Prospective Effect of Environment Changes on the Inundation Risk Levels

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ABSTRACT - *The overall dispassionate of the study is to produce information for an enriched land use planning with deference to flood hazards. The study evaluates the potential impact of environment change by pretending a dam break scenario in a high forceof rainfall event and estimates the vulnerability risk in the downstream region by integrating ArcGIS and Hydrologic Engineering Centers River Analysis System (HEC-RAS) technologies. In the past century, the indication of climate changes ispragmatic in terms of intensification in high intensity rainfall events. These events are of high concern, as amplified inflow rates may increase the prospect of a dam failure, leading to higher extent flooding events involving multiple significances. The 100 year historical rainfall data for the central Mississippi region reveals an increased trend in the intensity of rainfall rates after the 1970s. With more than 10% of high hazard dams in the central region, the damage can be far materialistic. The study determines existence of the high intensity rainfall event in the past 100 years for central Mississippi and simulates a Ross Barnett Reservoir dam break scenario and appraises the vulnerability risks due to inundation in the immediate downstream region, which happens to be the State Capital. The results designate that the inundation due to a Ross Barnett Reservoir failure under high intensity rainfall event is comparable to a catastrophic flood event experienced by the region in 1979, which almost equals a 200-year flood magnitude. The results indicate that the extent and depth of flood waters poses a substantial destructive threat to the state capital, overwhelming various infrastructural and transportation networks.*

Keywords: *GIS; flood simulation; dam break; climate change.*

I. INTRODUCTION

Allowing to the Intergovernmental Panel on Climate Change (IPCC), over the 20th century, the detected temperature and sleet changes in the United States was quite higher than the rest of the world. The expected temperature changes in central North America are higher than the global mean values, because of higher latitudes.

The central USA witnessed significant changes in temperature and rainfall, and conferring to the United States Environmental Protection Agency (USEPA) report, over the last century; the snow levels in Mississippi have increased by about 20% over the mean annual rainfall and are predicted to rise by 5–25% in the coming century during the state. The indication of the weather changes is perceived not only in terms of increase in the average rainfall, but also in terms of increase in the force of precipitation events, which is of high concern towards flooding problems.

The climatic changes have dreadfulsignificances that impact physical systems, preparation and social organization in many ways. Floods can also be measured as high-impact events, as they involve multiple consequences, such as disruptions in the transference and communication sectors, property damage and protracted submergence of agricultural lands, wetlands, *etc*. The adversity effects are greatest for floods than any other calamity. Of all the natural calamities, floods can be designated as catastrophic events whose impact lasts for a long period of time. The 100 year historical rainfall data for the central Mississippi region reveals an augmented trend in the intensity of rainfall rates after 1970s (Figure 1). These events are of high concern, as amplified inflow rates may increase the probability of a dam failure, leading to higher magnitude flooding events involving multiple penalties.

In a report prepared by the city of Roseville, CA, climate modification effects trigger the probability of dam failure, as dams are designed based on the expectations about the river flow behavior or hydrographs. The changes in the weather outlines due to climate change effects can bring momentous effects on hydrographs used for the design of the dam. In case of a dam failure in these rainfall events, the damage can be far more severe and materialistic to the State of Mississippi, with 277 high hazard dams.

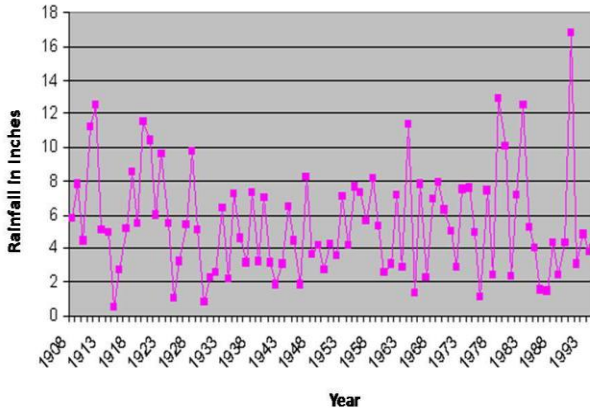

Fig 1. Intensity of the rainfall events

1.1 History of Ross Barnett Reservoir Dam:

The Ross Barnett Reservoir was built in 1960, positioned in the midst of the three most densely populated sections and economic centers of Mississippi, is one of the tall hazard dams that lacks an Emergency Action Plan (MDEQ, Division of Dam safety, 2000). Supplementary, the design lifetime of the earth-fill dam posing more risk to downstream region is of serious concern. Despite flood controller improvements of levees and clearance, the Jackson, MS, metropolitan area below the Ross Barnett Reservoir Dam suffers annual flood compensations from the Pearl River of about $10 M.A review of the literature recommends that a number of studies have been done for pretending dam break floods.

