Predictive Analysis for Intelligent Disaster Flood Management with Unstructured Data

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Abstract:

This paper focuses on the analysis of the Magnitude of Flood which has occurred in the past at various places around the world. Actual data of the places affected by Floods have been analysed. **43 graphs among the various factors related to Floods have been depicted** using the actual data of those places. The mean functions of these factors are found using statistical Analysis and an approximate equation is formulated which can determine the Magnitude of Flood which has come in any area. The Graphs between the Magnitude of floods using the equation and the actual destruction are made which further affirms "The Approximate Equation".

INTRODUCTION

Floods can come anytime and cause as much destruction as possible since it's one of the nature's havoc. But if we can analyse it and come onto certain conclusions, we can help mankind in a tremendous way. Our work focuses on these conclusions. The most obvious question for Flood analysis is "When Does a Flood come?" and "Can we give a mathematical relation to floods in the most approximate way?". Yes, Obviously we can, if we try to relate the natural features of a place with floods. The study will help us to look at floods from a different angle and we can get prepared for floods if we know how much destruction can prevail at a particular place if floods occur.

KeyWords: P(F),N,W,R,X,T,A,H.

"When does a Flood Come?"

A flood comes when the Rate of incoming water from any source is very large as compared to the Rate of its drainage.

Mathematically,

Flood occurs when $P(F)=dW_F/dt >> dR_n/dt$

Here dW_F/dt means the rate of incoming flood water and dR_n/dt means the rate of drainage of that water.

P(F) is a random variable for a flood to occur.

Factors Related to Floods:

At present, we are concerned about various factors which have direct/indirect relation with floods are:

1. The Regime Cross Section area of the flood affected place. (A) Unit: sq km

2.Height Flood affected Area from the flood causing source. (H) Unit:km

3. Displacement of the place from the flood originating source. (X) Unit:km

4. Recorded amount of rainfall in which has come in that area at the time of Floods. (R)Unit : mm

5. No. of rivers in the Affected Area. (N)(no unit only no. of river in the area to be studied)

6. Density of Trees acting as a barrier to floods in the Affected Area. (T) Unit:As fraction found by dividing tree cover by total area to be inspected.

7.Discharge of Water at the time of Flood. (W) Unit :Cusec

Thesis:

If we are able to find the approximate relation between the Magnitude of floods which occurs at a place with the factors listed above, an approximate equation can be determined which can tell The Approximate value of the Magnitude of Floods which occurred at a place. Let us see the relation.

Relation between the Impact of flood and the Area of a place:

As the area of a place increases, the Magnitude/Impact of flood decreases. This is because as the area increases the flood water will be distributed in the place thereby minimizing the Impact of Flood at that place.

$$\mathbf{I \propto 1/A} \qquad 1)$$

Here ,

"I" is the Magnitude or the Impact of Flood.

"A" is the Area of the flood Affected place.

Relation between the Impact of Flood and Number of Rivers at that place:

A major cause of flood is the overflow of rivers at that place. More number of rivers will cause more discharge of water at a place. That is why as the number of rivers increases the Impact of floods also increases.

$I \propto N$ 2)

"I" is the Magnitude or the Impact of Flood.
"N" is the number of Rivers at the flood affected place.

Relation between the Impact of Flood and Discharge of water from the rivers:

As the Discharge of water increases from a river, the Impact of Floods also gets increased.
This is because as the discharge will increase ,the volume rate of water flow increases thereby causing more damage to the place.

$I \propto W$ 3)

"I" is the Magnitude or the Impact of Flood.
"W" is the Discharge of water from the river.

Relation between the Impact of Flood and Displacement of the place from the flood originating source:

The places near to the rivers are more affected due to floods than the places far away from the river. The areas which are too much far away from the river might not get flooded. So we say that as the Displacement of the place from the river increases, the Impact of flood decreases.

$I \propto 1/X$ 4)

"I" is the Magnitude or the Impact of Flood.
"X" is the Displacement of the affected place from the flood originating source.

Relation between the Impact of Flood and Rainfall at the time of floods:

Heavy rainfall causes the rivers to overflow and cause floods. That is why as the amount of rainfall increases the Impact of floods also increases.

