Biannual Open Access Journal
Peer-Reviewed/Refereed International Journal
JOURNAL OF GLOBAL RESOURCES
ISDESR, Jaipur, India

www.isdesr.org

ISSN: 2395-3160 (Print)
ISSN: 2455-2445 (Online)
January 2025, Volume 11 (01)
DOI Prefix: 10.46587/JGR

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PREDICTION OF MAXIMUM FLOOD OF A WATER BODY TO MITIGATE THE IMPACTS ON AGRICULTURE AND URBAN AREAS

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How to cite this paper:
Durgam, Vikas and Reddy, Pinninti Pavain Kumar (2025) Prediction of Maximum Flood of a Water Body to Mitigate the Impacts on Agriculture and Urban Areas, Journal of Global Resources, Vol. 11 (01)

DOI:
10.46587/JGR.2025.v11i01.017

Received: 18 October 2024
Reviewed: 25 November 2024
Final Accepted: 09 Dec. 2024

OPEN ACCESS
Freely available Online
www.isdesr.org

Abstract: *Flooding poses a significant challenge, affecting the lives and livelihoods of people residing near riverbanks. Whether in urban cities or rural villages, the impacts are severe and widespread. In recent years, the frequency of unexpected floods has increased, driven by factors such as climate change, cloudbursts, heavy runoff, and inadequate drainage systems. These unpredictable events make it imperative to develop effective flood prediction and mitigation strategies to minimize losses and reduce impacts. This study focuses on predicting the maximum flood levels of a water body, with a practical case study of the Musi River near Chaderghat, Hyderabad. Using advanced hydrological modelling tools, flood analysis was conducted to better understand the river's behaviour during extreme rainfall events.* ***HEC-HMS****, a hydrological modelling system developed by the US Army Corps of Engineers, was employed for rainfall-runoff modelling. Additionally, unsteady flow analysis was performed using* ***HEC-RAS*** *to determine water surface profiles along the channel segment. With the exponential increase in population in and around Hyderabad, coupled with the presence of rural villages in the Musi River basin that rely heavily on agriculture, assessing flood risks has become a critical priority. The study demonstrates the use of GIS for identifying flood-affected areas, providing valuable insights for alerting communities and implementing targeted mitigation measures. By integrating hydrological modelling and geospatial analysis, this research emphasizes the importance of proactive flood management in protecting urban and rural communities, reducing flood-related damage, and enhancing resilience.*

Key words: Rainfall-Runoff Modelling, Unsteady Flow Analysis, Flood Inundation, GIS

Introduction

Flood prediction is much important to analyse the correct solution or to mitigate the impacts on the effecting body in prior. Such that we can decrease the damage happening in that particular case. This can be done by using the updated software's like HEC-HMS, HEC-RAS, GIS and etc., Estimating the maximum flood using the above software's involves several steps and considerations. As we are facing the huge floods with unexpected rainfalls and they are causing huge impacts which are very disturbing for the common people. As the people who are living in congested areas in urban areas and village areas of agriculture background will get affected more. So, by considering all the situations. We came to know that there is a major need of "Prediction of Maximum flood of a Water body to mitigate the impacts on Agriculture & Urban areas." And in this process, we will also come to know the soil types, water boundaries, flow analysis, maximum runoff and dynamic behaviour etc., Flooding is one of the most destructive natural disasters, causing significant damage to lives, livelihoods, infrastructure, and ecosystems worldwide. The impacts of floods are particularly severe in regions experiencing rapid urbanization, unplanned settlements, and agricultural dependence. With the increasing frequency of extreme rainfall events due to climate change, the need for precise flood prediction and effective mitigation strategies has become more critical than ever.

The prediction of maximum flood levels in a water body is essential to mitigate the adverse impacts on agriculture and urban areas. Flood events often result in substantial losses, particularly for rural agricultural communities and urban populations living in congested areas. Farmers face reduced crop yields and soil degradation, while urban areas suffer from damaged infrastructure, loss of property, and public health crises. Accurate flood prediction can provide early warnings, enabling authorities to take pre-emptive measures to minimize these damages. Modern tools and technologies such as **HEC-HMS (Hydrologic Modelling System), HEC-RAS (River Analysis System)**, and **Geographic Information Systems (GIS)** have revolutionized flood prediction and management. These tools allow for detailed analysis of critical parameters, including soil types, water flow boundaries, peak discharge, dynamic water behaviour, and maximum runoff. By leveraging these advanced software solutions, it is possible to simulate flood scenarios, assess risks, and identify vulnerable areas well in advance. This study focuses on predicting the maximum flood levels of a water body, with particular attention to the downstream regions of the Musi River near Hyderabad in Telangana, India. The region is characterized by its agricultural importance, with crops such as paddy, para grass, and vegetables being highly vulnerable to flood damage. Additionally, the area's urban infrastructure is at significant risk due to its proximity to the river and rapid urbanization. Through this research, we aim to develop a systematic framework for flood prediction using cutting-edge hydrological and geospatial tools. The primary objective is to minimize flood-related impacts on agriculture and urban areas by providing actionable insights for disaster preparedness and mitigation. By doing so, this study contributes to safeguarding livelihoods, enhancing resilience, and promoting sustainable development in flood-prone regions.

