An integrated geoinformatics and hydrological modelling-based approach for effective flood management in the Jhelum Basin, NW Himalaya

Presenter

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Introduction

- South Asia is at the brunt of climate change related disasters. India particularly, is witnessing increased incidences of weather-related extreme events, such as floods, droughts and heat waves [1].
- In September 2014, Kashmir the Northern Himalayan state of India, witnessed the most devastating flood in the recorded history of the region. Since 2014, the flooding threats in this region have been a recurring phenomenon every year [2].
- The magnitude of this event crossed all bounds of the recorded history of floods in the region not only in terms of discharge but also in terms of loss of life and property [3-6]. The event has generated a scientific consensus for an alarming need of robust flood mitigation strategy for the Kashmir region.

Introduction *continues*

- In the present study, using static land system parameters such as geomorphology, land cover and relief, we calculated comparative water yield potential (RP) of all the watersheds of the Jhelum basin (Kashmir Valley) using analytical hierarchy process (AHP) based watershed evaluation model (AHP-WEM) [8].
- Further we also tested the use of HEC-GeoHMS hydrological model for using it as flood forecasting model for the region [9].
- We also generated map of the locations wherein flood structural measures could be constructed as a management strategy to increase the lag time of the rapid water yielding watersheds.


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Results

- *Analytical hierarchy process (AHP) based watershed evaluation model (AHP-WEM)*

➢ Watershed morphometrics and land cover of Jhelum basin watersheds

➢ Validation of AHP-WEM

- *HEC-GeoHMS hydrological model simulations*
- *GIS overlay analysis for structural measures location determination*

Results *continues*

Analytical hierarchy process (AHP) based watershed evaluation model (AHP-WEM)

- Initially, we calculated 23 morphometric parameters to compensate for geomorphology and relief of the 24 watersheds of the Jhelum basin. In order to reduce the redundancy in the information, we performed multivariate analysis on the data and as such 7 parameters were inferred that represented all the morphometric information of the watersheds [8].
- For land cover, we generated 8 land cover categories governing in part, the hydrology of the Jhelum basin.
- The results revealed that among the 24 watersheds of the Jhelum basin, *Vishav* watershed with the highest runoff potentail is the fastest water yielding catchment of the Jhelum basin followed by *Bringi, Lidder, Kuthar, Sind, Madhumati, Rembiara, Sukhnag, Dal, Wular-II, Romshi, Sandran, Ferozpur, Viji-Dhakil, Ningal, Lower Jhelum, Pohru, Arin, Doodganga, Arapal, Anchar, Wular-I, Gundar,* and *Garzan* in the situation of same intensity storm event. (Table 1, Figure 1).

Table 1. Water yield potential categorization of Jhelum basin watersheds on the basis of AHP-WEM results

S no.	Watershed	AHP-WEM TR Score	Water yield	S no.	Watershed	AHP-WEM TR Score	Water yield
1	Garzan	13.03	Low	13	Sandran	21.36	High
2	Gundar	15.99	Low	14	Romshi	21.63	High
3	Wular I	18.11	Medium	15	Wular II	22.37	High
4	Anchar	18.83	Medium	16	Dal	22.53	High
5	Arapal	18.83	Medium	17	Sukhnag	22.83	High
6	Doodganga	19.13	Medium	18	Rembiara	23.33	High
7	Arin	19.38	Medium	19	Madhumati	23.48	High
8	Pohru	19.62	Medium	20	Sind	23.86	High
9	Lower Jhelum	20.11	Medium	21	Kuthar	24.65	Very high
10	Ningal	20.35	Medium	22	Lidder	25.48	Very high
11	Viji-Dhakil	20.43	Medium	23	Bringi	26.02	Very high
12	Ferozpur	20.60	High	24	Vishav	28.09	Very high