Katopodes examines the flooding patterns when a fixed element method (Galerkin formulation) model is applied on anirregular channel flow. By associating the results with the analytical solutions, the study rated the performance of the model to be poor. In another study, Hromadka analyzes a two-dimensional dam-break model established for a flood plain, with flow comparisons solving a diffusion model coupled to the equation of continuity. The study accomplishes this approach can better predict at a two-dimensional dam-break flood plain over a broad, flat plain more correctly than a one-dimensional model.

Similarly, Akanbi accessible a model to indicate the variations in the behavior of flood waters disseminating on a dry bed, and Zhao *et al*. Investigated the effects of changes in bed elevations on the overflowing patterns using three demarcated solvers and concluded that these models are useful for studying levee failure or dam break due to dangerous flood events. The competences of numerical models that simulate flooding due to failure of a dam/reservoir in a natural river were presented by Sharma; Zoppou and Robert. Opening review of these articles specifies that these studies focused on investigating the modifications between the flood model equations that were solved and estimated the level of stability and accuracy of the equations. These studies lack the submission of results on the communities, which can facilitate in identifying vulnerable locations.

On the other hand, a MEMA report obtainable examples of two dam break studies that have been executed for Oak Lake Dam (Rankin County) and Acacia Woods Lake Dam (Rankin County). In both cases, the dam break reproductions were done at the normal water level failure and have not measured future possible dam failure due to dangerous inflows caused by intense rainfall events. Additionalstudy on the Ross Barnett Reservoir by Davies was done from a hydraulic analysis dimension. In spite of frequent studies, there exists a knowledge gap in recognizing vulnerable locations due to dam failure and applying the results to enhance activities in planning and developmental fields.

II. METHODOLOGY

The study integrates geospatial technologies with the HEC-RAS model to simulate the dam break flood inundation for the determined rainfall scenario. HEC-RAS 4.0, a flood simulation model developed by the US Army Corps of Engineers, computes steady flow and unsteady flow (dam break) simulations. The preprocessing of the geometric data (extraction of the physical characteristics of the study region) and the post-processing of the outputs (to visualize the flooding impact) that are required by the HEC-RAS dam break model are done by using HEC-GeoRAS. HEC-GeoRAS, an extension in ArcGIS, facilitates integration and visualization of HEC-RAS inputs and outputs.

