# Hybrid Model Based on MCS Numerical Scheme and ANN Artifcial Intelligence for Simulation and Risk Evaluation of Coastal Erosion in South Bali

K. Dharmawan*, P. V Swastika, I.P.W Gautama, I.G.N.L. Wijayakusuma
Departement of Mathematics, Faculty of Mathematics and Natural Sciences, Udayana University, Bali, Indonesia
*Head of team. Email : k.dharmawan@unud.ac.id

## Abstract

This study aims to develop erosion mitigation strategies through simulation-based design of optimal wave barrier structures, both rigid breakwaters and porous media such as mangrove vegetation. We propose a hybrid model integrating numerical simulation, artificial intelligence, and risk management theory. The initial fluid run-up model will be simulated using the momentum-conserving staggered grid (MCS) scheme, both with and without wave barriers. The simulation results will then serve as training data for an artifcial neural network (ANN) to evaluate amplitude damping and optimal structural dimensions of the wave barriers. Infrastructure risks near the shoreline will be analyzed using the fragility function approach within a risk theory framework.

**Main Novelty**

- Integration of MCS-ANN models in the context of erosion mitigation
- Combined simulation of rigid structures and porous media in an integrated model
- Application of risk functions in coastal fluid modeling

**Research Impact**

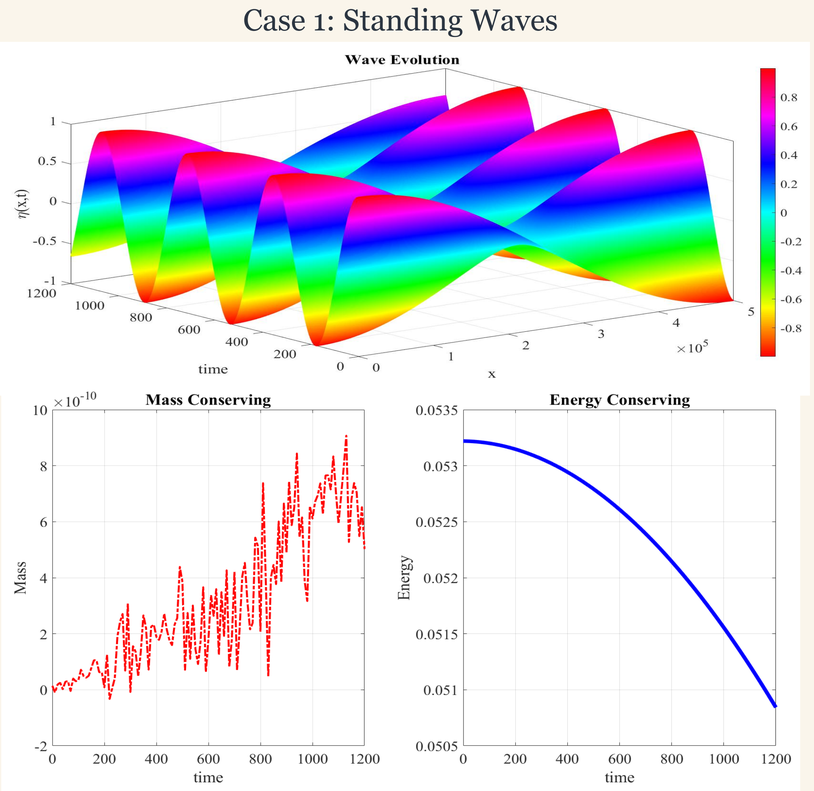
- Supporting national priority programs for technology-based disaster mitigation
- Involving a multidisciplinary team from Udayana University and the Meteorology, Climatology, and Geophysical Agency (BMKG) of Indonesia.

