

Relation of Probable Maximum Precipitation Depth-Area-Duration Using GIS

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Abstract

The relationship between depth-area-duration is important for the design of hydraulic structures such as dams, weirs. Probable maximum precipitation(PMP) is necessary to design floods for optimal design of such structures. The objectives of this study are to evaluate PMP from heavy storm data from 1972 to 2000, then to use GIS to correlate and present the results and to establish the depth-area-duration relationship. The study gathered heavy rainfall, temperature and dew point temperature of Thailand. These data estimated the PMP by considering the dew point temperature. The PMP can be calculated for each rainfall duration to obtain spatial rainfall distribution using GIS(Arcview). The depth-area-duration relationship can be established which enables the development of envelope curves. The results are a set of contour maps of PMP for each rainfall duration for Thailand and depth-area-duration relationships for areas between 100 and 50,000 km.2 at 1, 2 and 3 days rainfall duration.

1.Introduction

The relation among depth-area-duration is important for the design of hydraulic structures such as dams, weirs and flood control structures. Probable maximum precipitation (PMP) is essential and needed to firstly estimate in order to use as design floods so that the structures are safe from overflow by flood events and maintain security of the construction and people around. Therefore the PMP is a key factor to obtain design flood of a structure or a project related to people lives and their properties . PMP is expected maximum rainfall in a time frame of the study area, normally derived from data of rainstorm occurred in the nearby area. Since the PMP has been derived from any proper single storm, it can have a large error. PMP values should be evaluated from many historic heavy storm events from all over the country . Since this can be done at the spots of storm occurring and the calculated PMP from all spots in the country can be correlated . This makes the derived values of PMP of the whole country to be corrected and ready to be used.

There are two major methods to obtain PMP : Statistic estimation and Meteorological method. In many countries they prefer Meteorological method which contains 3 steps: Maximization of Storm Data, Storm Transposition and Relation among Depth-Area-Duration. In this study used rainfall maximization to obtain PMP by the following equations .

$$\ln W = 0.06td - 0.02 \quad (1)$$

Where: W = Humidity in atmosphere (centimeter)
T d = Maximum dew point temperature (Celsius)

$$PMP = P_{\text{actual}} \frac{W_{\text{max}}}{W_{\text{actual}}} \quad (2)$$

P_{actual} = Actual measured rainfall.

W_{max} = Humidity of maximum dew point temperature.

W_{actual} = Humidity of dew point temperature at the rainstorm area.

2. Objectives

The objectives of this study are therefore to evaluate PMP from historic heavy storm data from 1972 to 2000 by using meteorological method , then using GIS to correlate and present the results , finally , the depth-area-duration relationship of maximum precipitation can be obtained.

3. Materials and Methodology

3.1 Study area : The study area is all every region of Thailand .Thailand locates at latitude $5^{\circ} 37' - 20.5^{\circ} 27' N$ and longitude $97^{\circ} 22' - 105^{\circ} 37' E$ covers area $513,115 \text{ km}^2$

3.2 Data

- 1) Statistic year 1972-2000 rainfall caused by monsoon , tropical storm and monsoon trough.
- 2) Monthly statistic year 1972-2000 maximum dew point temperature.

3.3 Procedure : In this study used meteorological method to obtain PMP which cover study area

- 1) Collect rainfall data from every rainfall station in all regions of Thailand duration of 1,2 and 3 days raining.
- 2) Calculate rainfall maximization by equation (1) and (2). These data helped to maximize the depth of heavy rainfall up to the probable values by considering the dew point temperature .
- 3) Analyze isohyets for duration of 1,2 and 3 days rainfall . The maximized rainfall depths can be calculated for each rainfall duration to obtain spatial rainfall distribution by using GIS .
- 4) From 3. create table relation among rainfall, area and duration.
- 5) Plot a graph relation of rainfall and area in semilog and develop envelope curve.
- 6) From graph in 5. able to make table relation among PMP-Area-Duration.

4. Results

From year 1972-2000 there were 108 storms hit Thailand. Top 3 heavy rainstorms from 5 regions of Thailand [North, Northeast, Central, East and South] were selected and calculated rainfall maximization to obtain PMP of 1,2,3 days duration as shown in table 1.

Table 1. Probable Maximum Precipitation [PMP] of top three rainstorm from five regions of Thailand.

