Impact of Downstream Flow Contribution on the Flood Prone Areas of a Hydropower Project

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Abstract

The sudden release from the dam during monsoon season is now becoming a grave concern, especially in the downstream areas. The situation worsens if rainfall occurs at the same time in the lower part of the region as well. Thus, the flow contribution due to rainfall and lateral flow plays a significant role while issuing flood warnings in downstream flood-prone areas. This study presents a coupled reservoir operation and a hydrodynamic model to simulate the hydrograph in the flood-prone region considering downstream flow contribution including baseflows. Standard Operating Policy has been adopted for the reservoir operation model, and a 1D hydrodynamic model has been employed as the flood routing model. The model has been applied at Ranganadi Hydropower Project located in Arunachal Pradesh, India. The flood-prone area is situated around 46 km downstream from the dam site. A Flow Duration Curve (FDC) was prepared for the flood-prone site for the different values of downstream flow contribution. The statistical analysis of the observed dam releases imparts that the releases from the dam contributes around 10% of flow in a year. Thus, from the FDC curve, the flow values with exceedance probability of more than 10% were considered which include Q95, Q70, Q50 and Q30. A flood event of 50 hrs. inflow hydrograph was considered in the analysis. The peak increment factors were calculated by comparing Q95 (considered as the reference downstream flow contribution value) with the other mentioned flow values. The results elucidate that the peak increment factor increases from 0.019, 0.068, 0.13 corresponding to Q70,Q50,and Q30 respectively. This analysis illustrated that for precise flood levels monitoring, it is necessary to incorporate downstream flow contribution.

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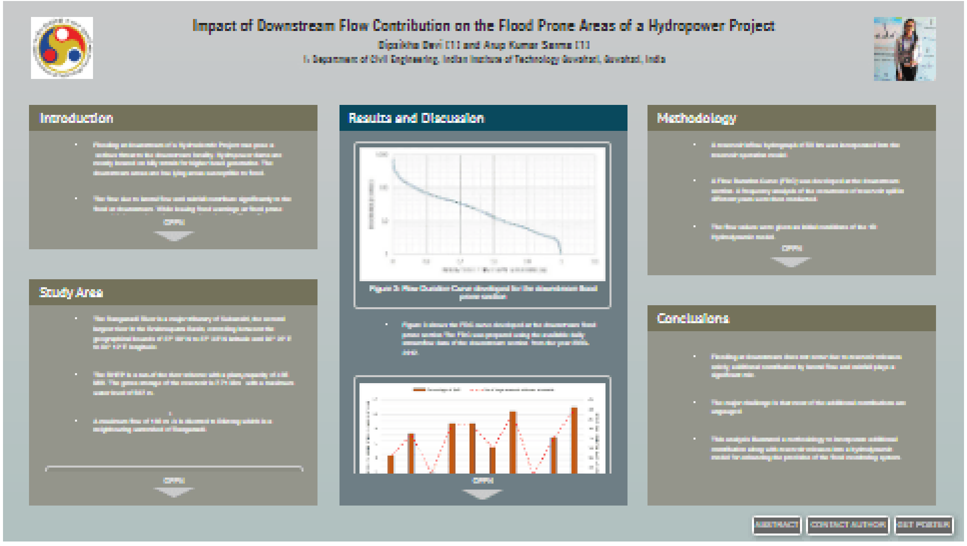

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INTRODUCTION

- Flooding at downstream of a Hydroelectric Project can pose a serious threat to the downstream locality. Hydropower dams are mostly located on hilly terrain for higher head generation. The downstream areas are low lying areas susceptible to flood.

- The flow due to lateral flow and rainfall contribute significantly to the flood at downstream. While issuing flood warnings at flood prone areas it is imperative to incorporate the other significant flow contribution at downstream.

- The accuracy of the flood warning system can be enhanced with the incorporation of reservoir operation and a hydrodynamic model in tandem.