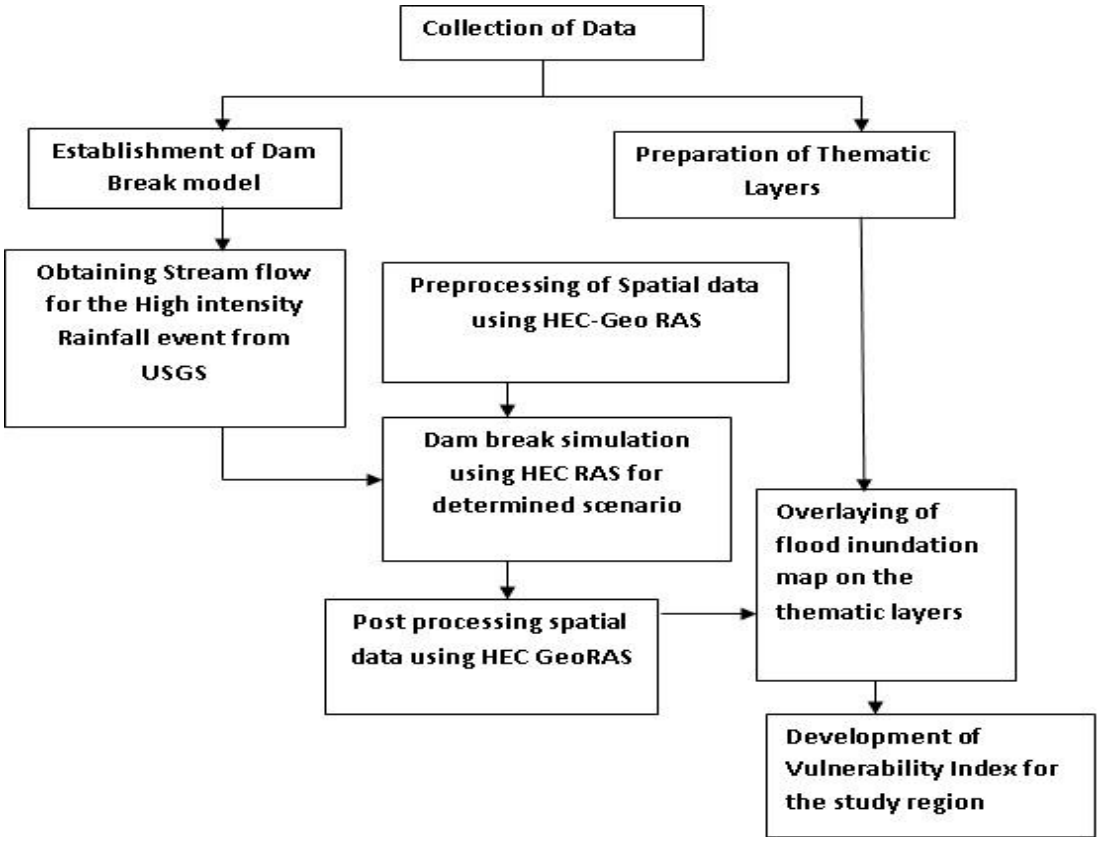

Fig2. Processing of data flow

III. RESULTS AND DISCUSSION

Integration of the scientifically engendered information in the scheduling process helps in exposing the long-term threats posed by flood menaces. It simplifies the present planning happenings to be designed in a futuristic manner and assists concerning retaining the social, economic and conservational functionalities viable in the face of hazard. In order to accomplish safe and supportable communities, urban planners should view and recognize the physical characteristics of hazard as an important indicator for identifyingvulnerable areas.

The interaction of the hazard with an urban area can have a potential impact on its cultural, historical, social, infrastructural and economical functionalities. Investigating the vulnerability of these functionalities in the face of a flood event will not only existing an insight about the instabilities that might occur in these inter-related functionalities, but also description the risk factor upon which the current developmental activities are being planned.

The analysis from this exposure assessment, as said by Geertman, can assist in progressing the inclusive nature of climate change factors in the organization process, thereby strengthening the focus of the supportable approach in the future developmental activities downstream of the Ross Barnett Reservoir Dam. As the downstream region (Hinds County) is taking part in the FEMA National Flood Insurance Program (NFIP), all the growing activities are bound to a 100-year base flood magnitude. With the presence of a high hazard dam in the upstream and with climate change effects in place, planning growing activities considering a 100-year flood hazard level may not hold good.

In this context, the spatial positions of the blocks with probable flood threat are assessed by calculating a vulnerability index from an integrated risk factor obtained from the spatial extent of the recognized hazard and the vulnerability risk of the region.

The study discusses the dam break recreation results under two sections: (1) hazard identification and (2) vulnerability assessment. While the hazard documentation section discusses the spatial extent and depth of the flood waters, susceptibility

assessment is described under the cultural-historical and social-infrastructural impacts due to inundation. Lastly, the study calculates the joined risk factor and presents the spatial location of high/medium/low defenseless blocks due to a Ross Barnett Reservoir Dam failure under a high intensity rainfall event in Hinds County.

