ecosystems.

One promising approach involves predictive monitoring and mitigation through real-time data collection. Water level fluctuations, tidal patterns, and related environmental parameters can serve as critical indicators for early warning systems (Zahura, 2022). Integrating these data into a centralized platform enables stakeholders to anticipate flooding events and implement timely interventions. Consequently, the development of floating docks equipped with IoT-based sensors for water level, temperature, and humidity monitoring represents a practical solution for enhancing resilience in coastal communities.

This study introduces an innovative floating dock system with automatic early detection capabilities, designed to adapt to dynamic tidal conditions. The system leverages IoT technology and LoRa-based communication to provide real-time alerts and facilitate proactive disaster mitigation. Beyond its technical functionality, the project embodies a community-centered approach by incorporating recycled materials and local knowledge, ensuring sustainability and replicability. By empowering fisherfolk and coastal residents with actionable information, this initiative aims to strengthen climate adaptation strategies and promote socio-economic stability in vulnerable regions.

Method

The methodology for developing the IoT-based floating dock system involved a structured approach encompassing site selection, initial condition assessment, design, assembly, and integration of monitoring instruments. Each stage was carefully planned to ensure the dock's adaptability to tidal fluctuations and its effectiveness as a disaster mitigation tool. The process adhered to engineering standards while incorporating community engagement principles to guarantee practical applicability.

Site Selection was the first critical step. The chosen location along the Jagir River in Surabaya was selected based on several criteria: proximity to fishing communities, accessibility for maintenance, and exposure to tidal dynamics. This area experiences frequent tidal flooding, making it an ideal testing ground for adaptive infrastructure. Geographic and hydrological factors were analyzed to confirm suitability, ensuring that the dock would serve both as a mooring facility and a monitoring station.

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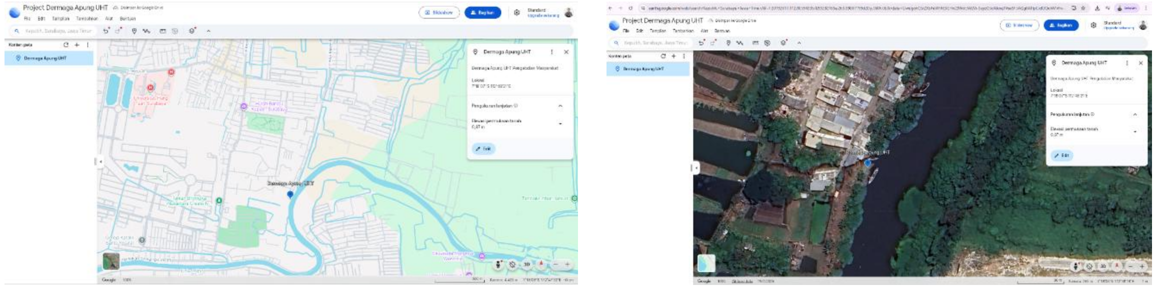
Picture 1. Location Map of the Floating Dock (b) Satellite Image of the Floating Dock Location via Google Earth



Source: Author’s Work, 2025.

Following site determination, an Initial Condition Survey was conducted to collect baseline data on environmental and structural parameters. This included assessing soil stability, water depth, and tidal patterns. Field observations revealed significant sedimentation and erosion risks, prompting preliminary interventions such as clearing debris and reinforcing soil with concrete blocks. These measures aimed to create a safe and stable foundation for subsequent installation activities.

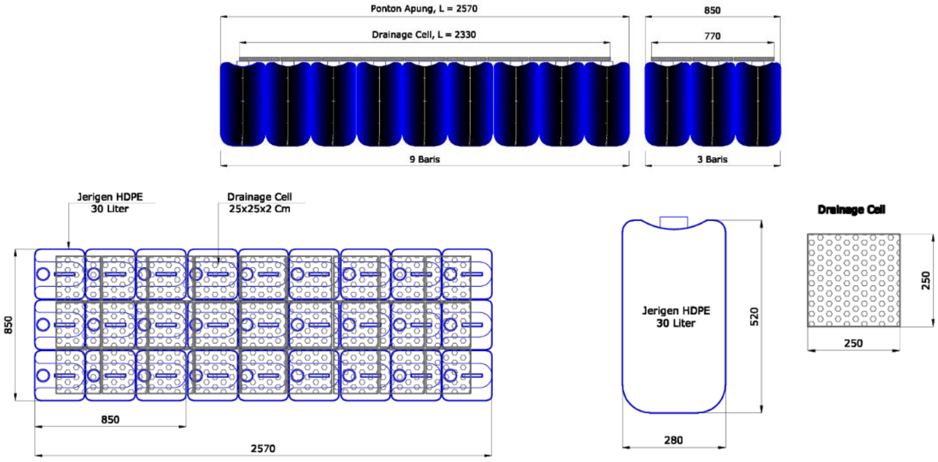
Picture 2. Initial Conditions (b) (c) Cleaning Process (d) Addition of Concrete for Soil Density

Source: Private Documentation, 2025.

