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ESTIMATION OF PROBABLE MAXIMUM PRECIPITATION ON THE PUNJAB CATCHMENT

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Abstract— Probable most extreme precipitation is a "Hypothetically, the best profundity of precipitation for a given term that is physically conceivable over a given tempest zone at a specific land area at a specific time" It is utilized to gauges the Probable greatest surge, examination of plan and hazard for high peril hydrological structures, for example, surge dams and Barrage. Fundamentally Probable most extreme precipitation (PMP) is a hypothetical precipitation profundity which is conceivable in existing encompassing catchment conditions and it has low likelihood which is not as much as the greatest precipitation. In this manner Probable most extreme precipitation (PMP) does not take after long haul climatic patterns. Different methods are utilized as a part of Probable most extreme precipitation (PMP) estimations yet the Moisture amplification method gives a superior outcome in examination with Hershfield method. There is 12.94% normal varieties of results happen utilizing these methods.

We are utilized these strategies for ascertaining Probable most extreme precipitation (PMP) for the Punjab catchment and drawn the Probable greatest precipitation (PMP) maps for examination of Probable most extreme precipitation (PMP

Keywords— Probable Maximum Precipitation, Precipitation, Hershfield approach, Storm Model Approach.

I. INTRODUCTION

According to the WMO (World Meteorological Organization), PMPs are defined as the maximum precipitation that may occur physically in a specific time period on a specific area. But according to AMS (American meteorological society) also called maximum probable precipitation, maximum possible precipitation (rare).] Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year. So basically probable maximum precipitation is theoretical precipitation depth of water which has very low probability to have a low value of precipitation which can occurs in design life of structures.

Probable maximum precipitation (PMP) is good measuring parameters for safe designing of hydraulic structures and has very low probability to exceed the design PMP values in the design life of structures. Nowadays, huge disasters occurring frequently and it is challenging issues for mankind. Floods caused by heavy rainfall or some others climatic region give a big impact on the living things and cause enormous properties and wealth loss. This kind of event increase year by year and therefore it has the responsibility to think about it. For counteract to this type of climatic condition, it is required a good design data of precipitation and detailed studies about this climatic conditions. This issue can be dealt with great responsibility.

For estimation of probable maximum precipitation many approaches are used but mostly two approaches generally used, Out of these two approaches, first one is storm model approach and second is Hershfield approach. Storm model approach is based on deterministic approach and uses the climatic conditions (temperature, relative humidity, precipitation) to estimate the probable maximum precipitation but Hershfield approach is based on probabilistic approach. In this method past historic record is analyzed by statistical approach.

Punjab which is state of India fall in northern region of the country has five rivers namely Ravi, Beas, Jhelum, Sutlej and Chenab. Estimation of safe Probable maximum precipitation (PMP) of catchment not easy for anyone because of catchment area of these rivers is not easily is estimated. It is using difficult to predict that which one area is more prone to precipitation effects and which one have least affect. These studies are helpful in designing the hydraulic structures coming up in the districts of Punjab and provide necessary protection works against natural disasters.

II. METHDOLOGY

Various methods are use in Probable maximum precipitation (PMP) estimation from which two widely used methods, Storm Modal Approach and Hershfield methods are used to calculate monthly Probable maximum precipitation (PMP) of Punjab catchment. Strom modal approach is a deterministic approach and it is based on maximize the environment condition of the selected catchment such as precipitable water, prevailing wind condition, etc., whereas Hershfield method is based on statistical approach and depends upon historical records of precipitation. Details of these two approaches are given in below sub section.

II -A. STORM MODEL APPROACH

Storm Model Approach is based on metrological conditions of the selected catchment (e.g. daily dew temperature, moisture content) that control the convective precipitation.

Estimate of Probable maximum precipitation (PMP) can be done by following equation

$$PMP = \frac{Z_m}{Z} P$$

Where

P = actual precipitation depth (mm)

Z = Precipitable water at the study site during the day of storm

Z_m = Maximum Precipitable water at the target site during the day of storm

The estimate of Z can be done by the following relation (Smith, 1966).

$$\ln(Z) = 0.1133 - \ln(\lambda + 1) + 0.0393 T_d$$

Where

λ = express an exponent value determined by power law relationship between moisture content and altitude of the atmospheric column. The value of λ depends on latitude of target site and season of the year when the storm has occurred (London, 1957).

t_d = surface temperature (in Fahrenheit). If t_d records does not readily available then t_d estimated as

$$t_d = \frac{237.3 \ln(r_h) + 237.3\left(\frac{17.27t}{237.3 + t}\right)}{17.27 - \ln(r_h) - \left(\frac{17.27t}{237.3 + t}\right)}$$

r_h = Relative humidity

t = maximum surface temperature (degree Celsius)

