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# Flood in the Bhogdoi Basin of Assam, India

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**----------ABSTRACT----------**
A close association of man with river is exist since time immemorial. Therefore one of the most conspicuous attributes of human settlement is man's affinity for riverine location. A large section of people in earth live in floodplains because of a good number of reasons for the strong attraction of riverine plains to man.

Flooding of the valleys during the rainy season is a common hazard in Assam. The Bhogdoi, an important south bank sub-tributary of the Brahmaputra, is prone to cause floods. The catchment of this river lies in the Naga Hills, but mostly in the Jorhat district of Assam. The middle and lower most part of the basin are most seriously affected by flood, bank erosion, sand deposition etc. People of this region are trying to solve the problem created by flood. It is common experience that despite all such effort, every year the amount of losses and ravages of flood have gone up at an accelerated rate.

Here an attempt has been made to study the flow characteristics of the Bhogdoi River by analysing the various hydrological data and also to examine and analyse the various factors responsible for recurrence of flood in the Bhogdoi basin in Assam based on field surveys and data from secondary sources. The collected data have been tabulated and processed up to desired level and depicted in the form of maps, hydrographs in due interpretation. Results, suggestive measures to control the increasing rate of flood damages and conclusion of study are drawn based on brief analysis of the problem.

***Keywords:*** *Bhogdoi River, River basin, Sub-tributary, Flood.*

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## I. INTRODUCTION

Bhogdoi is a river of varied nature. The river takes a furious look when it is in spate. Although the floods of this region are of climatogenic in origin, there have been influences of tectonic, physical, hydrologic and human interferences on their intensification.In the study area floods occur due to the heavy rain during the monsoon months i.e., May to October. The pressure system developed over the valleys and creates a climate of humid sub-tropical type. Floods are a common phenomenon during the rainy season causing damage to both life and property, especially the crops i.e., the rice. River channel here are wide with heavy silting resulting in poor drainage and stagnation of water. The valley as a whole gently slopes down from Jorhat to north-west with an average gradient of 13cm per km.By observing the entire region; it has been found that the river offers a helpful hand in the upliftment of economy of the region in several ways. Economy of the people is directly moulded by the river's action in each post flood period of the year.

### OBJECTIVES

The main objectives of this research work are:

1. To study the flow characteristics of the Bhogdoi river by analysing the various hydrological data to understand the flood situation of the basin area.
2. To analyse the causes and effects of floods in the study area and to provide some effective measures to control the rate of flood effects of the region.

## II. METHODOLOGY AND DATABASE

This research work is mainly confined to empirical studies based on data collected from primary and secondary sources. Primary data are collected through extensive field study and spot observation. Apart from this, some related literature and information have been gathered from secondary sources like books and journals, some official records etc. Moreover, drainage basin sheets of 83 J/1, J/2 and J/6, Survey of India at 1:50000 scales used for mapping the study area of Bhogdoi basin of Assam and satellite imagery of IRS P6 LISS-III, January, 2010 has been used to prepare the land use land cover map of the study area using GIS. The collected data are then tabulated, analyzed and presented in the form of charts, diagrams to observe a meaningful relationship between the existing realities and the collected data.

**STUDY AREA:**

The study area is lies in the eastern part of the Brahmaputra Valley with an area of 543.98 sq. Km (Figure 1). Its geographical location is $26^0$28' N to $26^0$49' N latitude and $94^0$03' E to $94^0$28' E longitude. It is bounded by Brahmaputra River in north and Mukokchung District of Nagaland in south. In its east, there is Sivsagar district and in west, Kakodonga river. The Bhogdoi River is a sub-tributary of Brahmaputra. It has its source at Long Samtang of Mukokchung (Naga Hills) and is falling down at Kakadonga River in North-west of Jorhat flowing for 162.5 km through the Jorhat town.