Objective of the Project

- To find out the maximum flood for a water body.
- Here, The River Musi is selected as a practical site.

Problem identification

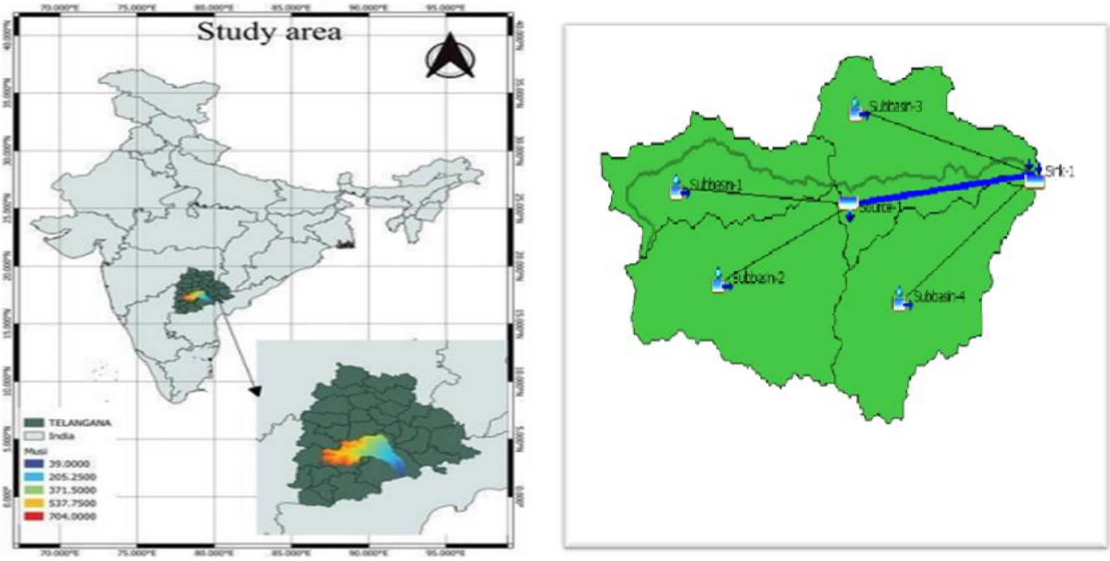
- Flooding is a significant threat to agriculture and urban areas, causing damage to crops, infrastructure, and human settlements.
- Predicting maximum flood levels is crucial for effective flood management and mitigation strategies.

- Here we can say that inefficient agricultural practices or lack of disaster preparedness in rural areas leading to crop damage and also the urban life cycle get impact.

Focus Region

Here, we are taking the practical case study of River Musi situated on the right bank downstream of Hyderabad city in the Telangana state of India.

Figure 01: Location Map



Geospatial Solution

Geospatial solutions play a pivotal role in flood prediction, management, and mitigation. By utilizing advanced tools and techniques, it is possible to predict maximum flood levels and implement effective measures to reduce losses and mitigate impacts.

1. **Flood Prediction and Impact Reduction**: A geospatial approach is proposed to predict the maximum flood levels of a water body, such as the Musi River, to minimize the occurrence of losses and mitigate their impacts. Advanced geospatial tools allow precise analysis and forecasting, which are essential for proactive planning and risk management.
2. **Case Study – Musi River Basin**: A practical case study focuses on a section of the Musi River basin, located on the right bank downstream of Hyderabad city in Telangana, India. This area is significant due to its agricultural dependence and vulnerability to floods.
3. **Agricultural Significance**: The major crops cultivated in the study area include paddy, para grass, and vegetables. These crops are highly susceptible to flood damage, and their protection is critical for ensuring food security and supporting the livelihoods of local farmers.
4. **Peak Discharge Analysis**: Geospatial techniques are used to estimate the peak discharge of the Musi River at specific sections during extreme rainfall events. Accurate discharge estimation is vital for understanding the flood magnitude and its potential impacts on the surrounding areas.
5. **River Stage Estimation**: Using the computed peak discharge, the river stage along a specified length of the Musi River, particularly around the Chaderghat region, is estimated. This data is crucial for determining flood levels and assessing the extent of potential inundation.
6. **Inundation Prediction**: Based on the estimated river stage and peak discharge, the geospatial solution predicts inundation areas during extreme rainfall events. This

information aids in identifying high-risk zones, enabling authorities to prioritize flood mitigation efforts, evacuation planning, and resource allocation.