## Research Methodology

| Development of MCS Numerical Model | Artificial Intelligence Integration ANN | Infrastructure Risk Evaluation |
|---|---|---|
| Implementation of a momentum-conserving staggered-grid scheme for high-accuracy wave simulation and mass-energy conservation. | Training of artificial neural networks using simulated data for the prediction of optimal configurations of barrier structures. | Risk analysis of near-shore infrastructure using a fragility function approach within a risk theory framework |

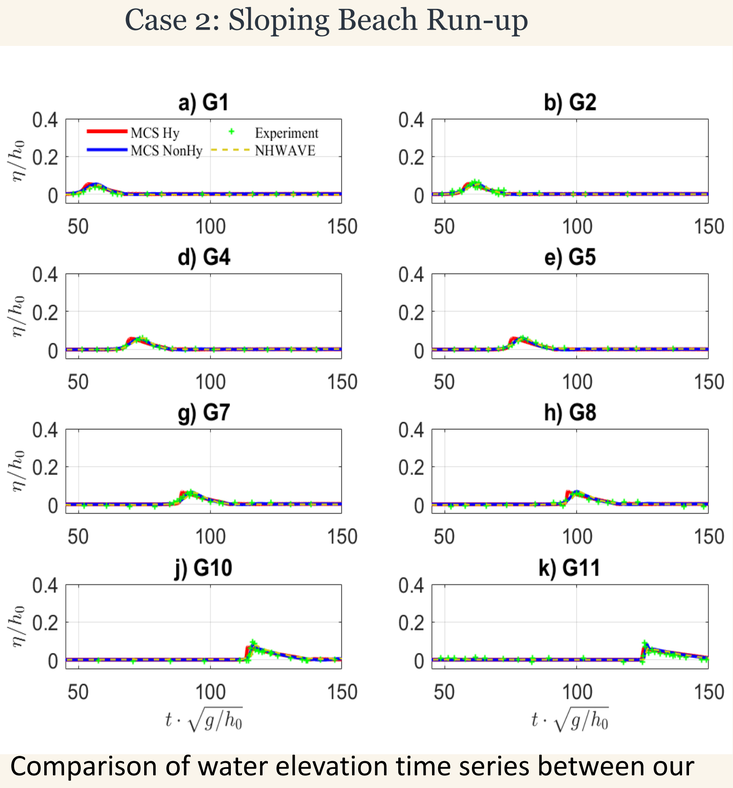
## Results and Discussion

### Case 1: Standing Waves



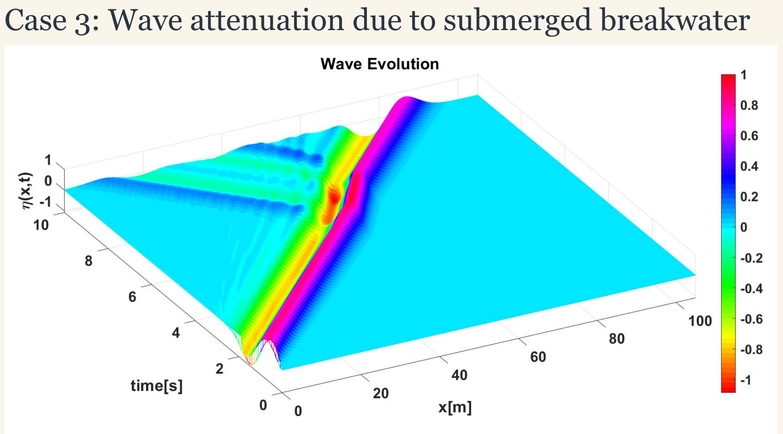

Our scheme is Second order accurate, mass and energy conserving, free from damping error

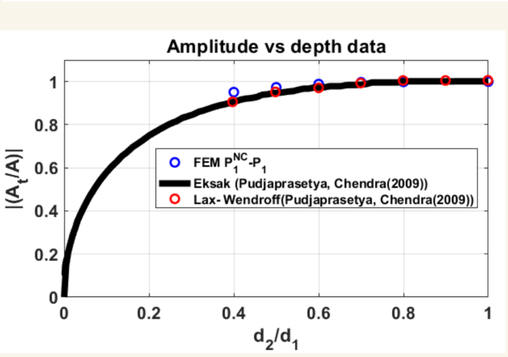
### Case 2: Sloping Beach Run-up




Comparison of water elevation time series between our numerical against experiment using $\epsilon = 0.055$ are in good agreement