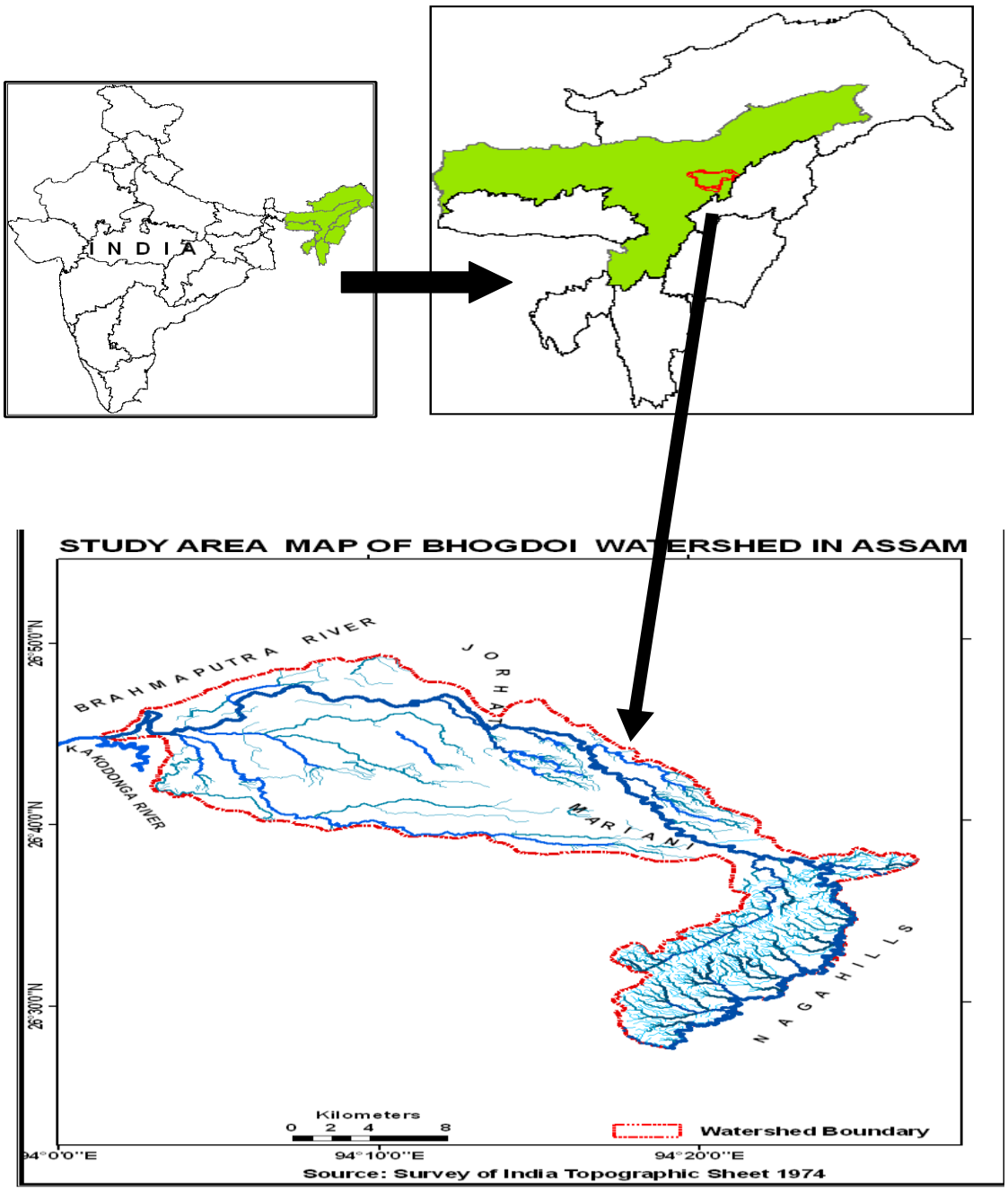


Fig .1: Location map of the study area of Bhogdoi Basin, Assam.

## III. ANALYSIS AND RESULTS

Flooding of the valleys during the rainy season is a common hazard in Assam. It causes immense destruction of crops, property and even of life in the region. The first written account of flood in the Brahmaputra valley reveals that there was flood in 1241 in its upper parts.