- The model was applied to Ranganadi Hydroelectric Project (RHEP) located in Arunachal Pradesh, India. The downstream flood-prone area NT Road Crossing is 46 km from the dam site, was considered in the study.

STUDY AREA

- The Ranganadi River is a major tributary of Subansiri, the second largest river in the Brahmaputra Basin, extending between the geographical bounds of 27° 00' N to 27° 35' N latitude and 93° 22' E to 94° 12' E longitude.

- The RHEP is a run-of the river scheme with a plant capacity of 405 MW. The gross storage of the reservoir is 7.71 Mm^3 with a maximum water level of 567 m.

- A maximum flow of 160 m^3/s is diverted to Dikrong which is a neighbouring watershed of Ranganadi.

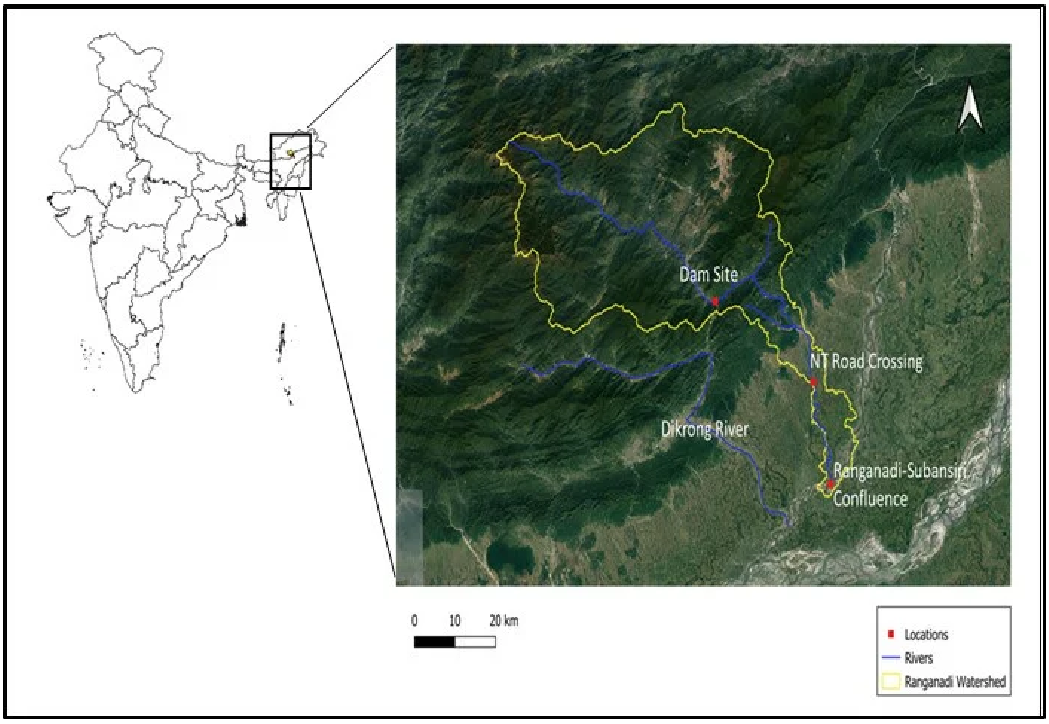

Figure 1: Case Study Area

RESULTS AND DISCUSSION

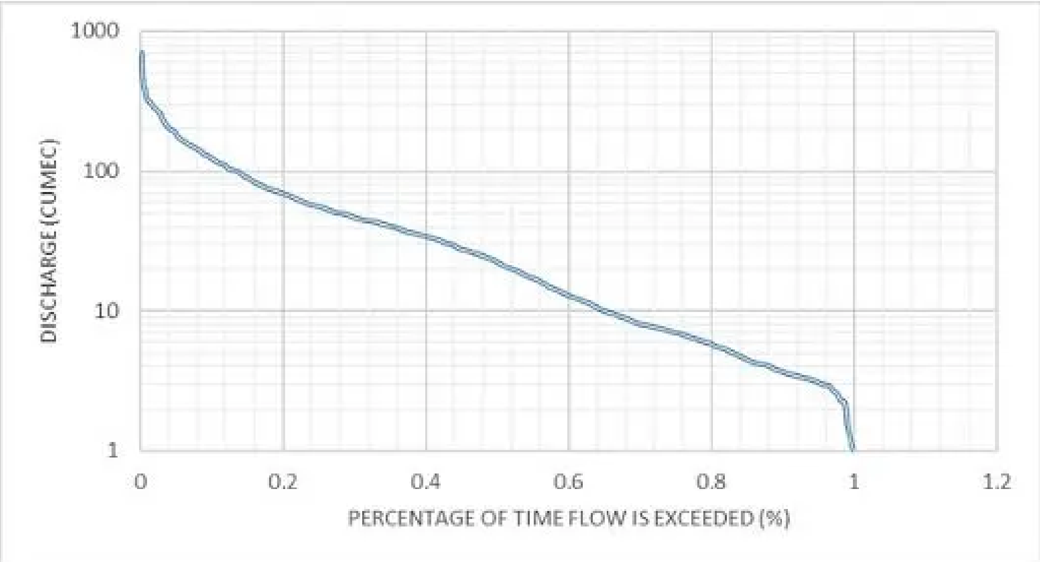

Figure 3: Flow Duration Curve developed for the downstream flood prone section