Storm name	Region	PMP(mm.)		
		1 day	2 days	3 days
1. Tropical storm Carla, 5 Sept.1977	North	277.1	290.4	294.5
2. Depression, 12 Oct. 1985	North	196.3	212.8	242.7
3. Tropical storm John	North	164.4	184.9	186.0
4. Depression ,15-17 Aug. 1974	Northeast	488.2	551.0	645.6
5. Typhoon Kai-Tuk, 3-11 Jul.2000	Northeast	277.8	313.0	314.1
6. Tropical storm Base, 12 Aug. 1978	Northeast	201.2	249.1	299.3
7. Tropical storm Ira ,4 Oct. 1990	Central	213.4	319.1	341.2
8. Depression ,20 Sept. 1992	Central	137.3	227.4	296.6
9. Depression ,23-31 Oct. 1999	Central	201.8	220.4	229.1
10. Depression, 24-29 Jul. 1999	East	371.4	639.7	638.3
11. Depression ,11-17 Jul. 2000	East	281.7	409.1	589.2
12. Tropical storm Maria, 28 Aug.-2Sept.2000	East	354.5	483.5	559.6
13. Tropical storm ,4-7 Jan. 1975	South	442.0	826.7	1108.4
14. Tropical storm Sarah, 16 Nov. 1973	South	233.5	370.6	577.6
15. Tropical storm Hilda ,4-9 Jan. 1999	South	361.8	502.8	555.6

Contours of PMP were generated by using GIS and shown as maps in Fig 1. These maps were the results examples of heavy rainstorm (3 days duration) which occurred in every part of Thailand.