Flood is a catastrophic agent which causes erosion, deposition and damages and changes the physiographic character of the valley (Stewart, 1967). Thus, the floods , in this study region creates all such problems and damages including damage to crops, losses of lives both human and cattle, erosion of built-up lands and river banks, deposition of thick sand over agricultural lands etc. References of such floods are found in old history books of Assam and books like the Yogini Tantra, Gurucharit etc. According to historical records, Bhogdoi is a gently flowing river and was not known to cause devastation in the past, thus the river have been allowed to flow very close to the rajabahar or royal rest palace. In the study area floods occur due to the heavy rain during the monsoon months i.e., May to October. Bhogdoi is a river of varied nature. The river takes a furious look when it is in high spate. Although the floods of this region are of climatogenic in origin, there have been influences of tectonic, physical, hydrologic and human interferences on their intensification. (Barman, 1986)

It was expected that the embankment along Brahmaputra would protect the study area from flood and expectation valid for few years. Later, Bhogdoi started its own flood as the river became shallow because of the sediments carried down by the river started aggradations of its channel. The bed of the Bhogdoi came up by 1.75 metre during the last 40 years at the place where the river crosses the A.T.Road. Flood water during the monsoon season gives tremendous lateral pressure on the embankment causing breaching of it in weaker sections and producing flash flood every year. As such, Jorhat is exposed to a constant threat of submergence and flooding of Bhogdoi, especially in the event of breach of the embankments along its bank. A breach in embankment, in April, 2004 caused devastation in the form of inundation in several areas of the lower part of its basin.

The high flood levels and the maximum water discharge of the Bhogdoi River at A.T. Road gauge station for the period 1991-2010 are shown in table below:

Table 1: Highest Flood Level (H.F. L) and Maximum Discharge of the Bhogdoi River at A.T.Road Crossing (1991-2010). (Danger level is 89.00 m)

| Year | Date | High Flood Water in meter | Date | Max. Discharge in cumecs |
|---|---|---|---|---|
| 1991 | 19.9 | 89.85 | 19.9 | 116.84 |
| 1992 | 22.7 | 89.73 | 8.8 | 134.99 |
| 1993 | 23.6 | 90.06 | 23.6 | 292.4 |
| 1994 | 2.7 | 89.68 | 2.7 | 126.64 |
| 1995 | 26.8 | 90.2 | 26.8 | 278.88 |
| 1996 | 31.7 | 90.45 | 31.7 | 410.98 |
| 1997 | 10.8 | 89.8 | 10.8 | 168.04 |
| 1998 | 11.7 | 90.17 | 11.7 | 248.1 |
| 1999 | 29.8 | 90.15 | 25.6 | 95.05 |
| 2000 | 17.6 | 90.41 | 23.8 | 98.66 |
| 2001 | 2.10 | 89.65 | 19.9 | 80.29 |
| 2002 | 12.8 | 89.98 | 12.8 | 201.75 |
| 2003 | 16.7 | 89.58 | 16.7 | 136.41 |
| 2004 | 25.7 | 90.86 | 15.7 | 365.5 |
| 2005 | 20.8 | 89.67 | 20.8 | 113.08 |
| 2006 | 20.7 | 89.57 | 20.7 | 186.5 |
| 2007 | 5.9 | 89.75 | 5.9 | 210.32 |
| 2008 | 29.6 | 88.26 | 10.7 | 79.61 |
| 2009 | 9.7 | 89.48 | 8.7 | 250.2 |
| 2010 | 1.6 | 90.4 | 10.8 | 308.3 |

Source: Upper Assam Water Resource Division, Jorhat, 2012.

The highest flood level of 90.86 meter occurred on 25$^{th}$ July, 2004. Other high levels of water in 90.45 meter (31$^{st}$ July, 1996), 90.41 meter (17$^{th}$ June, 2000). Likewise, minimum value of high flood level was 88.26 meter (29$^{th}$ June, 2008). The maximum value of high discharge recorded was 410.98 cumecs on 31$^{st}$ July, 1996 and the minimum figure for the high discharge was 79.61 cumecs measured on 10$^{th}$ July, 2008.