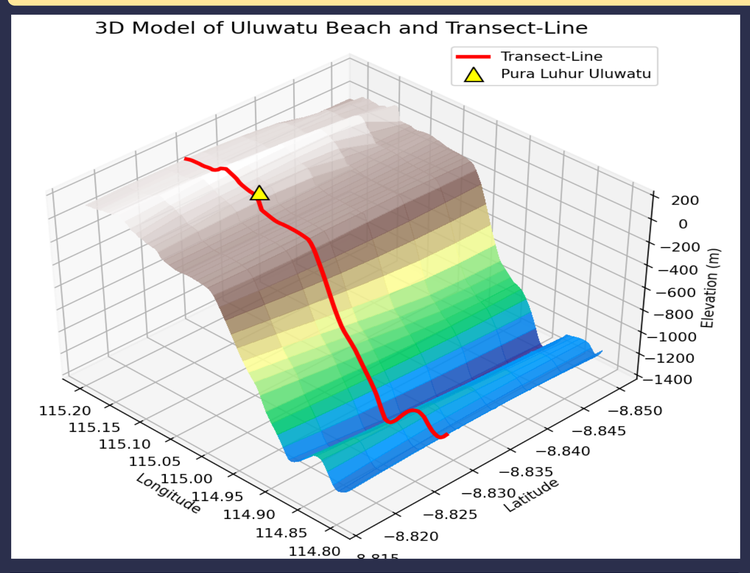
### Case 3: Wave attenuation due to submerged breakwater

