Changing Flood Intensity Zone of Dwarka River Basin in Eastern India

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Abstract

Flood is intrinsic components of the natural climate system and climate variability. Dwarka river basin has experienced 37 memorable meso to macro level floods between 1900 to 2010. Among them more than 75% floods phenomena have occurred after 1950. About 14 devastating floods have been recorded since 1900. Among these extreme flood events, 21.42% occurred before 1952 and rest 78.58% have agitated after 1952. According to the perception study and recorded secondary data, it is clear that the discrete and cumulative flood frequency have been progressively increasing over time. From the flood trend analysis due to the desperate intervention of human being in the basin area through various anthropogenic activities such as construction of barrage across river, embankment along river banks, khadan construction on the upper catchment area etc. to draw immediate profit from river and river command area, river has changed its character in diversified ways. The intensity of flood in terms of flood frequency, flood height and flood stagnation period has been increased many times. So it may be said natural forces alone do not cause floods today; rather, floods is a byproduct of the interaction between natural events and human activities. For that some scientific and creative measures are essential not only to abate flood intensity but also to make creative adjustment with flood.

Keywords: *Flood intensity, Flood Frequency, Retention capacity, Hydrological density, Flood vector.*

Introduction:

Long time before the flood was considered to be beneficial for human civilization when fertile soil carried by the river and flood was rhythmic in manner. But now the intensity of flood has increased many times due to extreme human interferences with river through construction of dam, embankment along river to draw huge profit at a time and flood is considered as terrifying occurrence as it carries huge amount of sand instead of fertile soil .

"Flood is defined as a state of high water level along the river channel or on coast that leads to inundation of land which normally submerged"(Khullar, 2000). In other words flood is simply defined as spilling of water body over normal level of discharge. In West Bengal the northern and central parts are flooded by rivers like Mahananda, Bhagirathi, Ajoy, Mayurakshi, Dwarka, Damador, etc. due to inadequate capacity of river channel, absence of embankment, high rate of sand deposition, construction of dam etc. (Majumdar, 1941). Due to loss of carrying capacity of Dwarka river the flood height and flood frequency have increased many times and even today normal flow of river is bringing high flood. In this situation some creative and scientific measures are essential not only to reduce flood intensity but also to make adjustment with flood.

Location:

Dwarka River is well known name in the river scenario of Bengal. Taking start from Chhotonagpur the river flows toward extra moribund deltaic region. The whole basin of Dwarka river lies between 23°58' and 24°29' north latitude and 87°18'E and 88°12'E longitude covering an area of 3569.76 sq.km. The study area includes two districts of Jharkhand (Pakur and Dumka) and two districts of West Bengal namely Birbhum and Murshidabad. This broad basin covers 12 CD Blocks. The total length of Dwarka river is 156.5km.