The study of annual maximum and minimum variability in flow has great signification in determining the hydrological characteristics of a river, which provides important information to engineers, hydrologists and others who an engaged in water resources development and management programs. Flood defined by vonte chow (1956) is a relatively high flow which overtaxes the natural channel provided for the runoff. Rostvedt and other (1968) have considered flood to be any high stream flow which overtops natural of artificial banks of stream. Flood has great impact on the human occupancy of the floodplain. Therefore the study of maximum flood flow of a river is helpful in assessing flood hazard in the floodplain. The knowledge of peak flow may help in designing bridges, culverts, flood channels, embankments, dykes, etc. to save the floodplain and its occupancy from the flood ravages. Similarly the study of mean low flow of a river helps in designing storage of water of irrigation and water supply in towns.

Table 2: Variation of Annual maximum and minimum Flows of the river Bhogdoi at A. T. Road Crossing Gauge station, Jorhat, Assam (1971-2010)

| Year | Max. Disch x | $(x-\bar{x})$ | $(x-\bar{x})^2$ | Min. Dich $x^1$ | $(x^1-\bar{x^1})$ | $(x^1-\bar{x^1})^2$ |
|---|---|---|---|---|---|---|
| 1971 | 258.17 | 46.92 | 2201.48 | 1.76 | 0.17 | 0.0289 |
| 1972 | 381.64 | 170.39 | 29032.8 | 1.66 | 0.07 | 0.0049 |
| 1973 | 236.37 | 25.12 | 631.01 | 1.54 | -0.05 | 0.0025 |
| 1974 | 153.97 | -57.28 | 3280.99 | 1.09 | -0.5 | 0.25 |
| 1975 | 76.13 | -135.12 | 18257.4 | 0.54 | -1.05 | 1.1025 |
| 1976 | 323.45 | 112.2 | 12588.8 | 1.44 | -0.15 | 0.0225 |
| 1977 | 401.98 | 190.73 | 36377.9 | 0.8 | -0.79 | 0.6241 |
| 1978 | 369.93 | 158.68 | 25179.3 | 0.6 | -0.99 | 0.9801 |
| 1979 | 55.32 | -154.93 | 24003.3 | 0.68 | -0.91 | 0.8281 |
| 1980 | 297.06 | 85.81 | 7363.35 | 0.74 | -0.85 | 0.7225 |
| 1981 | 183.17 | -28.08 | 788.48 | 0.31 | -1.28 | 1.6384 |
| 1982 | 239.95 | 28.74 | 826.27 | 0.11 | -1.48 | 2.1904 |
| 1983 | 346.81 | 135.56 | 18376.5 | 0.71 | -0.88 | 0.7744 |
| 1984 | 101.71 | -109.54 | 11999 | 0.8 | -0.79 | 0.6241 |
| 1985 | 239.17 | 27.92 | 779.52 | 0.69 | -0.9 | 0.81 |
| 1986 | 99.72 | -111.53 | 12438.9 | 0.71 | -0.88 | 0.7744 |
| 1987 | 221.34 | 10.09 | 101.8 | 0.97 | -0.62 | 0.3844 |
| 1988 | 115.17 | -96.08 | 9231.36 | 1.96 | 0.37 | 0.1369 |
| 1989 | 298.56 | 87.31 | 7623.03 | 1.96 | 0.37 | 0.1369 |
| 1990 | 146.72 | -64.53 | 4164.12 | 1.06 | -0.53 | 0.2809 |
| 1991 | 116.84 | -94.41 | 8913.24 | 1.57 | -0.02 | 0.0004 |
| 1992 | 134.99 | -76.26 | 5815.58 | 2.83 | 1.24 | 1.5376 |
| 1993 | 292.4 | 81.15 | 6585.32 | 1.35 | -0.24 | 0.0576 |
| 1994 | 126.64 | -84.61 | 7158.85 | 1.22 | -0.37 | 0.1369 |
| 1995 | 278.88 | 67.63 | 4573.81 | 2.08 | 0.49 | 0.2401 |
| 1996 | 410.98 | 199.73 | 39892.1 | 3.1 | 1.51 | 2.2801 |
| 1997 | 168.04 | -43.21 | 1867.1 | 1.97 | 0.38 | 0.1444 |
| 1998 | 248.1 | 36.85 | 1357.92 | 2.46 | 0.87 | 0.7569 |
| 1999 | 95.05 | -116.2 | 13502.4 | 0.64 | -0.95 | 0.9025 |
| 2000 | 98.66 | -112.59 | 12676.5 | 0.91 | -0.68 | 0.4624 |
| 2001 | 80.29 | -130.96 | 17150.5 | 0.6 | -0.99 | 0.9801 |
| 2002 | 201.75 | -9.5 | 90.25 | 0.59 | -1.0 | 1.0000 |
| 2003 | 136.41 | -84.84 | 7197.82 | 2.61 | 1.02 | 1.0404 |
| 2004 | 365.5 | 154.25 | 23793.1 | 2.5 | 0.91 | 0.8281 |
| 2005 | 113.08 | -98.17 | 9637.34 | 4.3 | 2.71 | 7.3441 |
| 2006 | 186.5 | -24.75 | 612.56 | 1.83 | 0.24 | 0.0576 |
| 2007 | 210.32 | -0.93 | 0.86 | 1.77 | 0.18 | 0.0324 |
| 2008 | 79.61 | -131.64 | 17329.1 | 4.61 | 3.02 | 4.1204 |
| 2009 | 250.2 | 38.95 | 1517.10 | 3.64 | 2.05 | 4.2025 |
| 2010 | 308.3 | 97.05 | 9418.7 | 2.5 | 0.91 | 0.8281 |
| | | | □ □ □ □ □ □ □ □ □ | | | |