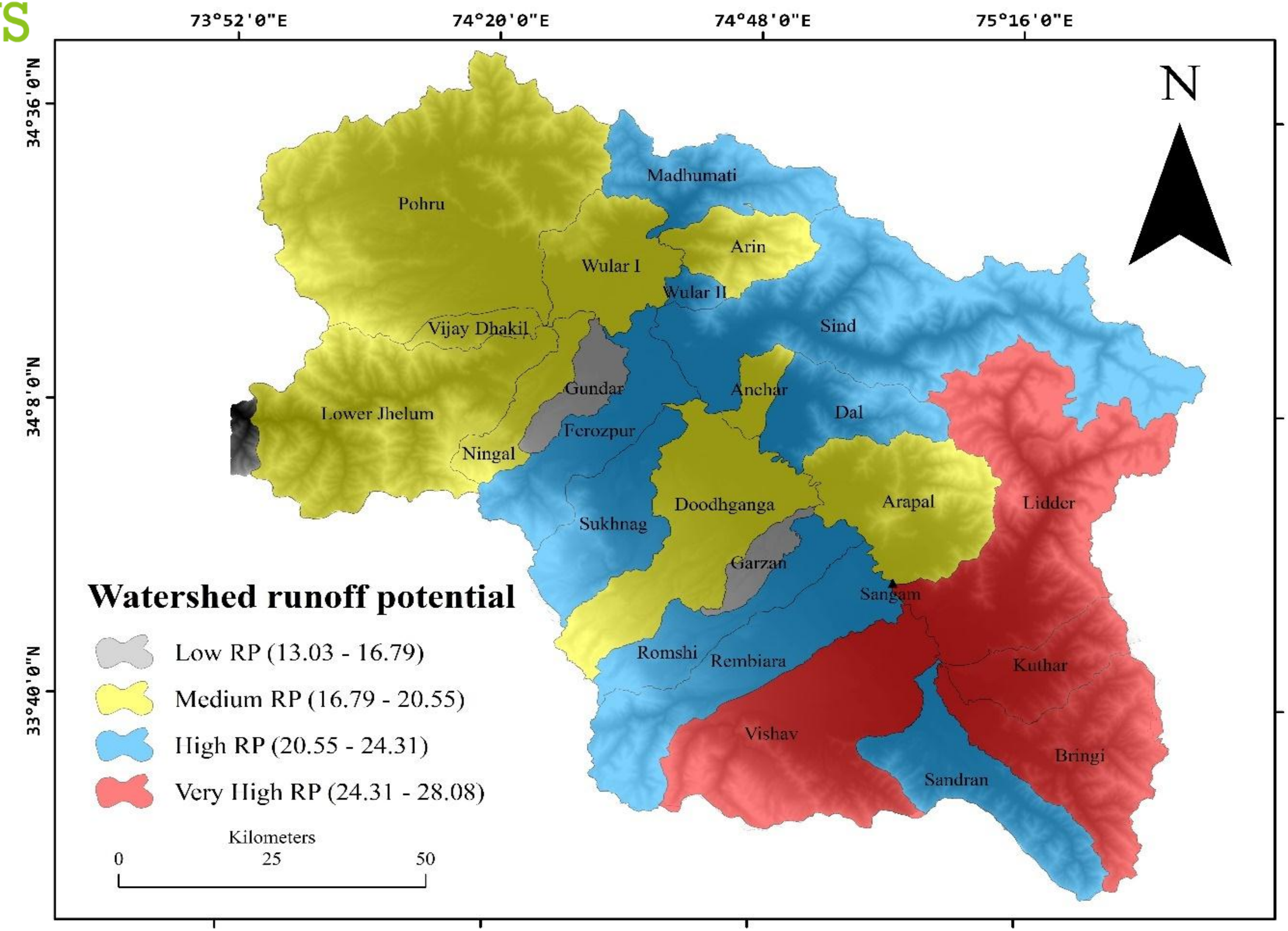

Figure 1. Comparative water yield potential categories of the Jhelum basin watersheds

Results ***continues***

Validation of AHP-WEM

For validating AHP-WEM results, we correlated the total water yield potential of the watersheds with the mean annual peak discharge (MAPD) values of the watersheds of 30 years. The results showed strong positive correlation of 0.71 between the modelled water yield potential and MAPD values of the watersheds (Figure 2).