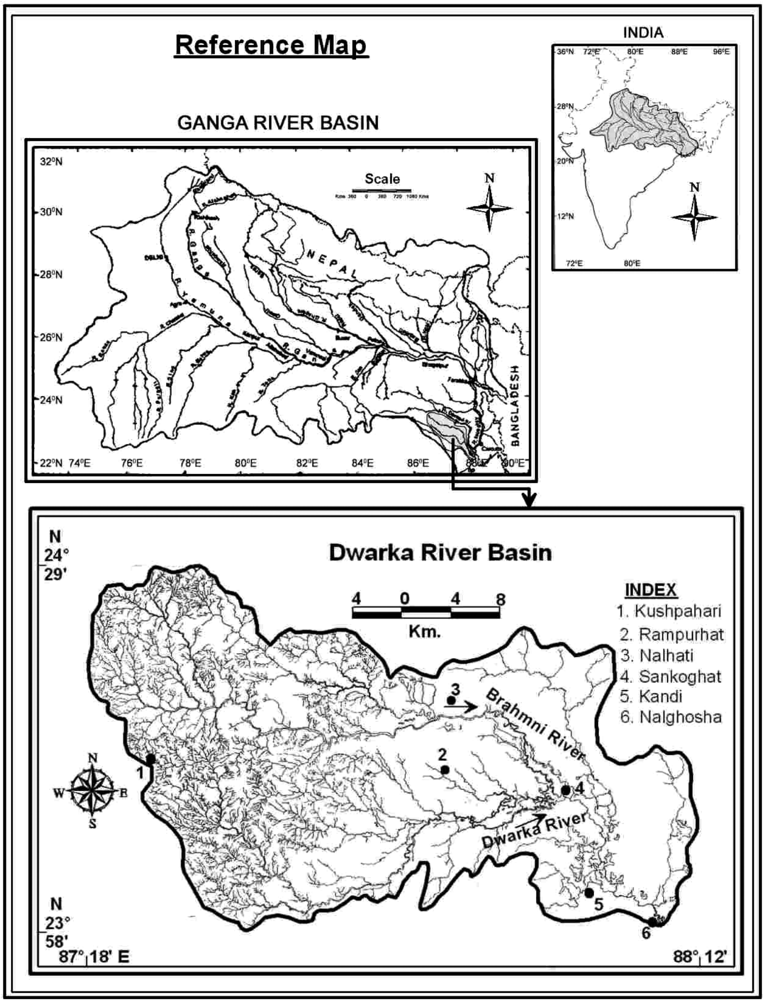

Fig. 1

Physical Background of the Study Area:

The Dwarka river originates from Chhotonagpur plateau and merges with Mayurakshi river in Murshidabad District. The upper part of this basin is located in Chhotonagpur plateau region having undulating plateau surface with large number of isolated hills. Maximum relief of this part is about 502 m. and middle part belongs to Rarh Bengal. The lower segment of this basin is plain area with numerous rivers, gullies, segments, bils swamps, levees, chars etc. The general slope of the entire region is about 1:3.54

The Dwarka river is extremely sinuous in nature and having large number of tributaries. In upper part number of tributaries is more and non perennial in character. But in lower part most of the tributaries are perennial in nature and bring huge amount of water during Monsoon period. Some important tributaries are Mor, Brahmani, Banki, Gomvira etc.

Climate of Dwarka basin is characterized by hot summer, high humidity as well as monsoonal annual rainfall. The average annual rainfall of this basin is about 124 - 130 cm, where 80% of the rainfall is received from June to September. As a result flood is a normal event in this period. Maximum temperature during summer rises up to 38°C and comes down to about 12°C during winter.

Database

The present paper has been prepared after the compilation of the secondary as well as primary data. The data about flood height, flood water stagnation period and flood affected area have been collected from Irrigation and Water ways Department of Government of West Bengal, Disaster Management cell of West Bengal Govt. and the perception study of the flood victims through scheduled questionnaires.

Methodical Frame

Entire basin has been subdivided into 67 equal size grids (64 sq.km of each) and flood frequency, flood height, flood water stagnation etc. data have been collected on the basis of each and every individual grid.

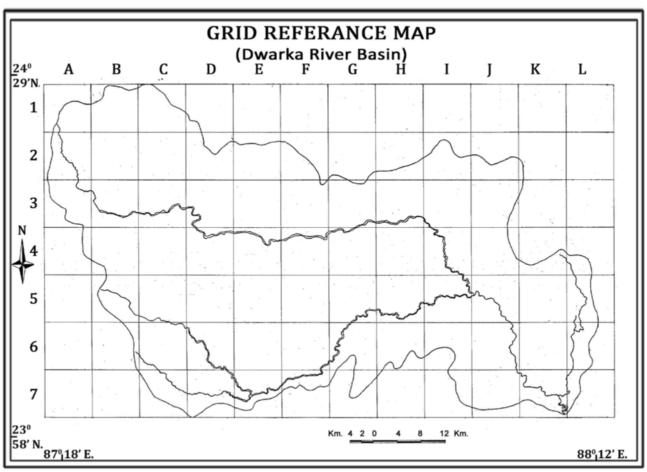

Fig. 2

In this paper average condition of flood frequency, flood water height, flood water stagnation of some seven major floods since 1978 to 2010 have calculated and plotted on map. Flood frequency has been initially calculated in the way that 1flood/5years or 1flood/2year or like. But for the convenience of discussion, all flood frequency data have been converted in respect to 1 year. For example, 1flood/1year indicates the value as 1; 1flood/2years indicates 0.5 or like (Mukhopadhyay et al 2011). Three individual flood intensity zoning maps have been prepared for the year of 1978, 2000 and 2007 as these are prominent flood years of the basin.