Source: Water Resource Department, Govt. of Assam

$\bar{x} = \frac{\Sigma x}{n} = \frac{8449.88}{40} = 211.247 = 211.25$

$S.D = \Sigma \sqrt{\frac{(x - \bar{x})^2}{n}} = \sqrt{\frac{41433.5.56}{40}} \quad 101.77$

Co-efficient of variation for Max. Flow = $\frac{S.D.}{\bar{X}}$

$= \frac{101.77}{211.25}$

$= 0.48\%$

For Minimum Flow-

$\bar{x} = 1.589 = 1.59$

$S.D = \sqrt{\frac{44.516}{40}} = 1.1129 \sqrt{\quad} = 1.0549$

$C.V. = \frac{S.D}{\bar{x}} = \frac{1.0549}{1.59} = 0.6638$

$= 0.66\ \%$

To study the characteristics of maximum and minimum discharge of the Bhogdoi river during the period 1971 though 2010, graphs are drawn to show the viabilities of annual maximum and minimum flows of the river. The mean annual maximum discharge is estimated at 211.25 cumecs. During the study period, the positive variation of flows ranges from 94.55 percent in 1996 to 4.78 percent in 1987 similarly the negative of flows varies from -73.33 percent in 1979 to -0.43 percent 2007(Table 4.-). Again in case of low flow the mean annual minimum discharge is estimated at 1.58 cumecs and during the period the positive variation of flow ranges between 191.77 percent in 2008 to 5.06 percent in 1972 and the negative variation from -93.67 percent in 2000 to -0.63 percent in 1991 ( table 2).

The coefficients of variation for maximum and minimum discharges are 0.48 percent and 0.66.percent respectively. The values are almost same.

Table 3: Annual number of flood waves of river Bhogdoi (1991-2008)

| Year | No. of flood waves | Year | No. of flood waves |
|---|---|---|---|
| 1991 | 21 | 2000 | 10 |
| 1992 | 20 | 2001 | 14 |
| 1993 | 19 | 2002 | 9 |
| 1994 | 12 | 2003 | 12 |
| 1995 | 18 | 2004 | 8 |
| 1996 | 18 | 2005 | 8 |
| 1997 | 12 | 2006 | 5 |
| 1998 | 11 | 2007 | 7 |
| 1999 | 16 | 2008 | 4 |

Source: Water Resource Dept., Govt. of Assam, Jorhat.