$I \propto R$ 5)

"I" is the Magnitude or the Impact of Flood.
"R" is the amount of rainfall at the time of Floods.

Relation between the Impact of Flood and the Density of the trees at the affected place:

Trees are a major factor to slow down the velocity of water coming at a certain place. They act as barriers thereby decreasing the impact of floods at a place. Therefore, as the density of trees increases, the Impact of floods at a place decreases.

$I \propto 1/T$ 6)

"I" is the Magnitude or the Impact of Flood.
"T" Density of Trees at the Flood affected place.

Relation between the Impact of Flood and the Height of the place Above the River or the flood causing source:

Height also plays an important role in determining the Impact of flood at a place. If the height of the place is too much above the river ,then the floods are less likely to come at that place. Therefore, as the height of a place above the river increases, the magnitude/Impact of floods at that place decreases.

$I \propto 1/H$ 7)

"I" is the Magnitude or the Impact of Flood.
"H" is the Height of the place above the river or the flood causing source.

Mathematically,

If we Include all the factors, then we conclude that

$$I \propto \frac{N.R.W.}{A.X.H.T}$$

8)

If we assume that the Right side of the proportionality symbol to be" λ" , the above term becomes,

$I \propto \lambda$

$I = K.\ \lambda$

or,

$$I = \frac{K.N.R.W}{A.X.H.T}$$

$I=10^6\,(K.N.R.W / A.X.H.T)$

with Units : $Cusec/km^3$ or (Ram Krishna)

9)

where "K" is the proportionality Constant.

Statistical Analysis

Now, to study this model more accurately, the relationship among all the factors on the right hand side of the 8th Term needs to be found out. In simple words, we need to find out the relation between say the number of rivers at a place and rainfall, the number of rivers with the discharge and so on with every factor and for every factor. To find this, we analysed seven places where flood occurred , collected the data and plotted graphs in order to find the find the most accurate functions of every factor in λ. The places which we focussed are the places having different terrains to cover as many terrains as possible.

The places which we covered were:

1.Kedarnath , North India. (June 2013)
2.West Champaran,Bihar, India.(September 2008)
3.Srinagar, Jammu and Kashmir, India.(May 2013)
4.Barmer,Rajasthan,India.(September 2014)
5.Krasnodar,Russia.(July 2012)
6.Zehiang,China.(June 2011)
7.La Plata, Argentina.(September 2011)

Analysis of Floods in Kedarnath , North India(June 2013):

We analysed the Area which is marked in the Figure 1A.This is the Area of Kedarnath town. River Mandakani and Saraswati meet before flowing into this town as one River. The studied Area is 0.5265 square kilometres. The soil here is Rocky Soil. There is a Lake known as Chorabari Lake which is at a height of 0.317 km above the town and at a displacement 1.5 km from the town. The calculated slope is -0.2113 . The studied place is very rocky with negligible amount of trees in it .The Area received a rainfall of 325 mm at the time of floods i.e. in the third week of June starting from 15th of June.Due to excessive rainfall ,this lake got overflooded and water ran down the steep slope flooding the town causing tremendous amount of destruction.The length of the river causing floods in this town is 2.03 km .The calculated Discharge is 65.72 cusec in the town at the time of floods.

Reason for flood:

Due to the breaking of Kedar Dome, a mountain which lies 6 km from Kedarnath Temple,the Chorabari Lake ruptured.This all happened due to a cloudburst at this place.

Analysis of Floods in West Champaran,Bihar, India.(September 2008):

The recorded amount of rainfall in the region is 428.72 mm in just four days starting from 18th August. The soil over here is loamy because of the large number of river present here.The length of the channels which caused flood at this place is 454.39 km.Gandak river flows in this Region which is one of the major cause of floods in this region. It is at an average displacement of 9 km from Champaran's mainland.The discharge due to the stream and Gandak amounted to be 1510.3 Cusec.The slope of the place is 0.0008 with respect to river Gandak.The place lies 0.008 km above the river Gandak.18% of the region has trees in it whereas the rest 82% is agriculture area intersected by streams and rivers.