- Figure 3 shows the FDC curve developed at the downstream flood prone section.The FDC was prepared using the available daily streamflow data of the downstream section from the year 2003-2012.

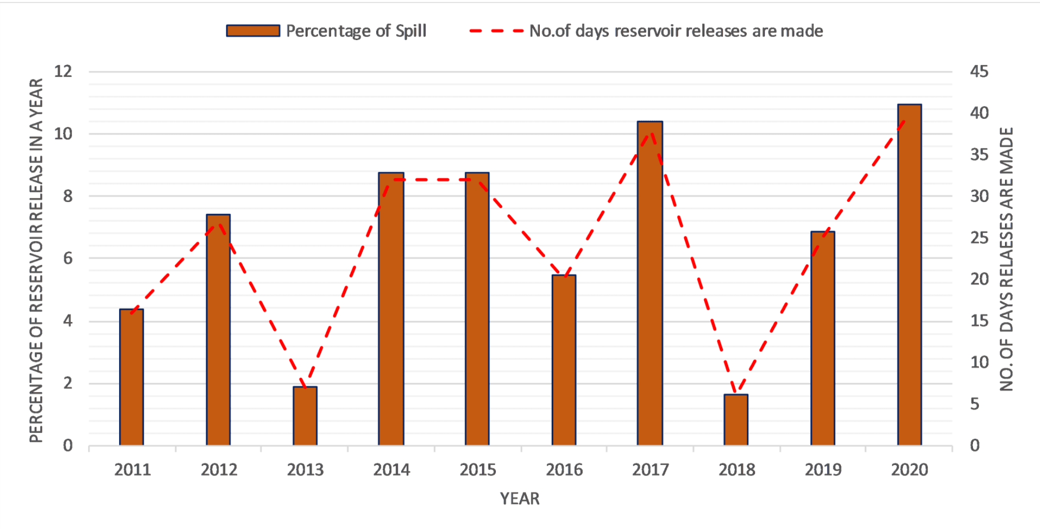

Figure 4: Frequency Analysis of the reservoir spill

- Figure 4 shows the total contribution of spill to the downstream flow. The reservoir spill were available from 2011-2020.

- From the investigation, in 2020 maximum reservoir spill was observed for 40 days.Thus, it is assumed that reservoir spill contributes 10.95% of flow at downstream.

- In this analysis, the flow values below 10.95% of percentage exceedance (Q95, Q70, Q50, Q30) were incorporated into the hydrodynamic model as different flood scenarios as downstream contributions.

- The peak increment factors were calculated comparing Q95 (considered as reference downstream flow contribution value) with the other mentioned flow values.