Table 4: Total loss of life and property by flood in the study area (2010-12)

| Year | Area flooded | Village affected | Population affected | Crop area Affected | Houses affected | Infrastructure damaged |
|---|---|---|---|---|---|---|
| 2010 | 361 hectare | 8 villages | 2459 persons, 1 death | | | One village road |
| 2011 | 520 hectare | 12 villages | 6030 persons | 174.5 hectare | 16 | 1.Mallow pam to Bormer Bhakta gaon connecting road 2.Gualjan to Bhoktagaon road 3.Bormer-Nahatia embankment. |
| 2012 | 1030 hectare | 27 villages | 16,253 persons | 205 hectare | | |

Source: field Survey, 2010-2012

The floods were regular annual features in the past but these are of slightly different in nature than that of the present one because of the absence of the embankment of the river during that time. These floods however, did not remain for a longer period of time. Today, in the Bhogdoi River, deposition and aggradations of the river bed can be viewed distinctly in a span of 23 kilometres of Bhogdoi from Gormur to Solmara. In this segment, the river bed appears to stand above the agricultural fields and villages on either side of its channel. This necessitated the erection of embankments on both of its banks in different phases. During the first phase the portion of embankment from JB Road to Pujadubi was completed in 1972. It was extended from JB Road to ChengeliAti in the second phase and from Pujadubi to Jorhat Engineering College in the third phase (Nath, 2010). Since then raising and strengthening works of these embankment have been undertaking for two times by the Water Resource Department of Assam.

In early days, the river Bhogdoi was flowing at a considerable distance from the present course. The old course is said to have passed a little to the east of the present Jorhat-Nimati Railway Line. The existence of a long line of swampy areas along this railway line indicates this possibility (Sharma, 2010).A long line of swampy areas to the west of the present Tocklai stream indicates that these swamps once formed a part of this stream which later got shifted to the present position. The confinement of subsidence, fissures and outflow of sands of the earthquakes of 1897 and 1950, along this line shows that this is a weak zone and may be a part of the said stream (Rao, 1950). However, this is no evidence of any more changes in the course of Bhogdoi or Tocklai within the town after the above changes. It is worth noting that before the construction of the embankment of Bhogdoi in early nineteenth century, Jorhat had been subjected to inundation by the river, particularly during the rainy monsoon season (Datt, 1959).

The Rajmao Tank site, which was once a low lying tract, is now the most elevated portion of the town, the elevation being of about 94.50 metre (310 feet) above mean sea level. Swamps of the Bali bat and Dacca patty areas being in a weak zone have an important bearing on the houses built recently over some parts of them. The level of the town is gently sloping from SSE to NNW which has a dominant effect in causing the north westward flow of the Bhogdoi River and its streams through the town (Sharma, 2010). The striking feature of the river is its shallowness for which its water level remains above the general level of the town. It is mainly due to the deposition of silts which the river is unable to carry. However, due to the construction of the embankment along the river, the town is immune from its flood.Besides, Bhogdoi its four streams namely, Tocklai, Jakharia Jan, Tarajan and Athubhanga River were also passes through the town. All of them were flowing parallel to Bhogdoi in the town area.

Remarkably, the river Bhogdoi and the Tocklai stream have come so close to each other near the water works on the Gormur Road that only the embankment stands between them. In that situation, if any damage occurs to the embankment, a channel of the former may force its way to the latter, because of the former's high water level. However, all the streams are very small in size and their flood can do little damage to the town side. In any case, the role of Bhogdoi and its streams is significant as the sources of water and natural drainage of the town.