Z_m is estimated by the following equation

$$\ln(Z_m) = 0.1133 - \ln(\lambda + 1) + 0.0393 t_d^{\max}$$

$t_d^{\max}$ = maximum of t_d values of the month in which storm is occurred

II –B. HERSHFIELD APPROACH

Hershfield method is based on statistical approach .In this method we are analysis the historic data of precipitation at the selected location. Hershfield method is based on frequency analysis of n annual maximum precipitation value observed at the catchment area. This method is based on following relation

$$k_m^{(i)} = \frac{P_M^{(i)} - \overline{P_{n-1}^{(i)}}}{\sigma_{n-1}^{(i)}}$$

$$k_m^{(\max)} = \underset{i=1....N}{Max}\left[k_m^{(i)}\right]$$

$$PMP(i) = \overline{P_n^{(i)}} + k_m^{(\max)}\sigma_n^{(i)}$$

Where

$k_m^{(i)}$ =represents the frequency factor corresponding to site *i*

$P_M^{(i)}$ =represents the maximum value from n annual precipitation data

$\overline{P_n^{(i)}}$ = represents the mean of the n annual precipitation values

$\overline{P_{n-1}^{(i)}}$ =represents the mean of the n-1 annual precipitation values excluding maximum precipitation from n annual precipitation values

II. STUDY AREA AND DATA DESCRIPTION

Punjab which is a state of India situated in northern region of India. Punjab is surrounded by Jammu and Kashmir in northern part H.P. in north east part Chandigarh in east Haryana in south, Rajasthan in south west and Pakistan in North West. Punjab has coordinates 31.1471^{o} N, 75.3412^{o} E.

III –A CLIMATE

Zone of Punjab has a major contrast in temperature variety, despite the fact that lone couple of area encounter temperature underneath 1 °C (33.8 °F). Ground ice is usually occurring in the lion's share of Punjab amid the winter season. The temperature rises slowly with lofty dampness and cloudy sky. Be that as it may, the rise in temperature is sharp when the sky is clear and moistness is low. Greatest temperature more often than not happens in mid of May and June. The temperature stays over 42 °C (107.6 °F) in the whole locale. Moga recorded the most elevated greatest temperature With Faridkot and Ludhiana is 110.60F, 110.12 and 110.03 individually. These territories encounter the most reduced temperatures in January. The Sun beams are slanted amid these months and the icy breezes control the temperature at daytime.

III (b) SEASONS

- Summer Season (April to June)
- Rainy Season (July to September)
- Winter Season (December to February)

III(c) Summer

Punjab begins encountering somewhat hot temperatures in February. Be that as it may, the genuine summer season starts in mid-April. The zone encounters weight varieties amid the midyear months. The climatic weight of the locale stays around 988 millibar amid February and it achieves 971 millibar in June.

III (d) RAINY SEASON

Punjab's stormy season starts in first seven day stretch of July as rainstorm streams created in the Bay of Bengal convey rain to the area. Rainstorm season gives a large portion of the precipitation to the area. Punjab gets precipitation mainly due to the rainstorm from the Bay of Bengal. This rainstorm wave enters in the Punjab from the southeast face in the principal seven day stretch of July. The winter season stays enormously cool with temperatures declining underneath solidifying at a few spots. Winter additionally acquires some western aggravations. Precipitation in the winter gives alleviation to the ranchers as a portion of the winter edits in the locale of Shivalik Hills are totally reliant on this precipitation. According to meteorological measurements, the sub-Shivalik region gets in excess of 100 millimeters of precipitation in the winter months.

III (e). WINTER SEASON

Temperature disparity is minimum in January. The mean day and night temperatures fall to 12 °C (54 °F) and 5 °C (41 °F), respectively.