Reason for Floods:

Due to the heavy monsoon rain on 18th August 2008,the Kosi embankment suffered a breach which caused the water to runoff in the neighbouring places covering almost each part of North West bihar and regions of Nepal.

Analysis of floods in Srinagar, Jammu and Kashmir, India.(May 2013):

The region under study has an area of 895.237 sq. km. There are as many as 9 rivers flowing through this place. The soil found over here is loamy and clayey soil. The place lies at an average height of 1.5889 km. above these rivers. The place experienced 558 mm of rainfall at the time of floods causing a discharge of 1007.374211 cusec.The length of channels causing rainfall at this place is 88.45 km.

Reason for floods:

The Torrential rains in the region from 18th Sepetember 2008 caused floods in the state of Jammu and Kashmir in May 2013.Several houses, especially low lying areas were washed away or entirely damaged.

Analysis of Floods in Barmer,Rajasthan,India.(September 2014):

The area of the region under study is 55.33 sq. km.The soil in Barmer is mostly sandy soil due to low amount of raifall in this region.The total lengh of the channels causing floods in this area is 232 km and lie at an average displacement of 22km from the mainland. The rainfall at the time of floods was 428.72mm. The discharge of water amounts to 46. 18cusec. The height of the place is 0.0245 km above the streams which caused floods in this area.The slope of the comes out to be 0.0011 with respect to the streams.

Reason for Flood:

Rainwater took the drainage route of rivers that once passed districts Rohali and Nimbala. These now-extinct rivers originated in the Jinjhiniali region in Jaisalmer, merged in Luni River before entering Barmer, and finally disappeared into the Rann of Kachchh in Gujarat, they say. Rainwater from Jaisalmer also took the drainage path of the extinct rivers, Leek and Sheepasaria . Water that came along this path caused havoc in Maluva village

Below are five tables of the real time data we collected:

Table 1:

ID	Place	Year of flood	Area (sq. Km)	No. Of Rivers	soil Type	Rainfall (mm)	Tree Density %
1	Kedarnath,Uttarakhand,India	2013	0.5265	1	Rocky	325	1
2	Champaran,Bihar,India	2008	3918.43	9	Loamy	385.5	18
3	Srinagar,Jammu and Kashmir,India	2013	895.237	3	Loamy andClayey	558	27
4	Barmer ,Rajasthan	2014	55.33	4	Sandy	428.72	14
5	Krasnodar,Russia	2012	108.32	1	Densily built with metalled Road	275	7
6	Zezhiang,China	2011	122.01	1	Densily built with metalled Road	175	1
7	La Plata,Argentina	2011	61.1	2	largely Clayey soil	400	6

Table 2:

ID	Place	length of the channel (km)	Altitude of the river (km)	Altitude of place (km)	Displacement of river (km)
1	Kedarnath,Uttarakhand,India	2.03	3.9	3.583	1.5
2	Champaran,Bihar,India	454.39	0.067	0.075	9
3	Srinagar,Jammu and Kashmir,India	88.45	1.5761	1.5889	2.2
4	Barmer ,Rajasthan	232	0.1875	0.212	22
5	Krasnodar,Russia	5.56	0.013	0.026	0.69
6	Zezhiang,China	34.95	0.004	0.2	6.12
7	La Plata,Argentina	4.4	0.004	0.003	9.73

Table 3 :