For year wise flood intensity zoning two parameters have been selected namely a) Flood water level height and b) Flood stagnation period. Weighted composite score method has been employed to integrate the flood data for each affected mouza (small administrative land unit).

Integrated flood map is prepared using three parameters namely flood level height, flood frequency and flood stagnation period. The standard scores have been calculated using weighted score method for removing their variations in basic unit expressions.

$$\text{Weighted score} = \frac{M}{n} \times 100$$

Where M = Maximum value of column; N = variable

Weighted score values are added together to show the composite weighted score. On the basis of composite weighted score, the entire basin area has been divided into four broad flood zones namely (i) intensive flood zone (>240) (ii) moderate flood zone (80-240) (iii) low flood zone (<80) (iv) no flood zone (0).

Flood Parameters

Flood Affected Area

Table 1 clearly shows that flood affected areas have been increasing over time. In last century 1978 flood year was the greatest as per flood extension and damage records. But flood year 2000 has washed out all the previous records and accounted the most extensive flood character. Figure 9 shows the status of most intensive flood extended areas. It is noticed that flood 2000 not only submerged the lower basin but also inundated extensive part of upper basin area.

Table 1: Distribution of Flood Affected Area

Flood zone	**1978**		**2000**		**2007**	
	Area (km^2)	**%**	**Area** (km^2)	**%**	**Area** (km^2)	**%**
Intensive flood zone	766.78	21.48	1023.81	28.68	613.64	17.19
Moderate flood zone	546.89	15.32	614.71	17.22	661.12	18.52
Low flood zone	350.91	9.83	610.43	17.10	376.97	10.56
No flood zone	1911.32	53.57	1320.81	37.0	1917.68	53.72

Three devastating flood years of these have been selected according to their devastating effects.

Flood during 1978

Memorable flood has been reported in 1978 in the lower area of Dwarka river basin. The inadequate capacity of river, extreme curvature of the river, convergence of large number of tributaries and huge downpour at a time was responsible for occurrence of flood during 1978. The lower portion of the Dwarka river basin is fertile and suitable for cultivation. So, the huge areal coverage in lower portion means loss of crop land. About 538 mouzas were affected by flood which is about 46.93% of the total basin area. Intense flood was recorded in the eastern part of Birbhum and Murshidabad districts. But extreme upper part of this river basin was not affected by the flood in 1978.

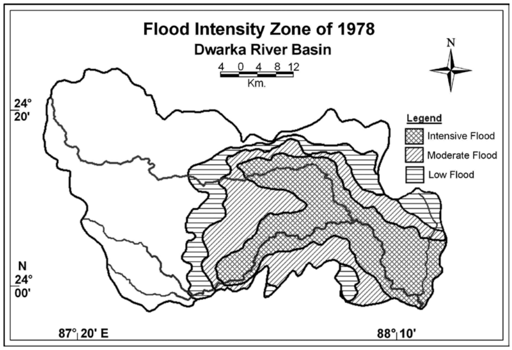

Fig. 3

Flood during 2000

During 2000 the most devastating flood has been recorded in Dwarka River basin. The main causes for such intense flood in 2000 were huge amount of downpour (654mm.)

Table 2: Number of Flood Affected Mouzas during 1978

FLOOD EVENTS →			1978		2000		2007	
Flood Zone	Weighted Score	Districts affected	No. of Blocks affected	No. of Mouzas affected	No. of Blocks affected	No. of Mouzas affected	No. of Blocks affected	No. of Mouzas affected
Intensive zone	<20	Murshiidabad	5	153	5	170	5	90
		Bibhum	4	110	4	149	4	123
Moderate zone	20-100	Murshiidabad	5	58	5	63	5	55
		Bibhum	4	78	4	89	4	80
Low zone	>100	Murshiidabad	1	2	1	1	3	72
		Bibhum	3	80	3	83	4	107

