SPATIO-TEMPORAL OF HYDRO-CLIMATIC MODELING FOR DISASTER RISK ASSESSMENT: A MULTI-DECADAL ANALYSIS IN THE JENEBERANG WATERSHED

アユコ ヒラニ サレー

https://hdl.handle.net/2324/7363757

出版情報：Kyushu University, 2024, 博士（工学），課程博士
バージョン：

（様式２）

氏　　名　：AYUKO HIRANI SALEH　（アユコ　ヒラニ　サレー）

論 文 名　：SPATIO-TEMPORAL OF HYDRO-CLIMATIC MODELING FOR DISASTER RISK ASSESSMENT: A MULTI-DECADAL ANALYSIS IN THE JENEBERANG WATERSHED
（災害リスク評価のための時空間的な水理水文モデルの構築：Jeneberang川流域における数十年の解析）

区　　分　：甲

論 文 内 容 の 要 旨

Flooding appears as the most prevalent and devastating natural hazard affecting communities around the globe. In recent decades, the frequency of extreme weather events, including floods, has been rising, a trend closely connected to climate change. The rising occurrence of natural disasters has been followed by a significant increase in human fatalities, extensive economic losses, and expenses associated with recovery efforts. Among these natural disasters, floods stand out for causing widespread destruction, as it impacts infrastructure, agricultural lands, and urban environments, often leaving socio-economic on affected populations. On of the huge cases of flood-related occurred in 2019, when heavy rainfall brought on by intense monsoons that produced destructive floods in the southern islands of the Sulawesi. The Jeneberang watershed, a critical area within South Sulawesi, with unprecedented water levels leaving inconceivable damages to communities, infrastructure, and natural ecosystems. The heavy flooding also causing widespread displacement and highlighted the vulnerability of the area to extreme weather events. This event required the South Sulawesi's government to re-evaluate its decades' worth of flood management strategies, recognizing that existing infrastructure and policies were inadequate in addressing the climate challenges that intensify flood risks. The principal objective of the research for this thesis are to identify the impact of the annual flood disaster triggered by extreme rainfall based on historical data available over the years. By integrating historical data, rainfall trends, and an assessment of past flood management practices, this study provides insights into potential strategies for improving resilience and minimizing future losses.

This thesis consists of five chapters.

Chapter 1 introduces the introduction, which contains the background, region of interest, problem identification, and this chapter also outlines the contribution to engineering, highlighting the development and application of hydrological modeling techniques to assess disaster risk and support regional planning.

Chapter 2 focuses on the investigation the trigger of flood disaster and identification the flood inundation area in the Jeneberang River Basin. This study was determined by single input point of flow rate data and rainfall data from six rainfall gauges. Results revealed that the severe flooding in January 2019 along the Jeneberang River basin, largely due to heavy rainfall and reduced river capacity, had widespread impacts. Contributing factors included sediment accumulation, local topography, and the construction of settlements directly on riverbanks. Analysis of land use maps identified that predominantly occupied by rice fields and other flood-prone land, are particularly vulnerable to inundation when river water levels rise. Additionally, the presence of residential developments along

the riverbanks exacerbates downstream land subsidence, further increasing flood risk. In contrast, the expansion of forested areas, approximately 4% of the basin, has shown potential in mitigating flood risks by enhancing water absorption and reducing runoff into the river. Simulation results at observation points were validated against measured data, showing a minor deviation of 0.1 meters (4.76%) at the first point and approximately 0.25 meters at the second, indicating reasonable accuracy in model predictions. Future flood prediction can be further refined by improving data inputs for calibration, thereby enhancing the precision of risk assessment and management strategies in the Jeneberang River watershed.

Chapter 3 further explores the erratic patterns in a watershed due to negative impacts of climate. The aims of this part were to better understand of precipitation patterns in the Jeneberang River Basin. The present research investigated precipitation data over a period of 23 years (1996-2019), which was obtained from three distinct rainfall stations. Results indicate that while overall rainfall trends are stable, certain months display significant changes. For instance, at the Alukeke station, rainfall peaks in December and January, with averages of 567.21 mm and 554.14 mm, respectively, and dips in June and July, with averages of 87.61 mm and 79.66 mm. Notably, rainfall variability is highest in September, with a standard deviation of 437.25 mm, reflecting marked fluctuations. Statistical testing at Alukeke revealed significant rainfall trends in May and June, with p-values of 0.03 and 0.04, respectively. Similarly, at Malino station, no significant trends were observed in most months, though June exhibited a notable trend (p-value = 0.01), indicating a significant shift in rainfall during this period. In contrast, analysis at Paladingan station revealed no statistically significant trends across all months, as p-values consistently exceeded 0.05 (ranging from 0.12 to 0.90), suggesting stable rainfall with negligible change over time. Sen's slope results further confirmed minimal variation in monthly rainfall rates, with values close to zero.

Chapter 4 deals the effectiveness of a tank model for simulating water flow and rainfall in the Malino Catchment Area (MCA). The model successfully captured detailed water movement across various soil layers, yielding a coefficient of determination (R^2) of 0.560 and a Nash-Sutcliffe Efficiency (*NSE*) of 0.526, indicating a good correlation between simulated and observed data, demonstrating the model's capability to approximate the real hydrological conditions of the MCA. Surface flow ratios were calculated, with daily surface flow at 2,464.94 mm, intermediate flow at 645.91 mm/year, base flow at 70.87 mm/day, and a total annual rainfall (*Rtotal*) of 3,996 mm,

Finally, the overall conclusions about the comprehensive study on the disaster risk assessment conducted for the Jeneberang watershed in South Sulawesi is presented in Chapter 5. These conclusions synthesized findings on the impact of precipitation variability and the effectiveness of hydrological modeling approaches applied throughout the research. By examining rainfall patterns, water flow dynamics, and model performance, this chapter highlighted key insights into disaster risks, influential factors, and areas requiring attention in flood mitigation strategies.