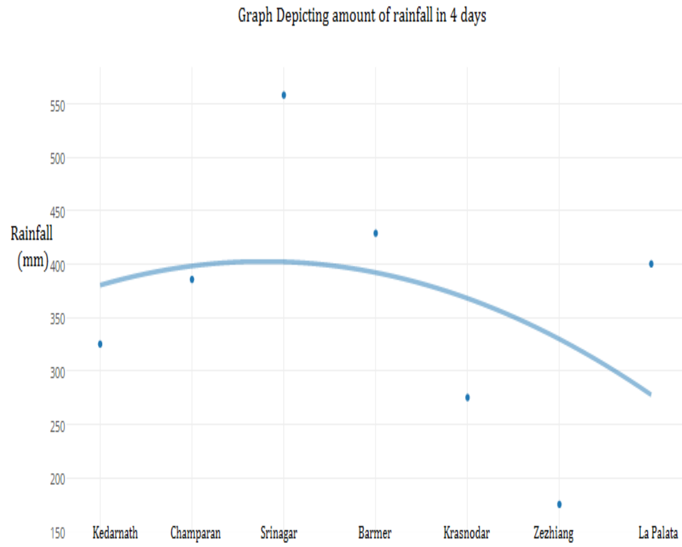
ID	Place	Slope	Lo	P	f	Tc	λ	D
1	Kedarnath,Uttarakhand,India	-0.2113	3.9	0.9	1	0.83708	5.303220043	907.4472396
2	Champaran,Bihar,India	0.000888	0.067	0.3	0.8	152.95857	0.001496506	2260.555001
3	Srinagar,Jammu and Kashmir,India	5.822	1.5761	0.45	0.7	148.95577	0.002016595	1007.374211
4	Barmer ,Rajasthan	0.0011	0.1875	0.2	0.82	53.237032	0.002902814	68.85786861
5	Krasnodar,Russia	0.018	0.013	0.8	0.725	2.3864449	0.164420216	4897.749404
6	Zezhiang,China	0.032	0.004	0.8	0.71	17.032091	0.030239421	645.6645676
7	La Plata,Argentina	0.0001	0.004	0.5	0.8	0.6312597	0.235400903	5753.198059

Table 4 :

ID	Place	1/T	1/N	1/A	1/R	1/X	1/H	1/w
1	Kedarnath,Uttarakhand,India	100	1	1.899335	0.003077	0.666667	-3.15457	0.001101992
2	Champaran,Bihar,India	5.55	0.111111	0.000255	0.002594	0.111111	125	0.000442369
3	Srinagar,Jammu and Kashmir,India	3.703	0.333333	0.001117	0.001792	0.454545	0.078064	0.00099268
4	Barmer ,Rajasthan	1.142	0.25	0.018073	0.002333	0.045455	40.81633	0.014522669
5	Krasnodar,Russia	14.28	1	0.009232	0.003636	1.449275	76.92308	0.000204175
6	Zezhiang,China	100	1	0.008196	0.005714	0.163399	5.102041	0.001548792
7	La Plata,Argentina	16.66	0.5	0.016367	0.0025	0.102775	-1000	0.000173816

Statistical Analysis:

Graph depicting amount of rainfall has been plotted for four days in which the flood came in these places which can let us to conclude something.



Inference:

The average rainfall for all the places is 363.88 mm which means that a flood is bound to occur if it has rained more than 350mm in 3 to 4 days.

Moreover,

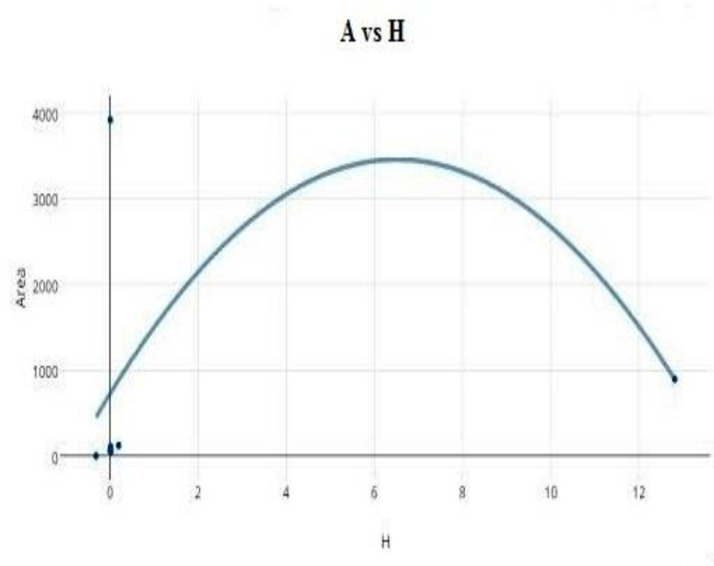
The graphs of the factors which are related to floods were plotted and their respective equations written.This was done because one factor canrelated to the other factors in many ways. For an instance, the no. of rivers of the place may have a different relationship with the height of the place and another relationship withthe area of a place.That is why is the need to find out the exact functions of all these factors with respect to the other factors, graphs were plotted and their mean graphs were found.