The Design Phase focused on creating a modular floating dock structure capable of adjusting to water level changes. Technical considerations included buoyancy calculations, load capacity, and structural resilience against wave forces. Recycled jerrycans were selected as pontoons for their cost-effectiveness and environmental benefits. The frame was constructed using welded iron to provide durability, while drainage cells were incorporated into the deck to prevent water accumulation and reduce slip hazards during high tides.

Parallel to structural design, the Instrumentation Design integrated IoT-based sensors for real-time monitoring. Ultrasonic water level sensors were chosen for their precision in detecting tidal variations, complemented by temperature and humidity sensors to capture environmental conditions. These sensors were connected to a microcontroller (ESP32) and linked to a LoRa communication module, enabling long-range, low-power data transmission. The system architecture was designed to ensure continuous operation even in remote areas with limited connectivity.

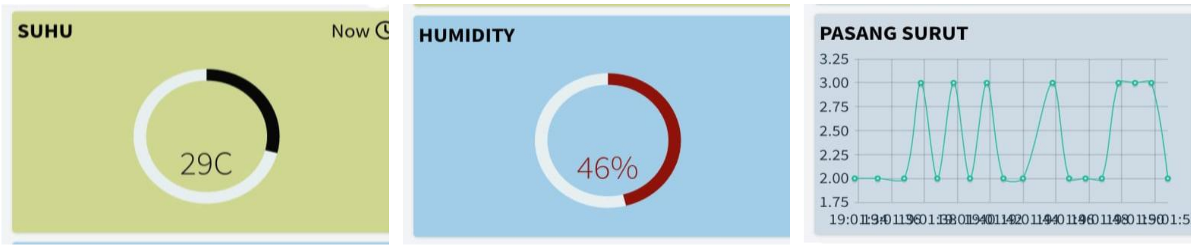
Picture 3. Floating Dock Diagram



Source: Private Documentation, 2025.

The Assembly Process involved constructing the dock frame, securing jerrycans as pontoons, and installing the deck. Each component was tested for stability and buoyancy before integration. Special attention was given to the mooring system, which utilized chains and guide piles to maintain positional stability under dynamic water conditions. The assembly was completed with waterproof enclosures for electronic components to safeguard against harsh marine environments.

Picture 4. HMI in Smart Phone



Source: Private Documentation, 2025.

Once the physical structure was completed, the IoT Integration Stage commenced. Sensors were calibrated to ensure accurate readings, and data transmission was tested through the LoRa network to a cloud-based platform (ThingsBoard). The dashboard provided real-time visualization of water levels and environmental metrics, accessible via smartphones for community members and stakeholders. Alerts were configured to trigger notifications when water levels exceeded predefined thresholds, enabling early warning for potential flooding events.

Picture 5. Frame Welding Process, Jerry Can Assembly for Pontoon, Pontoon with Frame, Addition of Drainage Cell as Deck

Source: Private Documentation, 2025.

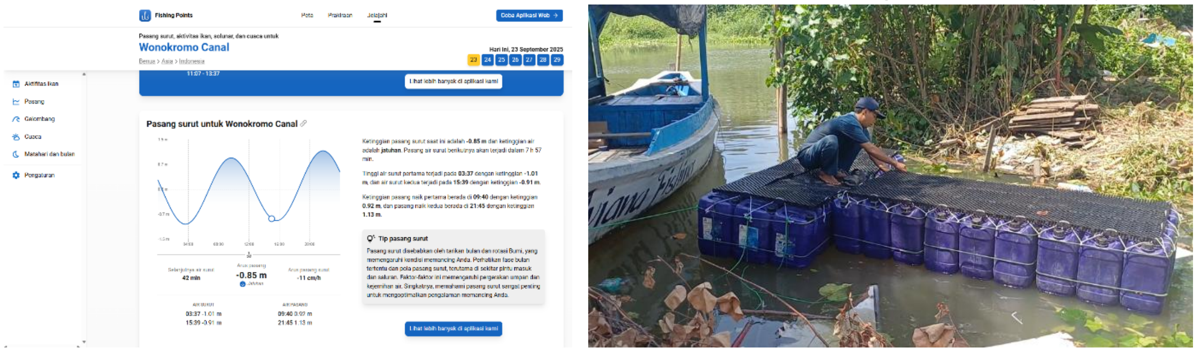
To ensure sustainability, the system was powered by a Renewable Energy Setup consisting of a 20W solar panel connected to a battery backup. This configuration guaranteed uninterrupted operation during power outages and minimized reliance on conventional electricity sources. The energy system was tested under varying weather conditions to validate performance and reliability.