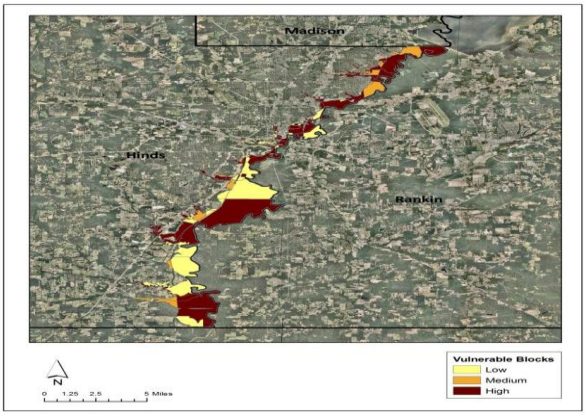

Fig 3. Levels of vulnerability at a census block level

IV. CONCLUSIONS

The detached of the study is to assess the impending impact of climate changes on the barrage risk levels in a Ross Barnett Reservoir Dam failure scenario. Most of the preceding studies that were done on the impressions of dam failure mainly focused on the hydraulic analysis dimension, analyzing the design failure causes of the dam. Thus, filling the gap, the present study pretends the impact of Ross Barnett Reservoir Dam failure under a high intensity rainfall event on the downstream region and directed a flood helplessness index of the blocks.

Simulation of Ross Barnett Reservoir Dam failure under a high intensity rainfall event yielded results with the flood hazard impact (spatial extent and depth grids) encompassing till the end of Hinds County. The results exposed alarming material indicating the spatial extent and depth grids of flood hazard to equal a 200-year magnitude flood. The numbers of acres coming under flood waters and the maximum depths almost match with the 1979 catastrophic flood.

These results bear utmost consequence, as the current developing activities in the downstream counties are bound to 100-year flood greatness, while situated under a quite possible 200-year flood threat. Helplessness assessment in this event of a 200-year magnitude flood hazard exposed the possible disturbances that can occur to cultural, commercial, transportation and infrastructural amenities, affecting their inter-connected functionalities. Lastly, the study developed a combination index to identify the spatial location of vulnerable areas by normalizing individual indicators at a census block level. The overall detached of the research is to generate information for an improved or enhanced land use planning with respect to flood hazards.

By sensational the long-term flood threats, the study assists the planning authorities at the local or county level in identifying vulnerable zones and integrating the essence of information in its future developmental activities. The basic intention of planning or developmental strategies is to build safer societies by locating expansions away from the hazard-prone areas.

Categorizing vulnerable areas under various possible scenarios plays an important role in the decision-making process. The increase in the helplessness levels that might occur due to climate change affects downstream of Ross Barnett Reservoir can help the local government to improve the inclusive nature of conservational factors to their focus on achieving sustainable development.

REFERENCES

1. IPCC. Summary for Policymakers. In *Climate Change 2007: The Physical Science Basis*; Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L., Eds.; Cambridge University Press: Cambridge, UK/New York, NY, USA, 2007; p. 996.
2. Easterling, Williams. Adapting North American agriculture to climate change.*Agr.Forest Meteorol.***1996**, *80*, 1–53.
3. United States Environmental Protection Agency. *Climate Change and Mississippi*; US EPA: Washington, DC, USA, 1998.
4. *City of Roseville. Dam Failure*. Available online: http://www.roseville.ca.us/civica/filebank/ blobdload.asp?BlobID=19067 (accessed on 19 November 2012).
5. Zhu, N.H.; Turner, E.R.; Doyle, T.; Abdollahi, K. *The Potential Consequences of Climate Variability and Change*; GCRCC and LSU Graphic Services: Baton Rouge, LA, USA, 2003.
6. FEMA. *Grants Target Mississippi Flood Risks.* Avaiable Online: http://www.fema.gov/news-release/ grants-target-mississippi-flood-risks (accessed on 21 August 2012).
7. Idaho National Laboratory. *Assessment of Potential Flood Events and Impacts at INL's Proposed Remote-Handled Low-Level Waste Disposal Facility Sites*; US Department of Energy: Idaho Falls, ID, USA, 2010.
8. Jami, E.; Scuddkr, M.; Johan, G.; Wilfrid, G. Lessons from a dam failure. *J. Sci.* **2000**, *100*, 121–131.
9. *Proactive Measures Needed to Prevent Future Dam Disasters*; Association of State Dam Safety Officials: Lexington, KY, USA, 2004.
10. US Army Corps of Engineers. *Pearl River Watershed Study. 2004.* Avaiable Online: http://www.mvk.usace.army.mil/offices/pp/projects/prws/background.htm (accessed on 17 August 2012).