Graphs with Area on the 'y' axis:

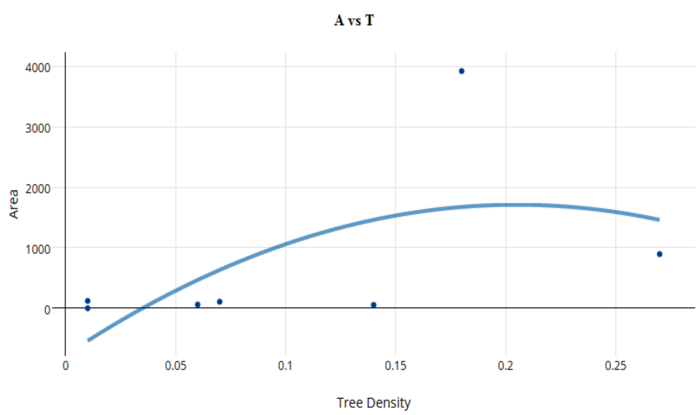
According to the Approximate model 9, the area of a place is related to its

1. Height Flood affected Area from the flood causing source. (H)
2. Displacement of the place from the flood originating source. (X)
3. Recorded amount of rainfall in which has come in that area at the time of Floods. (R)
4. No. of rivers in the Affected Area. (N)
5. Density of Trees acting as a barrier to floods in the Affected Area. (T)
6. Discharge of Water at the time of Flood. (W)

The graphs of Area are shown below taking these factors on the x axis:



A=(-64.54 ± 362.8)H^2 + (840.1 ± 4639)H + 723.2±717.8



A= (5.915e^5 ±9.973e^4)T^2 + (2.424e^4±2.914e^4)T + (-773.5 ±1671)

Avg/Mean Function For Area of a place (A):
(394.26735±1252.76609)μ_1^2 + (-102.5106±2221.72207)μ_1 + 959.45±1891.86667
Here μ_1 represents all the functions other than Area ie $\frac{N.R.W}{H.T.X}$.
The equation depicts that the 1/A is going to vary as this quadratic equation with respect to all the other factors i.e $\frac{N.R.W}{H.T.X}$ in the Approximate Model.

Average Mean Function For height of the place above the river (H):
(213.87442±327.050755)μ_2^2 + (15.761533±1279.049)μ_2 + 6.75783±5.540516

Here μ_1 represents all the functions other than Height,i.e $\frac{N.R.W}{A.X.T}$
The equation depicts that the height of the place above the river(1/H) is going to vary as this quadratic equation with respect to all the other factors i.e. $\frac{N.R.W}{A.X.T}$ in the Approximate Model.

Average Mean Function For Number of Rivers at a place(N):
(16.27657±32.2533)μ_3^2 + (-31.50694±32.253549)μ_3 + 2.1713±3.475
Here μ_3 represents all the other functions other than N,ie. $\frac{R.W}{A.H.T.X}$
The equation depicts that the factor Number of rivers(N) is going to vary as this quadratic equation with respect to all

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the other factors i.e $\frac{R.W}{A.H.T.X}$ in the Approximate Model.

Average Mean Function For Rainfall(R):
(203.9143±823.46629)μ_4^2 + (-402.41597±1563.04742)μ_4 + 216.32833±98.8933
Here μ_4 represents all the other functions other than R,ie. $\frac{N.W}{A.X.H.T}$

The equation depicts that the Rainfall (R)is going to vary as this quadratic equation with respect to all the other factors i.e $\frac{N.W}{A.X.H.T}$ in the Approximate Model.

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Average Mean Function For Displacement of the place from the source (X):
(116.429094±248.206422)μ_5^2 + (-1279.0477±53.1207)μ_5 + 9.549±10.9506
Here μ_5 represents all the other functions other than X,i.e. $\frac{N.R.W}{A.H.T}$.
The equation depicts that 1/X is going to vary as this quadratic equation with respect to all the other factors i.e $\frac{N.R.W}{A.H.T}$ in the Approximate Model.

