FLOOD HAZARD AND VULNERABILITY ASSESSMENT IN UPPER GIN RIVER BASIN IN SRI LANKA UNDER CLIMATE CHANGE

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Date

ABSTRACT

Flood Hazard and Vulnerability Assessment in Upper Gin River Basin in Sri Lanka under Climate Change

Floods are a frequent major disaster throughout the world, usually resulting in fatalities and massive economic and environmental damage. Seasonal and localized flooding is one of the extremely common natural disasters in Sri Lanka. There are two monsoon seasons (Southwest and Northwest monsoon) and two inter- monsoons (First Inter and Second Inter monsoon) in Sri Lanka, each of these monsoon seasons are followed by floods induced by heavy rainfall. The Southwest monsoon, which comes between May and September, has the greatest impact on the southern region of Sri Lanka. This research is developed to assess the flood hazard, vulnerability, and risk of the Thawalama watershed for climate change in future representative concentration pathways (RCP) 8.5. The Research methodology begins with selecting Events, which was determined by different statistical approaches. The Gumbel method was the best fit for determining the event's return periods. A 12-year return period (2003) was selected for calibration, and a 5-year return period (1999) was selected for validation. Further, the future climate rainfall data was bias-corrected using the linear scaling method. The future climate rainfall data was divided into two centuries: mid-century (2040-2070) and end-century (2070-2099). Thereafter, the 5-year Return period and 12-year Return period were estimated through the Gumbel method for both mid and end centuries. The Hydrologic Engineering Centre's Hydrologic Modeling System (HEC-HMS) was calibrated for 2003 and validated for 1999 at the gauging station of the Thawalama catchment to obtain lateral flows and inflow inside the catchment. Thereafter, Hydrological Engineering Centre's River Analysis System (HEC-RAS) was calibrated and validated for the lateral flows and inflows obtained from HEC-HMS for 2003 and 1999 respectively. Similarly, the future lateral flows and inflow were derived using HEC-HMS by importing climatic rainfall data for selected events of 5-year and 12-year return periods in both mid and end centuries. Thereafter, HEC-RAS was used to get flood inundation, flood depth, and flood velocity maps. Finally, to achieve objectives, flood depth and flood velocity were imported to the Arc-GIS interface to develop flood hazards, and population density was used to develop flood vulnerability. Hence, a flood risk map was prepared by multiplying flood hazards and flood vulnerability. The HEC-HMS was calibrated with Nash Sutcliffe (NSE)=0.80, Root mean square error standard deviation (RMSE st dev.) =0.40, and Percent Bias (P-bias) =17.65% and Validated with NSE=0.67, RMSE st dev.=0.60 and P-bias=15%. Thereafter, HEC-RAS was calibrated with NSE=0.66, Coefficient of determination (R^2) =0.83 and P-bias=3.98% and Validated with NSE=0.62, Coefficient of determination (R^2) =0.79 and P-bias=3.28%. The results show an increasing trend of flood inundation area for both the 5-year return period (17.36 km^2,17.40 km^2,19.77 km^2 for years 1999,2052,2091, respectively) and 12-year return period (19.55 km^2, 20.06 km^2, 21.18 km^2 for years 2003, 2058, 2098, respectively). Thereafter, sudden increment of flood hazard, flood vulnerability, and flood risk was obtained after mid-century in both 5-year and 12- year return periods. Almost 22 Grama Niladhari Division (GND) were found to be a very high-risk category and 21 GND were found to be at a high-risk category at the end century of the 12-year Return period in the year 2098 whereas 19 GND were found to be a very high-risk category and 23 GND were found to be at a high-risk category at the end century of 5-year Return period in the year 2091. Flood hazard, flood vulnerability, and flood risk is increasing suddenly after mid-century in both 5-year and 12- year return periods. Hence, from the viewpoint of disaster reduction, the information derived from this study can help to estimate the probability of flood damage for the local population.

Keywords: Bias-correction, Flood-inundation, HEC-HMS, HEC-RAS, Return period, Risk

DEDICATION

“I would like to dedicate my work to my family”.

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CE	-	Coefficient of efficiency
DEM	-	Digital Elevation Model
GND	-	Grama Niladhari Division
HEC	-	Hydrologic Engineering Center
HMS	-	Hydrologic Modeling System
IPCC	-	Intergovernmental Panel on Climate Change
LULC	-	Land-use Landcover
MAE	-	Mean absolute error
NSE	-	Nash Sutcliffe Efficiency
P-Bias	-	Percentage bias
RAS	-	River Analysis System
RCP	-	Representative concentration pathway
RCM	-	Regional Climate Models
RMSE	-	Root Mean Square Error
SCS-CN	-	Soil Conservation Service Curve Number
SS	-	Skill Score