## IV. FLOOD FREQUENCY ANALYSIS:

A number of physical characteristics of floods are important in considering the impact of flooding on man, i.e, the frequency of flooding, peak flow etc. Graphical plotting position method developed by E.J. Gumball is used here. The peak discharges are generally called flood, whether or not they actually cause inundation. The series of one peak per one year is called the annual series and the data are then ranked in order of their magnitude and the probability "p" of each event being equalled to or exceeded (plotting position) is calculated by the potting position formula as -

$$P = \frac{M}{N+1} \quad \ldots\ldots\ldots\ldots \text{(i)}$$

Where P means probability, M is the ranking order of a particular flood and N is the total number of events in the series. Again the probability of occurrence and the recurrence interval are reciprocal to each other. Hence,

$$Tr = \frac{N+1}{M} \quad \ldots\ldots\ldots\ldots \text{(ii)}$$

Where Tr is recurrence interval. From the table, the statement relating to the statistical probability of flood events can be made.

Table 5.Maximum Annual Discharge in m3s-1 and Probabilty of flood in % of Bhogdoi River (1991-2010)

| Year | Maximum Annual Discharge (m3s-1) | Rank | Discharge (m3s-1) | Reccurence Interval | Probability (P) | P in % |
|---|---|---|---|---|---|---|
| 1991 | 116.84 | 21 | 201.75 | 1.95 | 0.51 | 51% |
| 1992 | 134.99 | 22 | 186.5 | 1.86 | 0.53 | 53% |
| 1993 | 292.4 | 23 | 183.17 | 1.78 | 0.56 | 56% |
| 1994 | 126.64 | 24 | 168.04 | 1.7 | 0.58 | 58% |
| 1995 | 278.88 | 25 | 153.97 | 1.64 | 0.6 | 60% |
| 1996 | 410.98 | 26 | 146.72 | 1.57 | 0.63 | 63% |
| 1997 | 168.04 | 27 | 136.41 | 1.51 | 0.65 | 65% |
| 1998 | 248.1 | 28 | 134.99 | 1.46 | 0.68 | 68% |
| 1999 | 95.05 | 29 | 126.64 | 1.41 | 0.7 | 70% |
| 2000 | 98.66 | 30 | 116.84 | 1.36 | 0.73 | 73% |
| 2001 | 80.29 | 31 | 115.17 | 1.32 | 0.75 | 75% |
| 2002 | 201.75 | 32 | 113.08 | 1.28 | 0.78 | 78% |
| 2003 | 136.41 | 33 | 101.71 | 1.24 | 0.8 | 80% |
| 2004 | 365.5 | 34 | 99.72 | 1.2 | 0.82 | 82% |
| 2005 | 113.08 | 35 | 98.66 | 1.17 | 0.85 | 85% |
| 2006 | 186.5 | 36 | 95.05 | 1.13 | 0.87 | 87% |
| 2007 | 210.32 | 37 | 80.29 | 1.1 | 0.9 | 90% |
| 2008 | 79.61 | 38 | 79.61 | 1.07 | 0.92 | 92% |
| 2009 | 250.2 | 39 | 76.13 | 1.05 | 0.95 | 95% |
| 2010 | 308.3 | 40 | 56.32 | 1.02 | 0.97 | 97% |

Source: Compiled from the data collected from Water Resource dept. Rajabari, Jorhat

## V. SUGGESTIONS

Based on the study, some suggestions may be put forwarded for controlling the rate of flood and adjusting with its after-effects. These are summarised as-

- To reduce sediments load in the river and to protect banks and embankments, scientific afforestation in its upper course and in the plains should be affected. Moreover, make the river free from pollution.
- Digging of the bed of the Bhogdoi River and erection of embankments on both of its bank in different phases can reduce the flood damages in the region.
- The low-lying areas of the region may be allowed to be flooded during the monsoon season. Without growing kharif crops, shifting the emphasis to pre-kharif and rabi crops.
- Changing the cropping pattern by growing flood-resistant crops like jute and varieties of early or late varieties of rice in the chronically affected areas.
- Flood water should be allowed to flow into the beels and marshy areas so that it produces the congenial atmosphere for breading of fishes.

## VI. CONCLUSION

In conclusion, it may be reiterated that hazardous impact of regular flood on crops, properties and life should be reduce through various long time and effective measures as suggested here in right earnest and expeditiously. The information provided by this study may provide a reliable basis for such an integrated approach for development in the area.

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