Average Mean Function For Tree Density (T):

$(28.57523 \pm 95.8055)\mu_6^2 + (-48.8585430 \pm 23.1804613)\mu_6 + 0.203735 \pm 0.09150167$

Here μ_6 represents all the other functions other than T i.e. $\frac{N.R.W}{A.X.H}$

The equation depicts that the 1/T of a place is going to vary as this quadratic equation with respect to all the other factors i.e. $\frac{N.R.W}{A.X.H}$ in the Approximate Model.

Average Mean Function For Dischare(W):

$(827.603982 \pm 888.138147)\mu_7^2 + (-1076.393 \pm 1557.29311)\mu_7 + 1084.58333 \pm 2615.133333$

Here μ_7 represents all the other functions other than W i.e $\frac{N.R}{A.H.X.T}$

The equation depicts that the Discharge is going to vary as this quadratic equation with respect to all the other factors i.e. $\frac{N.R}{A.H.X.T}$ in the Approximate Model.

Now, putting the values of all the factors in the Approximate model we get Impact as:

$$I = \frac{(16.27657 \pm 32.2533)\mu_3^2 (203.9143 \pm 823.46629)\mu_4^2 (827.603982 \pm 888.138147)\mu_7^2}{(28.57523 \pm 95.8055)\mu_6^2 (213.87442 \pm 327.050755)\mu_2^2 (116.429094 \pm 248.206422)\mu_5^2 (394.26735 \pm 1252.76609)\mu_1^2}$$

10.)

Comparing it with equation 9 we get the value of K.

Multiplying the coefficient of $\mu_7^{2,}$ $\mu_7^{2,}$ μ_7^2 we get :2746780.423614136 M)

Multiplying the coefficients of μ_7^2 μ_7^2 μ_7^2 μ_7^2 we get:280543156.1709786 N)

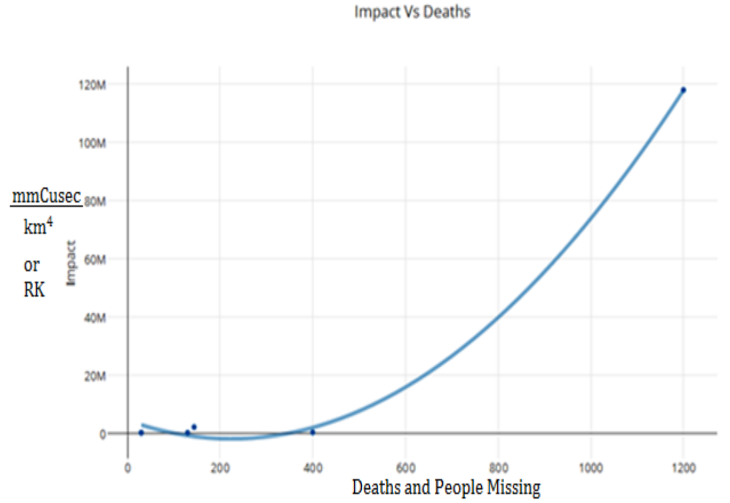
Dividing M by N we get the 'K' value for these 7 places is approximately 9.7×10^{-3}

Note : The exponent of **μ** lesser than 2 are ommitted and only the coefficients of **μ** having exponent 2 are multiplied together, to calculate 'K'.

To justify the Mathematical model, real time death toll of these places were taken and graph was plotted.Table 6 depicts the Imapct found by the formula and the real death and missing people toll data.

Table 5:

Place	Impact (RK)	Death and missing people toll
Kedarnath, uttarakhand,India	117802863.7	1200
West Champaran,Bihar,India	154441.8075	400
Srinagar,Jammu and Kashmir,India	250	25
Barmer,Rajasthan,India	28281.9819	130
Krasnodar,Russia	1980296.044	144
Zejhiang,China	77204.40534	30



Conclusion

We can see from the graph the Actual death rates matches with the Impact found by our mathematical model. Errors will always be there in models which are related to nature. Furthermore Mathematical analysis can strengthen the model further.

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