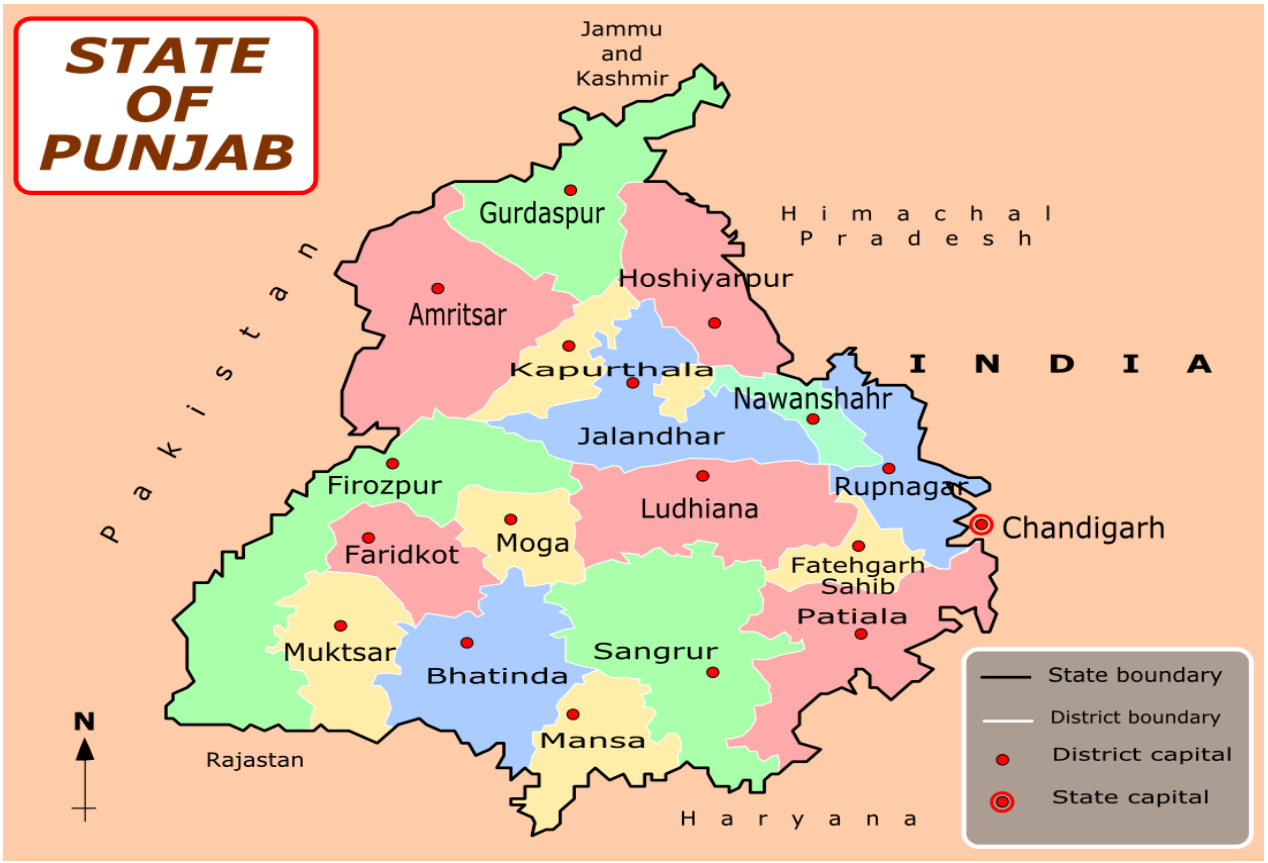

Figure 1: Punjab map from: https://upload.wikimedia.org/wikipedia/commons/f/fa/Punjab_district_map.png

Data on climate variables were accessible for Punjab catchment area for the period 1901-2002 from the source: http://www.indiawaterportal.org/met_data/. India Water Portal's nebulous vision is to make water a more noticeable issue in India by sharing learning uninhibitedly and transparently, keeping in mind the end goal to impact understanding Data on climate factors (Precipitation, greatest temperature) were accessible for Punjab catchment zone for the phase 1901-2002 from the web site: http://www.indiawaterportal.org/met_data/. India Water Portal's vision is to make water a more visible issue in India by sharing knowledge freely and openly, in order to influence understanding on water issues and to empower action's on water issues and to empower action.

III. RESULT AND DISCUSSION

After applying both approaches i.e. storm model approach and Hershfild approach on precipitation data of Punjab catchment area on seventeen districts, we are occurs different results and a huge variation in Probable maximum precipitation estimated values of different districts. These results are given below and a comparison is also given for checking most safe design method for hydraulic structures.

IV-RESULTS OF STORM MODEL APPROACH AND HERSHFIELD METHOD

Storm model approach is based on deterministic approach and climatic conditions, therefore the results of storm model approach is slightly more

TABLE 1: Results obtained using both the approaches

District	Strom modal approach PMP in mm	Hershfield method PMP in mm
AMRITSAR	859.55	744.63
BHATINDA	622.37	538.70
FARIDKOT	606.55	546.00
FATEHGARH SHAIB	886.35	734.59
FIROZPUR	557.74	514.60
GURDASPUR	971.21	987.82
HOSHIYARPUR	1121.36	978.68
JALANDHAR	885.18	779.90
KAPURTHALA	860.99	760.01
LUDHIANA	818.88	697.44
MANSA	664.97	565.15
MOGA	692.26	615.67
MUKATSAR	547.84	490.44
NAWANSHAHR	1193.29	875.11
PATIALA	889.29	746.94
RUPNAGAR	1053.528	886.52
SANGRUR	733.83	631.78

V. COMPARISON

By applying the Moving average method on the data to minimize the error and to make the data consistent. After that applying both approaches on the data and calculate the Probable Maximum Precipitation of the Punjab catchment.

