Abstract

Flood is the most frequent natural hazards in the world. Many factors like hydrology, atmospheric conditions and human behaviour are responsible for flood. In the case of fluvial flood, rivers fluvio-geomorphological factors are significant. In India fluvial flood is mostly dominated. Fluvial flooding is triggered by significant rainfall and the obstruction in drainage systems.

The study adopts a case study in the Ajay basin area which flows through the Bihar, Jharkhand and West Bengal states. The lower part area of the basin lies in West Bengal which is very flood prone. The increased flood potential in the lower Ajay basin has heightened the flood risk in the Bhagirathi-Hugli River basin and its surroundings.

To analyse the flood situation and assess the state of vulnerability, the fluvio-geomorphological characteristics of the basin area are discussed. The characteristics of the basin and the morphometric characteristics are analysed using the GIS platform. Morphometric results reveal that the basin shape is elongated, and it currently stands in the old stage of the erosion cycle. Most significantly, following the break of slope and related factors, the river is divided into three parts: Upper, Middle, and Lower. Morphometric and channel characteristics indicate the high flood potential in the lower part of the basin. The gradual decrease in the channel intake capacity due to high sedimentation and human encroachment on the river is increasing its flood vulnerability. The historical background of the flood is analysed with reference to statistical parameters. The maximum floods were recorded in the years 1978 and 2000 and average flood occur almost every year.

The identification of flood-prone area is a crucial aspect of flood management. Recent disaster management plans, such as those from (2008) and the recommendation of Niti Aayog's 2021 have emphasised the importance of identifying the spatial extent of floods. This study focuses on predicting the spatial extension of floods using both qualitative and quantitative data. In the absence of comprehensive hydrological data, AHP (Analytic Hierarchy Process) and FUZZY-AHP methods are applied on a geospatial platform to identify potential flood areas. Notably, the study integrates limited past hydrological data, such as peak gauge heights over the past 40 years, with current topographic data to delineate flood-prone areas.

Simulation-based hydrological models, implemented through software like HEC-HMS and HEC-RAS, are used to identify flood areas and flood depths. The study also examines the relationship between flood-prone areas and contributing factors, determining that low carrying capacity, channel width variation, poor drainage conditions, tributary channel degradation, and human encroachment are major causes of flooding. Spatial validation through KAPPA statistics and overall accuracy assessments are used to analyse the model's suitability. The predicted spatial flood extension is used to estimate vulnerability potential and risk.

To analyse the state of vulnerability, the study considers factors closely related to social, economic, and physical aspects. A vulnerability index is developed at the micro-level, using Gram Panchayat administrative areas. The region's agriculture-based economy, characterised by prevalent mud houses, is highly vulnerable to floods. The study incorporates existing resilience factors to enhance risk prediction. Results are classified according to intensity and vulnerability index values, with risks identified using a GIS platform.

For better flood management, the study discusses several existing non-structural solutions. The current condition of embankments is analysed by measuring soil texture, and texture graphs are used to assess seepage probability. An empirical formula is applied to predict seepage probability. Although the Lower Ajay basin is protected by earthen embankments, their failure has resulted in significant economic and social losses, with long-term damage effects. The failure of the earthen embankment is due to the unscientific use of the embankment, particularly the movement of sand-loaded heavy vehicles, bed cultivation, and unscientific sand quarrying. Therefore, the research emphasises non-structural solutions such as constructing flood shelters in required area, improving road networks quality and increase the road length according to route mapping from resident to flood shelter area, modifying paddy seeds, providing crop insurance from the government side, raising awareness.

The scope of resilience is discussed both quantitatively and qualitatively, with a cost-benefit assessment included for the development of resilience strategies. Prediction of flood potential area in is a critical step in this study. The study's uniqueness lies in its ability to predict vulnerability by combining socio-economic conditions with an assessment of resilience.

This study takes a holistic approach to understanding hydro-fluvial conditions in the river, presenting an analysis of flood conditions, predicting the state of vulnerability, and providing recommendations for sustainable management solutions.