C101

Flood Risk Mapping Using Machine Learning: Case studies from Japan

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Introduction

Japan faces considerable flood risks due to its climatic conditions, including heavy rainfall events and typhoons, which are exacerbated by climate change. In response, Japan has evolved its flood control planning and policies, shifting from traditional river channel-focused control to a more comprehensive, watershed-oriented management approach. Japan faces substantial flood risk because of its climatic setting—especially intense rainfall and typhoons, and these hazards are being amplified by climate change. In response, the country has progressively updated its flood-control planning and policies, moving beyond conventional measures centered on river channels toward a broader, watershed-scale management framework. This approach, often referred to as **"River Basin Disaster Resilience and Sustainability by All,"** promotes integrated actions across the basin, including flood prevention, exposure reduction, and timely, appropriate evacuation, with participation from all relevant stakeholders.

Even with these advances, persistent challenges remain. The rising frequency and intensity of heavy rainfall events require ongoing adaptation and refinement of flood-risk management, such as strengthening infrastructure resilience, upgrading early-warning capabilities, and expanding community-based disaster preparedness to reduce future flood impacts. Accordingly, this study aims to apply machine-learning methods, such as Random Forest (**Saber et al., 2021; Saber et al., 2023**), to predict **FFS** across multiple Japanese basins, including the Kyukitakami River (**Fig. 1**).

Approach and methods

In this paper, we apply a machine-learning model to produce a nationwide flood hazard map for Japan. The model is designed to support both classification and regression applications. We first select several representative case studies from Japan to develop and test the approach, and then extend the trained model to generate flood hazard estimates across the entire country. The input data are compiled from satellite-derived datasets, while flood reference points are obtained from Japan's MLIT flood hazard map.

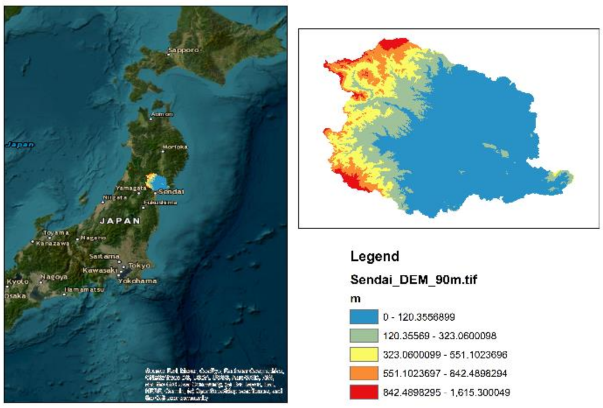

Fig. 1 (a) The location map of the Kyukitakami River basin.

Two primary datasets were assembled for machine-learning-based flood susceptibility mapping. First, a flood inventory of observed inundation locations was compiled from post-flood field surveys. Second, non-flood points were generated by randomly sampling locations across the catchment within a GIS environment.

In addition, ten flood susceptibility conditioning factors

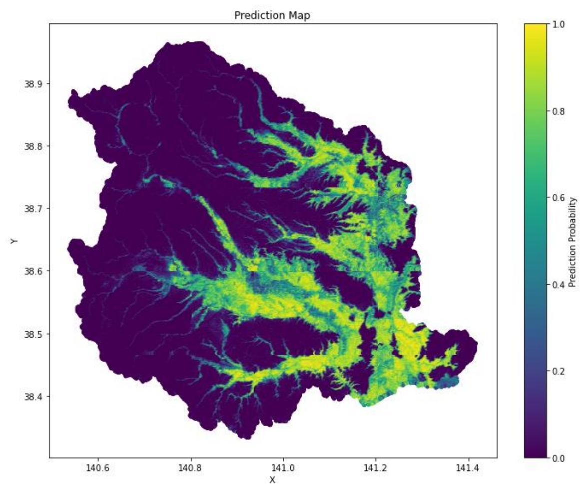

Fig. 2 Flood susceptibility map by the machine learning for only one case.

were prepared for modeling: elevation, slope, aspect, plan curvature, hillshade, horizontal flow distance, stream power index (SPI), geology, rainfall, and land use/land cover. For analysis, all factor layers were generated in ArcGIS and standardized to a consistent spatial resolution.

The complete dataset was then randomly split into training (70%) and testing/validation (30%) subsets. To examine the relative contribution and suitability of the conditioning factors, we applied both an information gain ratio analysis and a multicollinearity assessment using the variance inflation factor (VIF). Model performance was evaluated using multiple accuracy metrics, including the area under the ROC curve (AUC). Finally, the machine-learning outputs were compared with results from the Rainfall–Runoff–Inundation (RRI) model.

Results and ongoing research

The flood hazard map developed after model training several cases in Japan based on the data collected from MLIT flood hazard map. The model training and test on these cases, then we have applied over the whole of Japan. The data shows good matching with the MLIT flood hazard map (Fig. 3. Further validation suing real observed flood data is still onoging.

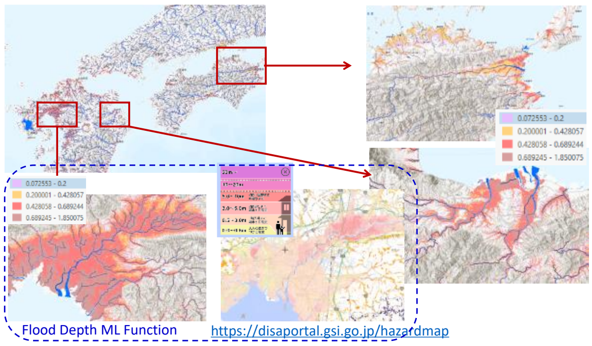

Fig. 3 developed flood hazard map compared with MLIT Map.

Conclusion

ML models are successfully used in predicting of flooding hazard in Japan. The outcomes of this study can be used as guidance for the planners and managers to mitigate the floods in the high prone flood susceptible regions. Our future plan is to validate the map based on real time observations

Acknowledgment

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