Technologies to be used:

- HEC-HMS (Hydrologic Modeling System)
- HEC-RAS (River Analysis System)
- Flood Map (GIS-based flood inundation model)
- ArcGIS or QGIS (spatial analysis and visualization) and etc.
- Develop land use plans to balance agricultural, residential and commercial needs.
- Use remote sensing to predict and manage natural disasters like floods and droughts, minimizing their impact on rural communities.

Short-term benefits

The implementation of effective flood risk management strategies and advanced tools like HEC-RAS can yield several immediate benefits within 1-2 years, significantly improving the well-being of communities and the environment:

1. **Reduced Crop Damage**: By identifying flood-prone areas and implementing appropriate mitigation measures, crop damage can be reduced by 10-20 percent, ensuring better agricultural productivity.
2. **Increased Yields**: With minimized flood impacts and improved water management, agricultural yields are expected to rise by 5-10 percent, enhancing food security and farmer income.
3. **Improved Farmer Resilience**: Enhanced flood preparedness equips farmers with better tools and strategies to adapt to adverse conditions, strengthening their ability to recover from flood-related losses.
4. **Reduced Infrastructure Damage**: Proactive flood mitigation measures can prevent damage to roads, bridges, and other critical infrastructure by 10-20 percent, reducing repair costs and ensuring smoother connectivity.
5. **Improved Public Health**: Minimizing flood hazards helps reduce waterborne diseases and other health risks, leading to better overall public health outcomes and reduced healthcare burdens.

Long-Term Benefits (10+ years)

- Over the course of 10+ years, the adoption of advanced flood management strategies and sustainable practices is expected to bring about transformative changes, delivering significant long-term benefits:
- **Sustainable Agriculture Practices**: Proactive water and flood management will promote the adoption of sustainable agricultural practices, ensuring soil health, water efficiency, and long-term productivity.
- **Resilient Urban Infrastructure**: Investment in flood-resistant urban planning and infrastructure will reduce vulnerability to disasters, creating cities that can withstand and recover quickly from climate-related challenges.
- **Improved Food Security**: With sustained reductions in crop losses and higher agricultural yields, food security will improve, supporting the nutritional needs of growing populations.
- **Enhanced Ecosystem Services**: Effective flood management will protect natural habitats, preserve biodiversity, and ensure the provision of vital ecosystem services, such as clean water, air quality, and carbon sequestration.
- **Increased Economic Growth Rate**: By reducing disaster-related disruptions and fostering agricultural and industrial stability, economic growth rates are projected to increase by 2-3 percent, boosting overall prosperity.

- **Reduced Poverty**: The combined effects of improved agricultural productivity, economic growth, and enhanced resilience are expected to lower poverty levels by 10-20 percent, significantly improving quality of life for vulnerable populations.
- These long-term benefits highlight the critical role of innovative flood management strategies in driving sustainable development, fostering resilience, and creating a better future for communities and ecosystems alike.

Methodology

The methodology for flood prediction and analysis involves a systematic process that integrates hydrological and hydraulic modelling with geospatial analysis tools. The key steps are as follows:

1. **Data Collection**: The first step involves gathering all necessary data, including:
   - Topographic data
   - Hydrologic data
   - Hydraulic data
   - Soil characteristics
   - Land use/land cover information
2. **Delineation of Watershed**: The watershed of the study area is delineated using **HEC-GeoHMS**, a geospatial tool that integrates with GIS to prepare input data for hydrologic modelling. This step helps define the boundaries of the area contributing runoff to the river.
3. **Hydrologic Modelling**: Hydrologic modelling is performed using **HEC-HMS** to estimate the runoff generated from rainfall events. This includes analysing rainfall-runoff relationships and understanding how precipitation translates into river flow.
4. **Hydraulic Modelling**: Hydraulic modelling is conducted using **HEC-RAS** to simulate flood flow along the river channel. This step helps determine water surface profiles, flow velocity, and flood behaviour under different scenarios.
5. **Flood Inundation Mapping**: Using the results of hydraulic modelling, flood inundation maps are created. These maps visualize areas at risk of flooding, providing critical insights for emergency planning and mitigation measures.
6. **Statistical Analysis**: Statistical analysis is performed to correlate rainfall intensity and duration with flood levels. This step helps in understanding flood frequency and predicting flood magnitudes for various rainfall scenarios.