A graph between different districts and probable maximum precipitation by both the approaches are given below which show the clear difference between these two approaches. In this graph blue line show Hershfield method PMP results and red line show Storm model approach.

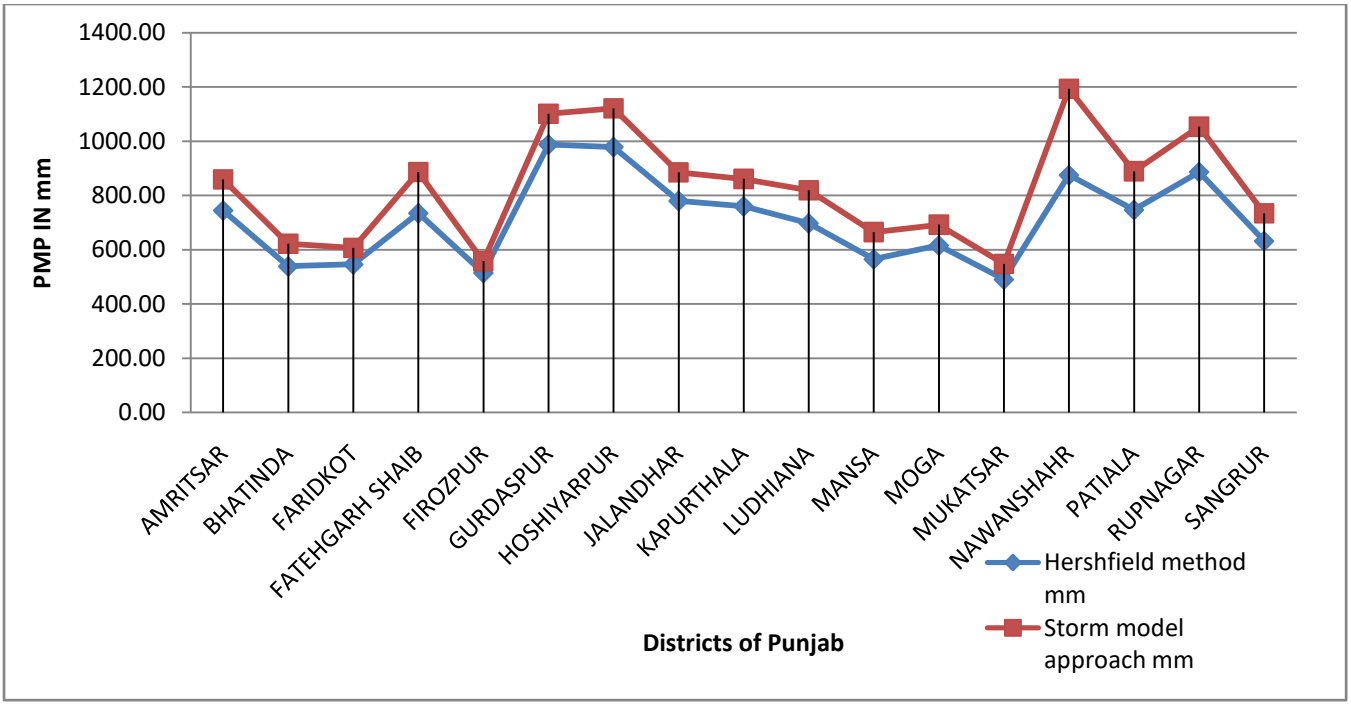

Figure 2 : comparison map between Hershfield and Storm Model Approach

VI. CONCLUSION

Both the approaches estimate safe probable maximum precipitation but the Root Mean Square Error (RMSE) of Hershfield method is 15.57mm and for Storm model approach RMSE value is 27.34mm. It is clearly show that RMSE value of Storm model approach is higher than Hershfield method, so its meaning is Storm model approach contain more error than Hershfield method. So Hershfield method is more accurate than Storm model approach and also estimates less value of Probable maximum precipitation than Storm model approach. Storm model approach estimates values of probable maximum precipitation for Hoshiyarpur, Nawanshahr and Rupnagar are respectivly1121.36mm, 1193.29 mm and 1053.528mm where as from Hershfild approach these values are respectively 978.68mm, 875.11mm and 886.527mm. Minimum probable maximum precipitation found in Faridkot, Firozpur, Bhatinda and Mukatsar.

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