Finally, a Pilot Testing Phase was conducted over seven days to evaluate the dock's structural integrity and the IoT system's responsiveness. Data collected during this period included tidal fluctuations, wave height, and weather conditions. The dock demonstrated stable performance, and the monitoring system successfully transmitted alerts during high-water events. These results confirmed the feasibility of deploying similar systems in other tidal-prone regions as part of a broader climate adaptation strategy.

Result

The implementation of the floating dock system equipped with IoT-based monitoring instruments yielded significant findings regarding its structural performance and technological functionality. This section presents the outcomes of the project, including the operational stability of the dock, the accuracy of sensor measurements, and the effectiveness of the early warning system. The results are supported by observational data, sensor readings, and user feedback collected during the trial period.

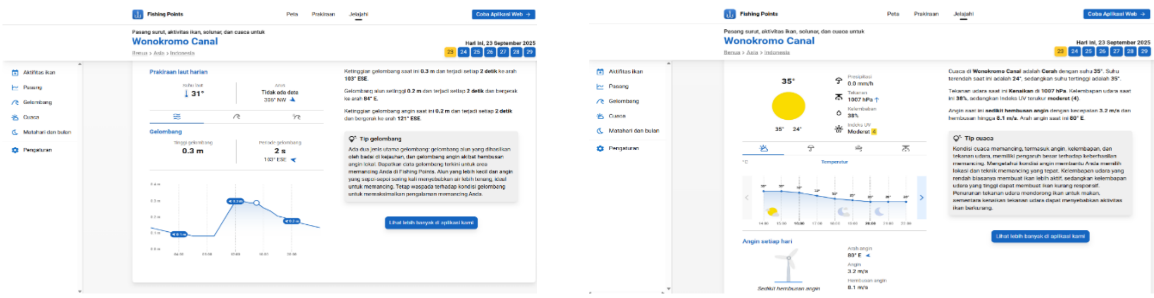
Picture 6. Example of Tidal Data for Wonokromo Canal and Floating Dock Buoyancy Test



Source: Author's Work, 2025.

Structural Performance was evaluated under varying tidal conditions over a seven-day observation period. The floating dock, constructed from recycled jerrycans and reinforced with an iron frame, demonstrated excellent buoyancy and adaptability to water level fluctuations. During high tides, the dock rose proportionally with the water level without compromising accessibility or structural integrity. No signs of deformation, displacement, or material failure were observed, confirming the reliability of the design for dynamic coastal environments.

Picture 7. Example of Wonokromo Canal Wave Height Data and Example of Wind and Weather Movement Data for Wonokromo Canal



Source: Private Documentation, 2025.

The Load-Bearing Capacity of the dock was tested by simulating typical operational conditions, including the mooring of small fishing vessels and pedestrian movement. The deck, reinforced with drainage cells, effectively prevented water accumulation, reducing slip hazards and maintaining safety standards. These features ensured that the dock remained functional even during periods of elevated water levels, validating its suitability for community use.

In terms of Sensor Accuracy, ultrasonic water level sensors recorded real-time tidal fluctuations with high precision. Data collected over the trial period captured both peak high tides and low tides, aligning closely with reference measurements from local hydrological stations. Temperature and humidity sensors also performed reliably, providing continuous environmental monitoring that can inform future climate adaptation strategies.

The Data Transmission System, powered by LoRa technology, successfully transmitted sensor data to the cloud-based dashboard at five-minute intervals. Despite the remote location and potential connectivity challenges, the system maintained stable communication throughout the observation period. The ThingsBoard platform displayed real-time graphs of water level, temperature, and humidity, enabling stakeholders to monitor conditions remotely via smartphones and web interfaces.

