



京都大学防災研究所
Disaster Prevention Research Institute
Kyoto University

国際共同研究（一般）

2024IG-03

Impacts of Flood and Fire Disasters on Future Land Use Distribution in Humid Tropical Peatland

March, 2026

Coordinator Apip

International Collaborative Research (Project No.2024IG-03)

Project Title : Impacts of Flood and Fire Disasters on Future Land Use Distribution in Humid Tropical Peatland
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Name of the DPRI Contact Person : Takahiro Sayama
Research Period / Duration of Stay : April 01, 2024 – March 31, 2026
Research Location / Location of Stay : BRIN, DPRI, Tropical Peatlands of Indonesia
Number of the Participants in the Project: (DPRI: 3 / non-DPRI: 4)

Anticipated Impact on Research and Education

- 1) Enables dynamic simulation of land-use distribution in tropical peatlands under recurrent flood-fire cycles by integrating empirical land-use transition probabilities into spatially explicit models
- 2) Improves understanding of psychological anomalies in local land-use behavior under repeated disasters, highlighting challenges in aligning scientific (etic) disaster mitigation policies with local decision-making processes

Research Report

(1) Purpose

The overall purpose of this collaborative research is to improve the estimation of climate change impact on disasters by coupling an empirical-based land-use model and hydrological/fire models. FY2024 activities aimed to collect hydrological data, verify the occurrence of compounding flood-fire events, and gather empirical data to parameterise a land-use change model. The FY2025 activities aimed to conduct dynamic simulations using human-disaster feedback on land-use distribution by integrating empirical land-use transition probabilities into spatially explicit models, and to publish the results in international journal papers.

(2) Summary of Research Progress

As part of the DPRI Collaborative Research Project on “Impacts of Flood and Fire Disasters on Future Land Use Distribution in Humid Tropical Peatlands,” two field surveys were conducted in FY2024. These activities aimed to collect hydrological data, verify compounding flood-fire events, and gather empirical data for land-use model parameterization.

In September 2024, field visits to the Batanghari and Musi River Basins in Sumatra Island confirmed overlapping flood and fire events through site observation and remote sensing. Instruments—including rain gauges, water level sensors, observation wells, soil moisture sensors, and a canal flow meter—were installed to monitor peatland hydrology in Batanghari river basin.

In February 2025, 120 questionnaires were distributed across four villages in the downstream area of the Batanghari River Basin. Results show that over 70% of respondents left their land

unattended after disasters, primarily due to financial constraints. Despite high perceived risk, most respondents expressed willingness to continue or adapt land use, underscoring the importance of integrating behavioral responses into future land-use modeling.

In July 2025, PI and Co-PIs presented researches in the 2nd international sociohydrology conference in Tokyo, Japan. In August 2025, additional questionnaire surveys are conducted in 4 villages in the Musi River Basin and the Instruments were installed in the field to monitor the peatland hydrology. Based on two-years questionnaire surveys, the study integrates flood model, damage-curve, replanting decision model and fires model and simulated land use dynamics affected by human-disaster feedbacks. Furthermore, the study applied the integrated model to Batanghari river basin and simulated the land use dynamics under present and future climate conditions using 15-NEXGDDP CMIP6 model outputs.

(3) Summary of Research Findings

Field surveys in Jambi confirmed that flood and fire events frequently occur within the same year in the same locations, validating the presence of compounding disasters in tropical peatlands. At multiple sites, post-flood and post-fire marks were clearly observed, and discussions with local communities supported the sequential occurrence of floods followed by fires. In areas where canal blocking was implemented, fire spread was limited, indicating localized mitigation efforts.

Hydrological monitoring revealed that groundwater levels dropped below 50 cm during extended dry periods, particularly when monthly rainfall fell below 100 mm for two consecutive months. While river levels fluctuated tidally during the dry season, groundwater remained relatively stable, responding only to prolonged surface inundation. These findings indicate weak hydrological connectivity between peat and river systems outside major flood events.

Nevertheless, the monitoring site for river–peatland system interaction and connectivity in the Batanghari area (245 ha) experienced a prolonged flooding period of nearly seven months, with total rainfall reaching 1,700 mm and an estimated floodwater volume in the peatland of approximately 3.7 million m³. Based on monitoring data and water balance modeling, the river system was shown to contribute significantly to the increase in peatland floodwater volume, accounting for 65.1%, while net rainfall over the peat area contributed only about 34.9%.

During the rainy season, particularly under flood conditions, the river system plays an important role as a source of water recharge for the peatland ecosystem, especially in areas that have been exposed or disturbed due to canalization. Therefore, the management of peatland cover and water storage must be integrated with improved watershed governance from upstream to downstream to maintain the connectivity between river and peatland systems under both wet and dry seasonal conditions.

Questionnaire data from 167 land owners showed that 86% left their land temporarily unattended following floods or fires, with nearly one-third reporting abandonment periods exceeding four months. These observations provide key transition probabilities for parameterizing land-use change in stochastic model. These empirical insights strengthen the coupling between hydrological modeling and land-use dynamics under repeated disaster exposure.

The integrated models show that median annual fire increases 54% in the future. Furthermore, abandonment increases cumulative fire extent by 1042 km² (+6.6%) now and +1940 km² (+8.0%) in the future, relative to non-abandonment scenario. In addition, by 2100, abandonment will reduce agricultural land and expand unmanaged, abandoned areas.

Preliminary sociopsychological analysis reveals a discursive gap in how flood-prone communities conceptualize inundation. The frequent use of *air pasang* ("water rising") illustrates cognitive reframing rooted in cultural heuristics, serving as a coping mechanism to downplay risk and psychological burden. This localized terminology supports a resilience narrative that legitimizes continued settlement in ancestral lands despite recurring hazards.

(4) Publications of Research Findings

- Muhammad A. Humaedi, Apip, Reza A. Prayoga, Adhis Tessa, Aliena A. Pasisir, Eva M.nYamamoto, Kodai Yamamoto, Florence Lahournat, Takahiro Sayama, 2025, Local Perceptions of Waterlogging: Community Understanding of "Flooding" and "High Tides" as Adaptation Mechanisms for Hydrological Disaster Resilience in Peatland Communities, *Frontiers in Water* (The manuscript has undergone review and is currently under major revision)
- Yamamoto, E., Yamamoto, K., Apip, Humaedi, A., Sayama, T., 2025, Integrating Human-Disaster Interactions into Flood and Fire Risk Assessments in Tropical Peatlands, *Frontiers in Water* (The manuscript under preparation)
- Humaedi, A., Apip, Yamamoto, K., Yamamoto, E., Sayama, T., 2025, Post-Disaster Economic Turbulence: Analysis of the Socio-Economic Impacts of Floods and Fires on Peat Ecosystem Communities, *International Journal of Disaster Risk Reduction* (The manuscript under preparation)
- Apip, Yamamoto E., Erni Saurmalinda Butar Butar, Yamamoto K., Hidayat, Humaedi, A., Sayama, T., 2025, Monitoring and Modeling Peat Flow Systems to Enhance Local Community Knowledge on Land Use Management and Flood Risk Mitigation, *Modeling Earth Systems and Environment Journal* (The manuscript under preparation).