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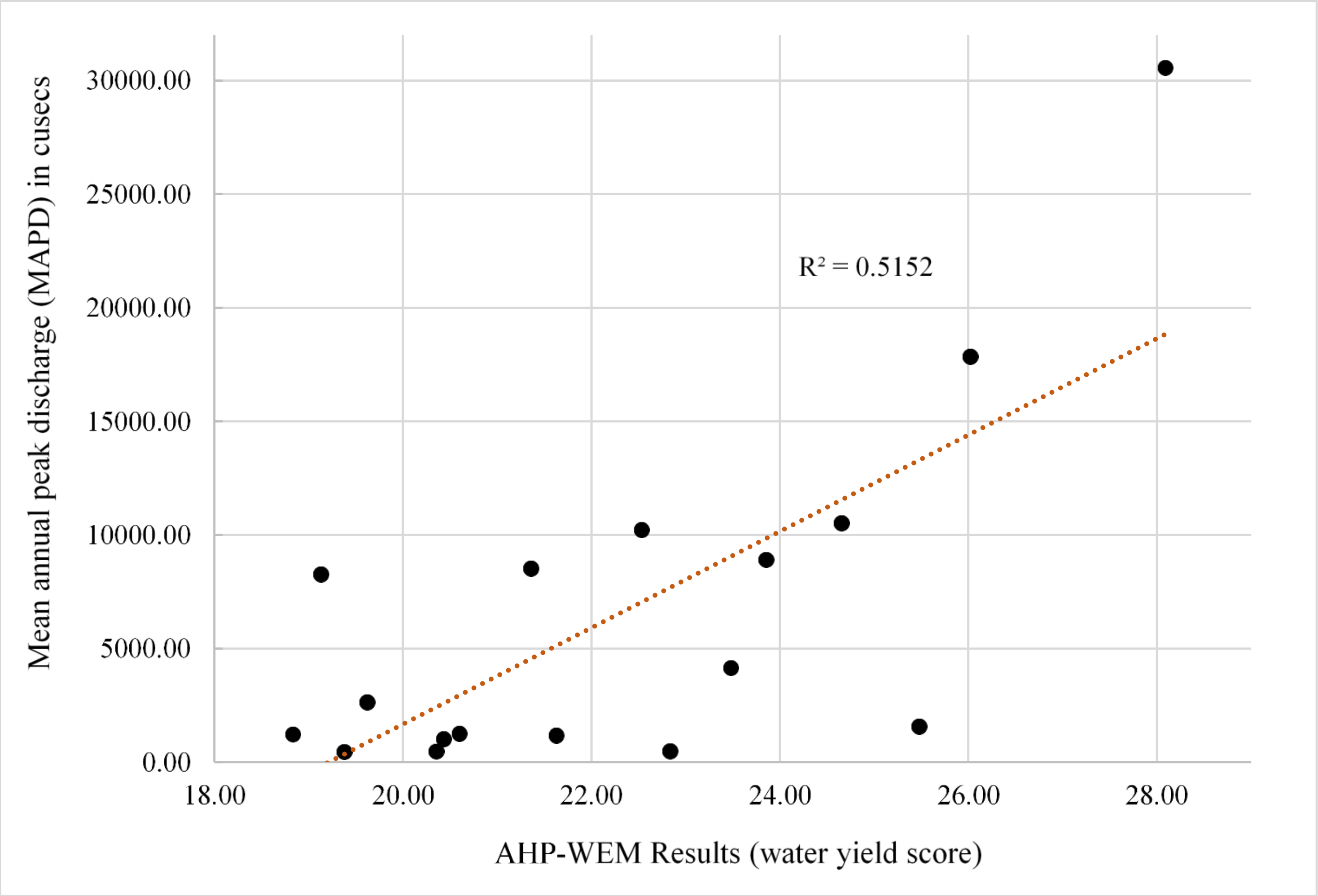

Figure 2. Scatterplot of MAPD and AHP-WEM results

Results ***continues***

HEC-GeoHMS hydrological model simulations

- We evaluated the performance of the HEC-GeoHMS model as a possible flood forecasting model for the Jhelum basin. It was observed that the model performs well for august-september period with a strong positive correlation of 0.94 ($r^2 = 0.88$), between the observed and simulated mean monthly discharge in the validation period (Aug-Sept, 2006-2016) (Figure 3).
- The model was run at Sangam discharge station which covers *Vishav, Bringi, Lidder, Kuthar* and *Sandran* watersheds of the Jhelum basin for a period of 21 years (1995-2016) (Figure 1). The results inferred that this model is one of the good models freely available to the flood forecasters, when realtime precipitation is available, to give early warning and prevent disaster in the region.