Mitigation Strategies

Mitigation Strategies are like to reduce the damage

- Early warning systems
- Flood-control measures (levees, dams, detention ponds)
- Land use planning and zoning regulations
- Agricultural practices (flood-tolerant crops, temporary relocation)
- Urban planning (flood-resistant construction, evacuation routes)

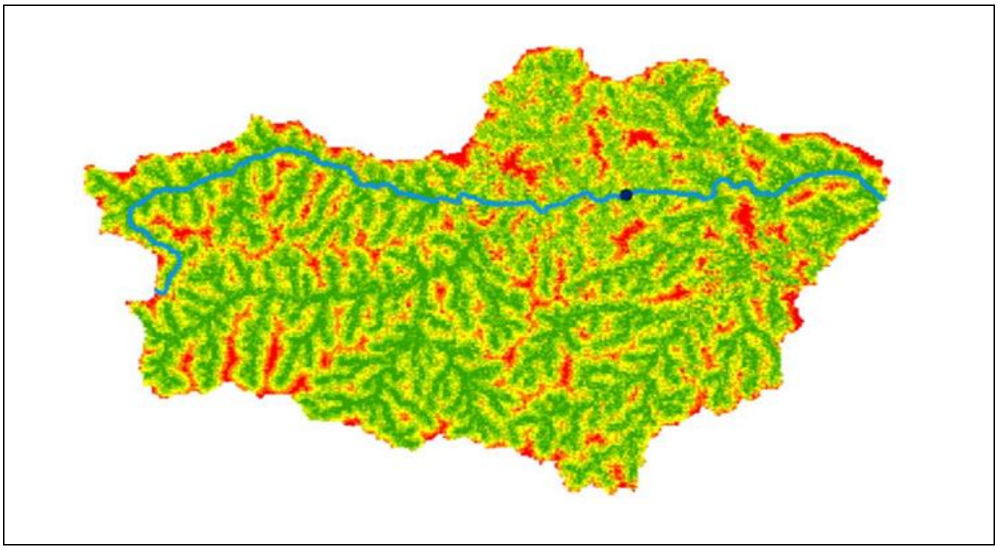
Community Benefits

Flood management and climate-resilient agriculture initiatives provide significant and far-reaching advantages to local communities. These benefits address both immediate needs and long-term challenges, fostering sustainable development and improving overall well-being. Key community benefits include:

1. **Reduced Flood Risk and Crop Losses**: Implementing advanced flood prediction and management strategies helps minimize the risk of floods, protecting lives, property, and livelihoods. For agricultural communities, reduced flood damage translates to lower crop losses, ensuring stable food production and reducing financial stress on farmers.

2. **Improved Food Security, Income, and Livelihoods**: By mitigating the adverse impacts of floods on agricultural lands, these initiatives enhance food production and availability. Improved yields lead to increased income for farmers and better food security for the community. This fosters a sense of economic stability and strengthens the foundation of rural livelihoods.
3. **Enhanced Community Resilience and Social Bonds**: Flood management initiatives strengthen the community's ability to adapt to and recover from disasters. Collaborative efforts in flood preparedness and agricultural resilience build stronger social bonds, encouraging mutual support and shared responsibility in addressing climate-related challenges.
4. **Increased Access to Markets, Services, and Infrastructure**: Flood mitigation measures, such as improved drainage systems and resilient infrastructure, ensure uninterrupted access to markets, healthcare, education, and other essential services. Enhanced connectivity boosts economic activities and improves the community's overall quality of life.
5. **Conservation of Natural Resources and Mitigated Climate Change Impacts**: Initiatives promoting climate-resilient agriculture and sustainable water management help conserve natural resources, such as soil and water. These efforts reduce environmental degradation and contribute to mitigating climate change impacts, ensuring long-term ecological stability.
6. **Empowerment, Economic Growth, and Improved Quality of Life**: These initiatives empower communities by equipping them with tools, knowledge, and resources to address floods and climate challenges effectively. The resulting economic growth, driven by increased agricultural productivity and reduced disaster-related disruptions, enhances the overall quality of life for individuals and families in the community.

Figure 02: Moderate to Significant Flood Hazard Level in Musi River



Conclusion

Based on the analysis conducted using HEC-RAS, it is evident that a majority of the areas adjacent to the Musi River exhibit moderate to significant flood hazard levels, as depicted in Figure 02. This highlights the need for effective flood management strategies in these vulnerable regions. The successful implementation of this project demonstrates the potential of such tools not only for academic research but also for practical application by government officials and policymakers. Adopting these methodologies can significantly enhance flood risk management and mitigation efforts. Therefore, it is strongly recommended to embrace advancements in software tools like HEC-RAS. Leveraging these technologies can play a pivotal role in minimizing environmental damage and safeguarding the lives and properties of affected communities.

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