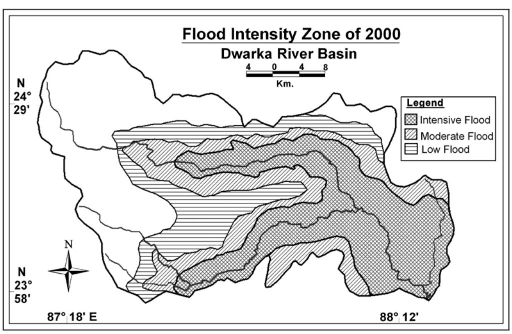

Fig. 4

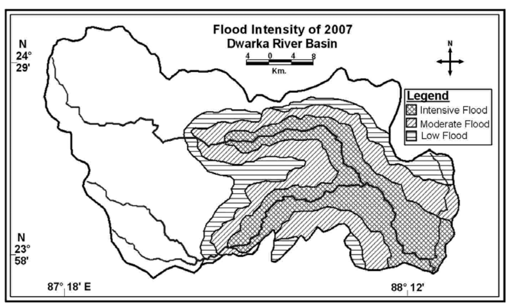

Fig. 5

within very short span of time, discharge of large amount of water (more than 45000 cusec) from dams all on a sudden, bringing of huge amount of water by tributaries to the main river, poor drainage condition etc. About 555 mouzas were affected by the flood which is about 63.0% of the total basin area. Gross record of loss including lives and properties was maximum during flood year 2000.

Flood during 2007

In the year 2007, large part of Dwarka River basin (middle and lower catchment area) was beaten by a severe flood due to large quantity of water release from Deucha dam and cyclonic rainfall (518mm). The areal coverage of flood was relatively low than previous two floods. About 537 mouzas were fully or partially affected by the flood during this year which is about 46.28% of the total Dwarka River basin.

Flood Frequency

Flood frequency means how many floods occur per unit period of time. Flood frequency depends on the frequency of downpour in basin area, uncontrolled discharge of water from dam or barrage etc.

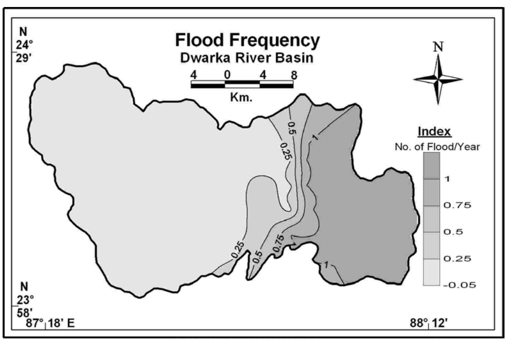

Fig. 6

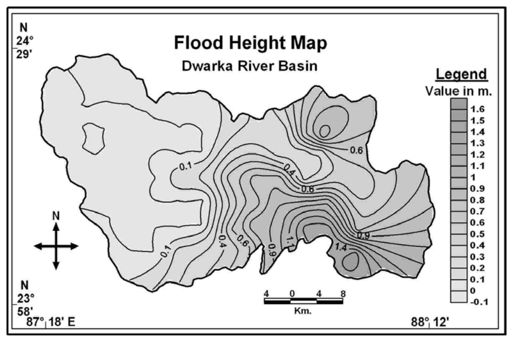

Fig. 7

In Dwarka river basin the frequency of flood varies from river confluence area to upper catchment. In lower catchment the flood occurrence is very frequent, almost one flood is experienced in every year. In 2007 three meso to macro level floods were experienced by the lower catchment dwellers. In middle catchment the frequency is comparatively lesser and in upper catchment there is no significant occurrence of flood.

Table 3: Distribution of Flood Frequency Area

Range of flood frequency/year	Area in km^2	% of area to total
>1	767.49	21.50
0.75-1	267.73	7.50
0.25-0.75	383.75	10.75
<0.25	2186.48	61.25

Flood Height

Flood height is the function of volume of discharge, topographical character, period of water accumulation etc. The region where the height of flood is more, possibility of flood devastation is also high. The flood height also varies from lower to upper catchments like that of the flood frequency.