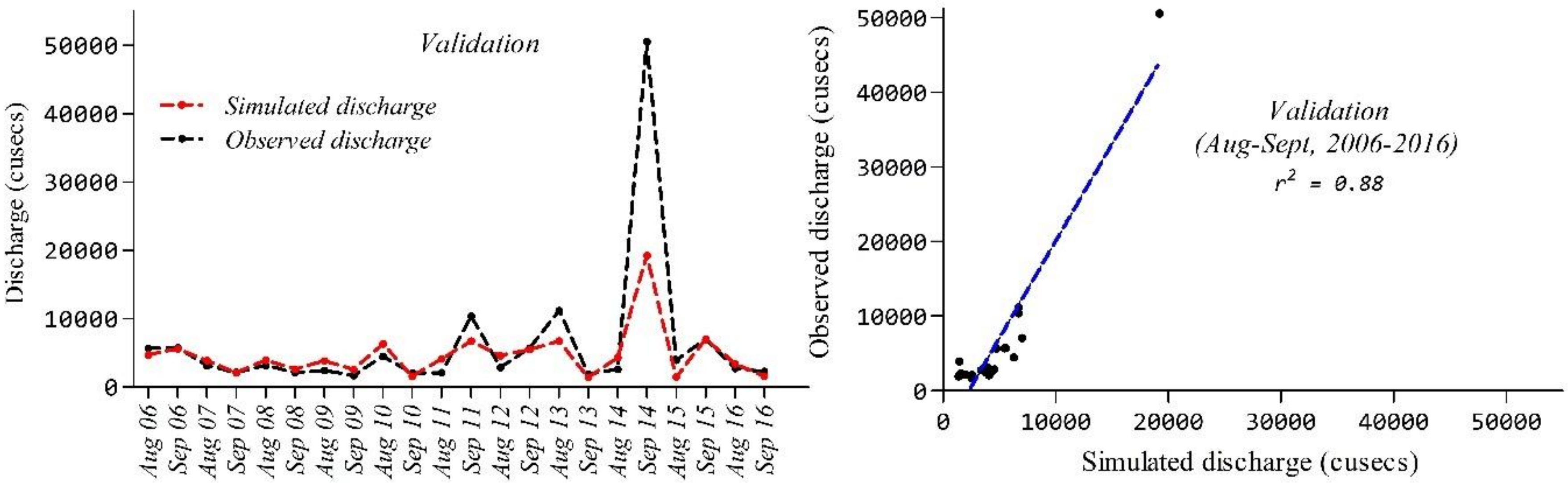

Figure 3 HEC-GeoHMS results of the validation period (Aug-Sept), 2006-2016

Results ***continues***
GIS overlay analysis for structural measures location determination

- Using slope, discharge density and land cover information of the high-water yielding watersheds, locations were determined for constructions of piano key-wiers and check dams as a management practice, to delay surface runoff during heavy rains through GIS based overlay analysis.
- Finally, location map was generated, showing areas where structural measures must be setup to increase the basin lag time of the very high-water yielding watersheds

Discussion

- In this study, morphometry and LC of all the Jhelum basin watersheds were used to understand their comparative water yield potential.
- It was observed that south Jhelum watersheds (South Kashmir) have very high water yield potential, that results them being very fast in discharging their water, after a heavy downpour.
- This is one of the reasons, behind initial heavy flooding of south Kashmir villages, prior to overall flooding of the whole Kashmir valley during 2014 deluge. HEC-GeoHMS hydrological model was used to infer its applicability for near real-time flood forecasting at *Sangam* where almost all the very high water yielding watersheds collate (Figure 1).