- The results elucidate that the peak increment factor increases from 0.019, 0.068, 0.13 corresponding to Q70,Q50,Q30 respectively.

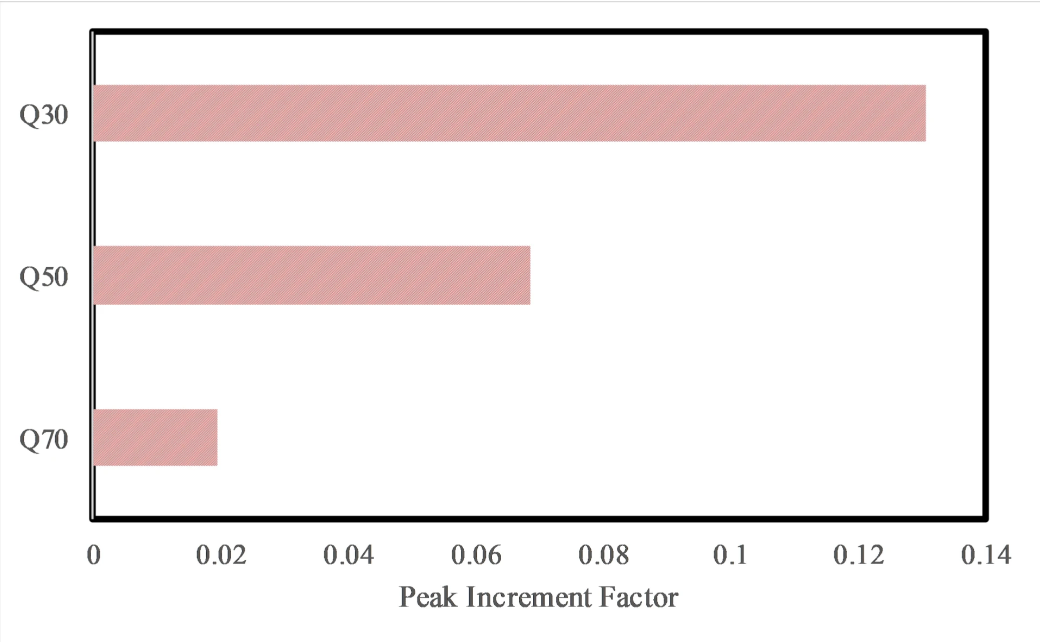

Figure 5: Flood Peak Increment Factor for different flow values

METHODOLOGY

- A reservoir inflow hydrograph of 50 hrs was incorporated into the reservoir operation model.

- A Flow Duration Curve (FDC) was developed at the downstream section. A frequency analysis of the occurrence of reservoir spill in different years were then conducted.

- The flow values were given as initial conditions of the 1D Hydrodynamic model.

- From the hydrodynamic model discharge and flood levels were obtained. The flood peak increment factor was then calculated for different flow values with Q95 as the reference downstream flow value.