A critical feature of the system, the Early Warning Mechanism, was tested by setting predefined water level thresholds. When these limits were exceeded, the system automatically generated alerts sent to users via email and mobile notifications. This functionality proved effective in reducing response time for potential flooding events, offering a practical tool for disaster preparedness in coastal communities.

The Energy Sustainability of the system was validated through the integration of a 20W solar panel and battery backup. The renewable energy setup ensured uninterrupted operation during the trial period, even under cloudy conditions. This feature enhances the system's resilience and reduces dependency on conventional power sources, making it suitable for deployment in remote or resource-limited areas.

Community Engagement Outcomes were also noteworthy. Local fisherfolk actively participated in monitoring activities and expressed positive feedback regarding the system's usability and benefits. The provision of real-time tidal information improved their ability to plan fishing operations and safeguard equipment during adverse conditions, demonstrating the social impact of the project.

The Environmental Adaptability of the dock was further confirmed through its performance during sudden weather changes, including strong winds and moderate wave activity. The mooring system effectively maintained positional stability, preventing drift and ensuring operational safety. These results highlight the dock's potential for replication in other tidal-prone regions.

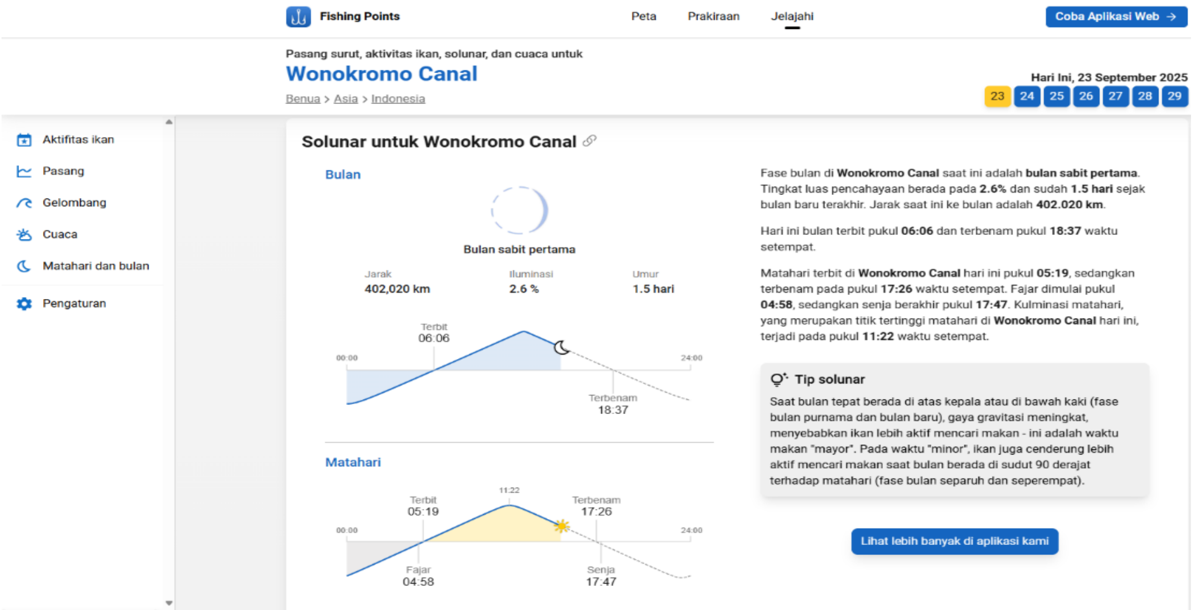
Finally, the Data Utilization Potential was evident in the historical records generated during the trial. The collected data can serve as a foundation for long-term trend analysis related to sea-level rise and climate variability. By integrating predictive analytics in future iterations, the system could evolve into a comprehensive decision-support tool for coastal management and disaster mitigation.

Discussion

The integration of a floating dock system with IoT-based monitoring technology demonstrates a significant advancement in coastal disaster mitigation strategies. The results indicate that the system effectively addresses the dual challenge of providing a functional mooring facility while simultaneously serving as an early warning platform for tidal flooding. This dual-purpose design enhances community resilience by combining infrastructure adaptability with real-time environmental monitoring, which is critical in regions vulnerable to climate-induced sea-level rise.

One of the most notable outcomes is the dock's structural adaptability under dynamic tidal conditions. The use of recycled jerrycans for buoyancy and iron framing for stability proved to be a cost-effective yet durable solution. This approach not only reduces construction costs but also promotes sustainability through material reuse. Compared to conventional fixed docks, the floating design minimizes damage risks during extreme tides, offering a replicable model for other coastal areas facing similar challenges.