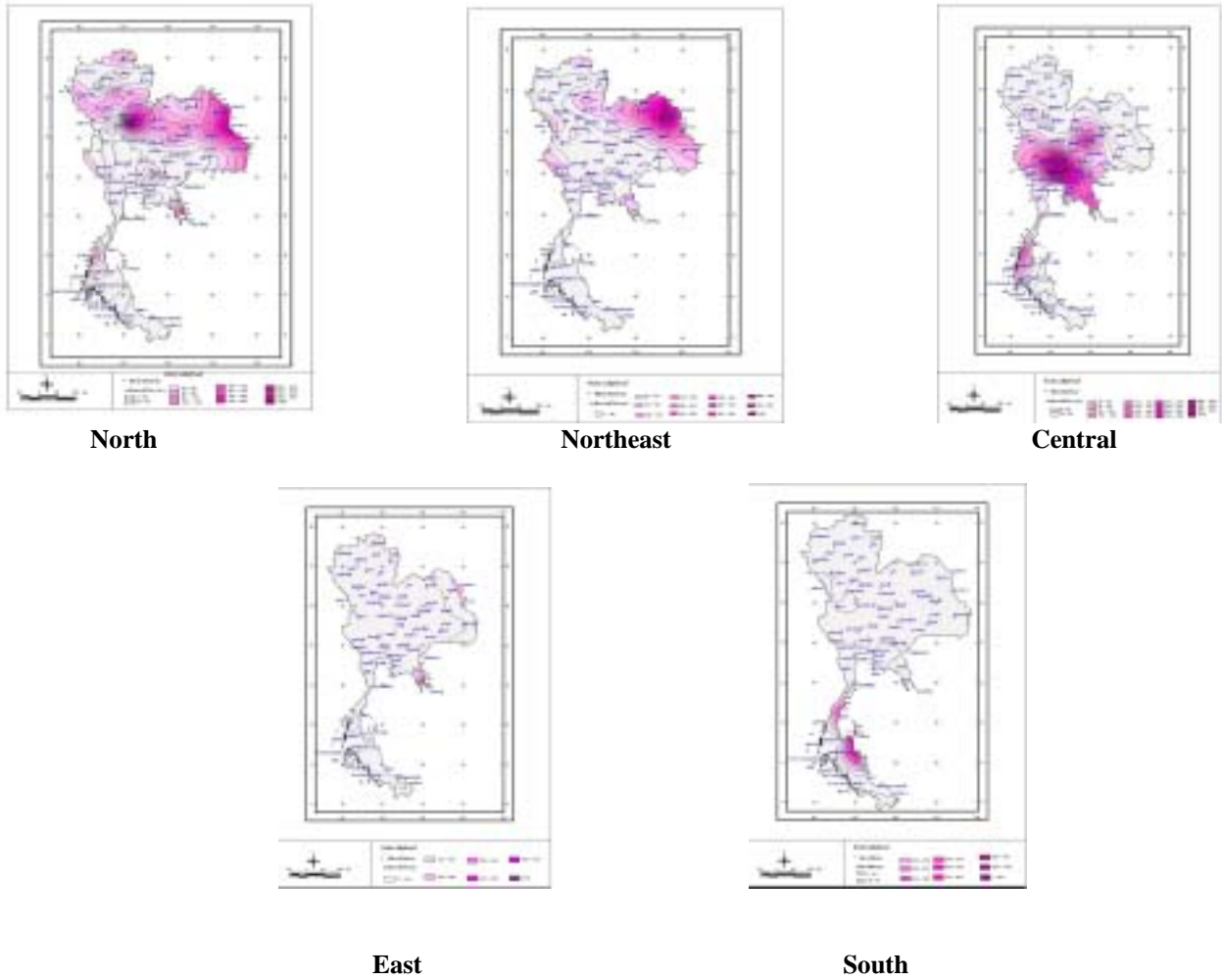


Fig 1. Map of maximum isohyets of 3 days duration of rainstorm in every region of Thailand.

Envelope curves (Fig.2) presented the relation between rainfall and area which were derived from isohyets maps. Table relation among PMP-Area-Duration obtained from Fig.2 was shown in table 2.

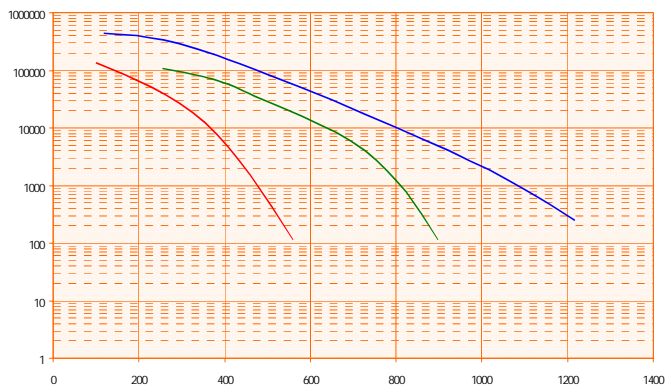


Fig. 2. Graph relation between area and rainfall 1, 2 and 3 days duration in southern region.

Table 2. Relation of PMP-Duration for each region of Thailand

Area (km. ²)	Rainfall (mm.)			Area (km. ²)	Rainfall (mm.)			Area (km. ²)	Rainfall (mm.)		
	1 day	2 days	3 days		1 day	2 days	3 days		1 day	2 days	3 days
100	258	285	315	100	555	580	648	100	239	318	373
500	246	260	285	500	505	529	612	500	229	310	360
1,000	240	258	270	1,000	470	501	594	1,000	225	302	352
5,000	228	231	235	5,000	365	420	550	5,000	202	280	333
10,000	214	221	225	10,000	320	378	520	10,000	182	260	318
20,000	204	210	215	20,000	270	332	480	20,000	161	235	290
30,000	194	202	205	30,000	240	310	436	30,000	148	218	269
40,000	188	194	198	40,000	220	285	406	40,000	138	204	252
50,000	181	188	190	50,000	205	270	376	50,000	132	194	240

North

Northeast

Central

Area (km. ²)	Rainfall (mm.)		
	1 day	2 days	3 days
100	400	620	640
500	395	560	635
1,000	390	540	620
5,000	370	460	580
10,000	348	420	560
20,000	326	380	500
30,000	310	350	474
40,000	290	320	450
50,000	270	310	425

East

Area (km. ²)	Rainfall (mm.)		
	1 day	2 days	3 days
100	610	915	1260
500	530	860	1150
1,000	510	830	1090
5,000	460	730	915
10,000	420	680	830
20,000	380	590	720

South

5. Conclusion

The major principles to calculate PMP by Meteorological method are rainfall maximization and relation among PMP depth-area-duration. Do rainfall maximization by adjust heavy storm to be maximum because humidity cause accurate probable precipitation. Between year 1972-2000 top three heavy rainstorms from each region of Thailand were selected and calculated for PMP. The results from this study obtained a set of contour maps of PMP for each rainfall duration for all over country of Thailand and the PMP depth-area-duration relationships for the area of 100 to 50,000 km² . at 1,2 and 3 days rainfall duration. Southern of Thailand has the most maximum rainfall of 1,2 and 3 days duration.

In addition using Geographic Information System (GIS) to show probable maximum isohyets maps of the whole country. These data apply to planning and making decision for developing in water resources and related work.

Acknowledgement

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