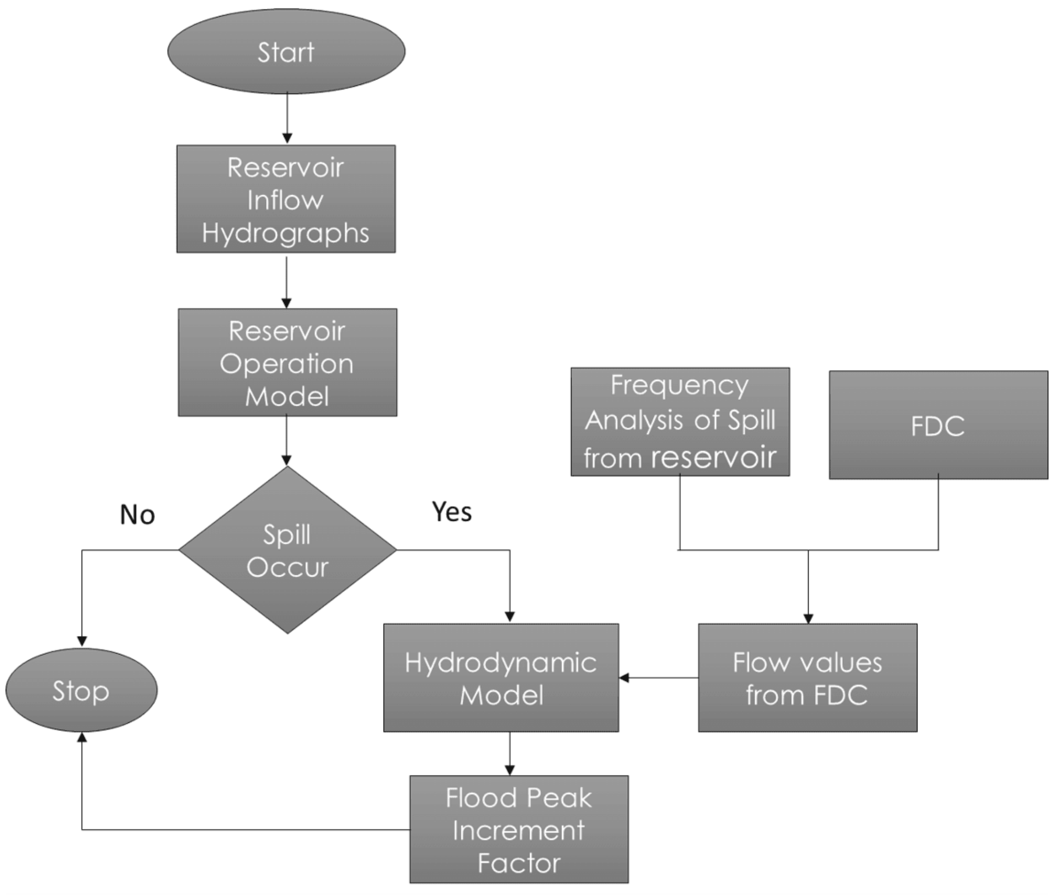

Figure 2: Flowchart of the Methodology Adopted

CONCLUSIONS

- Flooding at downstream does not occur due to reservoir releases solely, additional contribution by lateral flow and rainfall plays a significant role.
- The major challenge is that most of the additional contributions are ungauged.
- This analysis illustrated a methodology to incorporate additional contribution along with reservoir releases into a hydrodynamic model for enhancing the precision of the flood monitoring system.

ABSTRACT

The sudden release from the dam during monsoon season is now becoming a grave concern, especially in the downstream areas. The situation worsens if rainfall occurs at the same time in the lower part of the region as well. Thus, the flow contribution due to rainfall and lateral flow plays a significant role while issuing flood warnings in downstream flood-prone areas. This study presents a coupled reservoir operation and a hydrodynamic model to simulate the hydrograph in the flood-prone region considering downstream flow contribution including baseflows. Standard Operating Policy has been adopted for the reservoir operation model, and a 1D hydrodynamic model has been employed as the flood routing model. The model has been applied at Ranganadi Hydropower Project located in Arunachal Pradesh, India. The flood-prone area is situated around 46 km downstream from the dam site. A Flow Duration Curve (FDC) was prepared for the flood-prone site for the different values of downstream flow contribution. The statistical analysis of the observed dam releases imparts that the releases from the dam contributes around 10% of flow in a year. Thus, from the FDC curve, the flow values with exceedance probability of more than 10% were considered which include Q95, Q70, Q50 and Q30. A flood event of 50 hrs. inflow hydrograph was considered in the analysis. The peak increment factors were calculated by comparing Q95 (considered as the reference downstream flow contribution value) with the other mentioned flow values. The results elucidate that the peak increment factor increases from 0.019, 0.068, 0.13 corresponding to Q70,Q50,and Q30 respectively. This analysis illustrated that for precise flood levels monitoring, it is necessary to incorporate downstream flow contribution.