Picture 8. Example of Solunar Data for Wonokromo Canal



Source: Private Documentation, 2025.

The IoT-based monitoring system further strengthens the dock's functionality by enabling continuous data collection and transmission. The successful deployment of ultrasonic sensors, LoRa communication modules, and cloud-based dashboards illustrates the feasibility of integrating low-power, long-range technologies in remote coastal environments. The early warning feature, which triggers alerts when water levels exceed predefined thresholds, provides a proactive mechanism for disaster preparedness. This capability is particularly valuable for small-scale fishing communities that often lack access to sophisticated forecasting tools.

Beyond technical performance, the project underscores the importance of community engagement in disaster mitigation initiatives. Active participation by local fisherfolk during installation and testing phases fostered a sense of ownership and trust in the system. Their feedback highlighted practical benefits, such as improved planning for fishing activities and enhanced safety during high tides. This participatory approach ensures that technological solutions align with local needs and cultural contexts, increasing the likelihood of long-term adoption.

Finally, the broader implications of this innovation extend to climate adaptation and policy development. By generating historical tidal data and environmental metrics, the system creates opportunities for predictive analytics and evidence-based decision-making. Future enhancements could include integrating machine learning algorithms for trend analysis and expanding the system to monitor additional parameters such as salinity and wave dynamics. These improvements would position the floating dock as a comprehensive coastal management tool, contributing to sustainable development goals and resilience strategies in the face of global climate change.

Conclusion

This study successfully designed and implemented a floating dock system integrated with IoT-based early detection technology to mitigate tidal flooding risks in coastal areas. The project addressed critical challenges faced by communities living along tidal-prone rivers by providing a dual-function infrastructure that serves as both a mooring facility and a real-time monitoring platform. The results confirm that the system is structurally stable, technologically reliable, and socially impactful.

The floating dock demonstrated excellent adaptability to fluctuating water levels, maintaining operational safety and accessibility during high tides. Its modular design, constructed from recycled materials, not only ensures durability but also promotes environmental sustainability. These features make the dock a practical and replicable solution for other regions experiencing similar tidal challenges.

The IoT-based monitoring system proved effective in collecting and transmitting real-time data on water levels, temperature, and humidity. The integration of LoRa communication and cloud-based dashboards enabled remote monitoring and early warning notifications, significantly reducing response time for potential flooding events. This capability enhances disaster preparedness and resilience for vulnerable coastal communities.

Beyond technical achievements, the project underscores the importance of community involvement in climate adaptation initiatives. Active participation by local fisherfolk ensured that the solution was tailored to their needs, fostering trust and long-term usability. The system's ability to provide actionable information empowers communities to make informed decisions, safeguarding livelihoods and infrastructure.

Future development should focus on scaling the system for broader applications and integrating predictive analytics to anticipate long-term trends related to sea-level rise and climate variability. By combining engineering innovation with digital technology and community engagement, this project offers a sustainable model for coastal disaster mitigation and climate resilience.

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Reference

Alfonso Macías-Tapia, M. R. (2021). Effects of tidal flooding on estuarine biogeochemistry: Quantifying flood-driven nitrogen inputs in an urban, lower Chesapeake Bay sub-tributary. Water Research.

Byungho Kang, S. X. (2025). Accelerated land loss and nuisance flooding potential in the Barataria Basin: The impacts of land subsidence, sea-level rise, and tidal dynamics. Journal of Sea Research.

Faria T. Zahura, J. L. (2022). Kai Wang, F. Z. (2025). The response of dissolved organic matter dynamics to flood events in tidal estuaries. Journal of Environmental Management Journal of Hydrology: Regional Studies.

Kenneth B. Raposa, K. W. (2016). Assessing tidal marsh resilience to sea-level rise at broad geographic. Biological Conservation, 263-275.

Laura Falchi, P. L. (2024). On the contribution of tidal floods on damp walls of Venice. International Journal of Disaster Risk Reduction, 110.

Makan A. Karegar, T. H. (2015). A three-dimensional surface velocity field for the Mississippi Delta: Implications for coastal restoration and flood potential. Geology.

Manoochehr Shirzaei, J. F. (2021). Measuring, modelling and projecting coastal land subsidence. Nature Reviews Earth & Environment.

Rachel A. Burns, R. P. (2025). Numerical modelling of the hydrodynamics driven by tidal flooding of the land surface after dyke breaching. Nature-Based Solutions, 7.