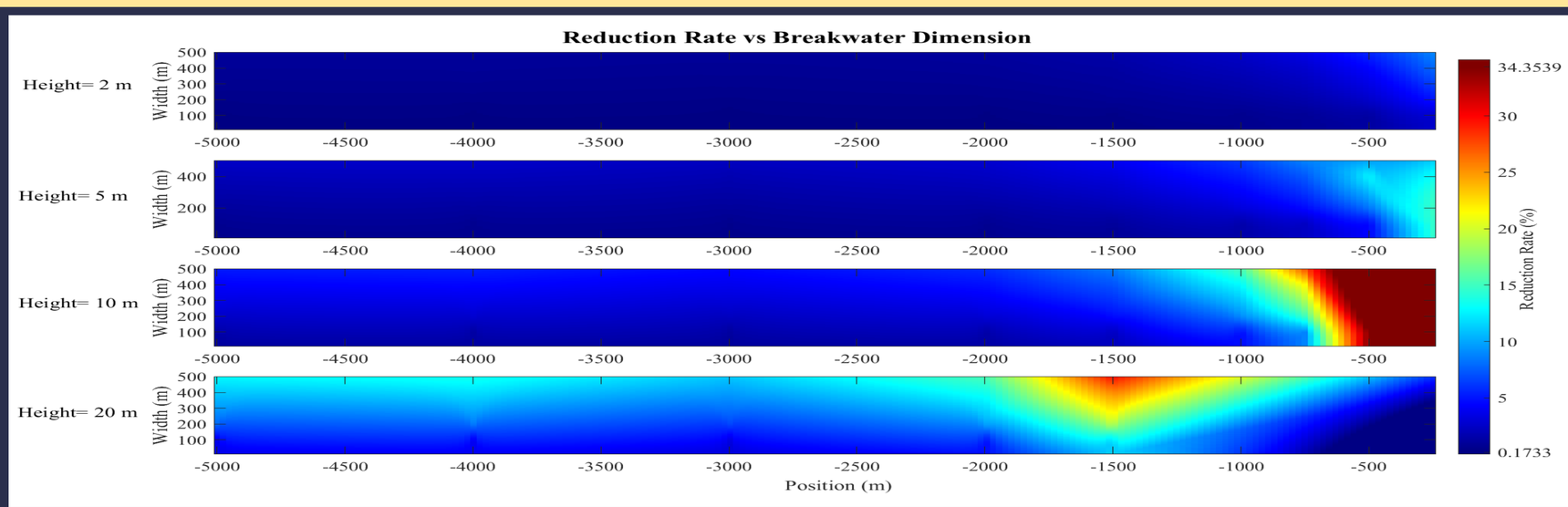


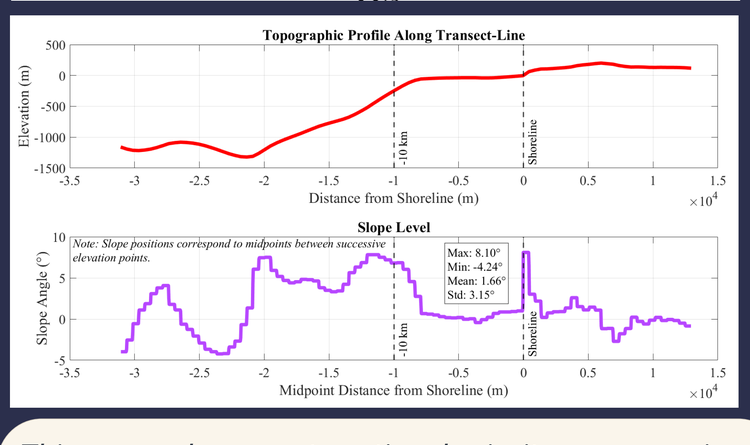



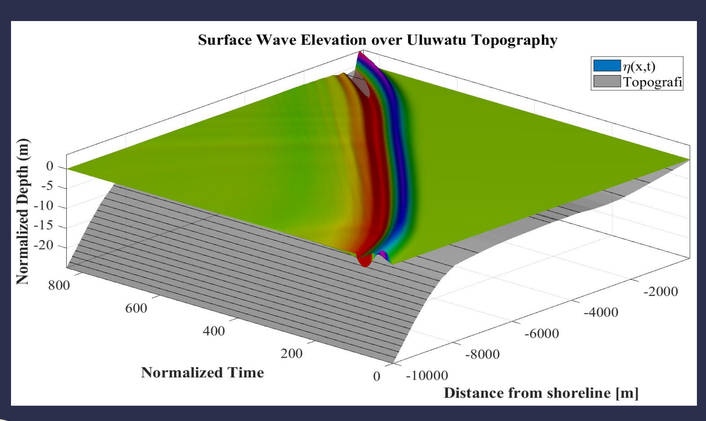

Wave transmission amplitude $A_t$ vs depth for optimum breakwater dimensions.

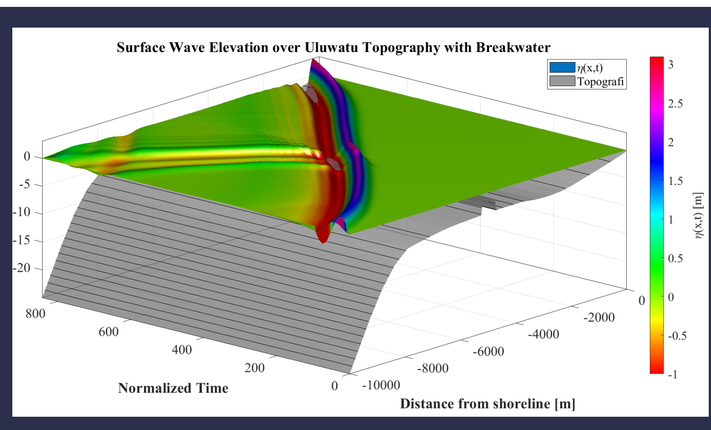
**Key Results: Uluwatu Artificial Breakwater Design for Coastal Abrasion.** The application of the specific bathymetry of Uluwatu Beach reveals that a 10 m wide and 10 m high artificial submerged breakwater, positioned 0.5 km from the shore, can reduce the shoreline wave amplitude by approximately 35% compared to a scenario without the breakwater.




"The results show that the proposed method is accurate and well-suited for the design of coastal protection structures in wave-exposed environments. Some of our results can be further used as training data for future ANN models."

*This research supports national priority programs in technology-based disaster mitigation, climate change adaptation, and achieving SDG-13 Climate Action through leading-edge scientific approaches and multidisciplinary collaboration.*

Environmental Conservation

*An integrated approach that considers rigid structures and porous media for sustainable coastal ecosystem protection*

## Conclusion and Impact

Methodological Innovation

*Development of a hybrid MCS-ANN model integrating nume-*