Discussion *continues*

- Model calibration was perfomed for a range of parameters such as CN and Muskingum. After lot of initial calibrations, the model was set up at r^2 = 0.87 for calibration and r^2 = 0.88 for validation.
- Further, since for effective flood management, it is necessary that flood control structural measures are set up at locations where abrupt inflow of water could be managed to delay the concentration of water at the downstream locations for early warning and evading the disaster.
- For this purpose drainage density and land cover layers were used to deduce such locations using overlay analysis. Areas with heavy drainage density and vulnerable land cover such as impervious surfaces and degraded land, were ranked high in the analysis [12].

Materials and methods

- The comparative water yield potential of the 24 watersheds of the Jhelum basin was evaluated from the analysis of the morphometric indices and the land cover of the basin watersheds in an AHP based watershed evaluation model (AHP-WEM).
- We used survey of India (SOI) topographic maps (1:50,000 scales), Indian Remote Sensing (IRS) P6 Linear Imaging Self-Scanning (LISS III) data with 23.5-m spatial resolution of October 21, 2008, and Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) 30-m resolution Digital Elevation Model (DEM) in AHP-WEM model.
- For HEC-GeoHMS, soil maps from the National Bureau of Soils Sciences & Land Use Planning (NBSS&LUP) at 1:250,000 served as base line data. Daily rainfall for years, 1995 till 2016 of *Kokernag*, *Qazigund* and *Pahalgam* stations, and mean monthly discharge data for the same period at *Sangam* station was used for setting up the model.

Materials and methods *continues*

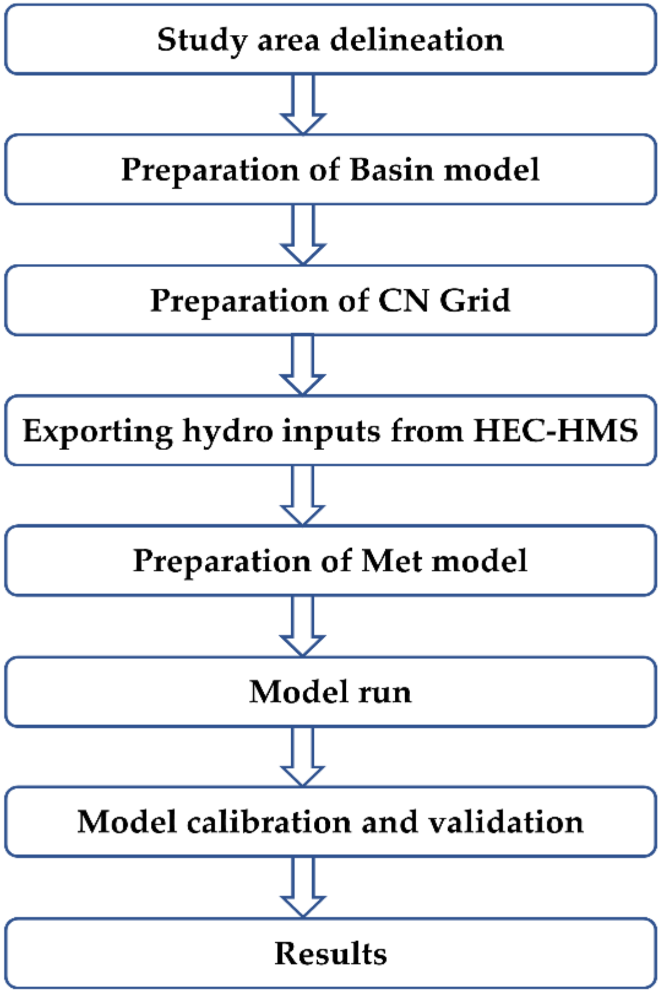

Figure 4. HEC-GeoHMS metholodogy included basin model generation and preparation of the CN grid followed by met model preparation.

Conclusions

- The three-tier strategy used in this work starting from determining, comparatively the highest water yielding watersheds to, finding the effective and efficient locations for the structural flood control measures, shall pave way to the disaster managers of the region for dealing the recurring floods of the region.
- The very high-water yielding watersheds have to be managed on priority basis and a dense network of automatic weather stations has to set up for near real time flood forecasting using HEC-GeoHMS model.
- The integrated use of geoinformatics and hydrological modeling in this study has focused on the holistic flood management of the Jhelum basin and has also paved way for further research in this area.

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