In Dwarka River basin the maximum flood height is noticed at the confluence area where flood height is more than 1.6 m. Depressed land, long water stagnation period etc. are influential factors for such greater flood height. In the upper catchment area flood height is nil because there is no sign of flood.

Table 4: Distribution of Flood Height Area

Range of flood height(m.)	Area in km^2	% of area to total
>0.8	659.69	18.48
.5-0.8	709.31	19.87
0.2-0.5	632.56	17.72
0-0.2	755.36	21.16
Nil	812.83	22.77

Flood Stagnation Period

Flood stagnation indicates how long flood water stagnates in a particular area.This period may vary according to the rate of movement of water through spill way, presence of topographical depressed land, slope of the land, number of tributaries etc.

Table 5: Flood Water Stagnated Zones

Range of flood stagnation (in days)	Area in sq.km	% of area to total
>10	472.64	13.34
4-10	1016.31	28.47
<4	1350.08	37.82
Nil	727.16	20.37

In lower catchment area of Dwarka river basin the period of flood stagnation is sometime more than 15 days. The tendency of stagnation is relatively greater in the right hand sector of the lower catchment where the flood height is also maximum. In upper catchment area due to the presence of significant slope and draining out ability of the channel the stagnation period is either marginal or completely nil (Fig.8).

Relationship between Flood Height and Flood Stagnation:

There is positive relationship between flood height and flood stagnation period in all the observed years for same 67 grids, although the magnitude of relationship is not uniform. In the lower catchment area the relationship is stronger than the average value indicated in the following table.

Table 6: Correlation and Regression Values between Flood Height and Flood Stagnation

Year	1978	1984	1995	1999	2000	2006	2007
Regression Coefficient	0.821	0.687	0.651	0.737	0.702	0.659	0.744
Correlation Coefficient	0.907	0.829	0.807	0.859	0.838	0.812	0.863

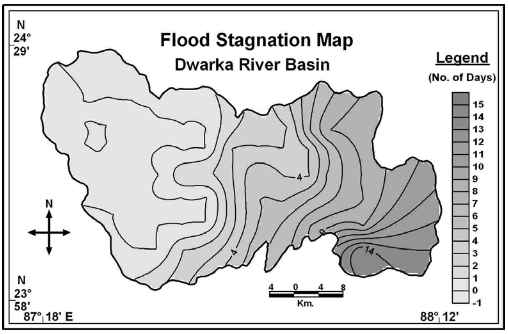

Fig. 8

Gradual degradation of drainage network, natural depression, and rise of water level of the master stream Bhagirathi etc. are mainly responsible for growing rate of positive allometry between flood height and flood stagnation period.

Integrated Flood Zones

Integration of different parameters like flood height, flood stagnation, and flood frequency for the measurement of flood can provide a detail picture of spatial flood character at a glance. This map (Fig.10) has been prepared on the basis of composite weighted score values which has mentioned in the early part of this paper.

1. Intensive Flood Zone

Basically the confluence area of Dwarka River basin comes under intensive flood zone. Almost all the mouzas of Kandi block experience intensive flood. Total area of intense flood zone is about 207.40 km^2.

Low lying topography, wetland character, poor drainage system, convergence of large number of meso level rivers etc. are mainly responsible for intensive flood. The fig. 9

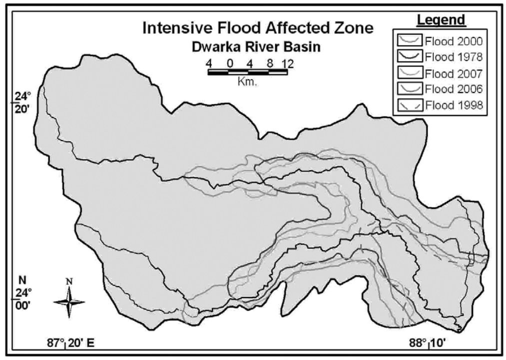

Fig. 9

is showing the variation in areal coverage of intensive flood zone in different major flood years.

2. Moderate Flood Zone

Relatively upper part of Dwarka River basin specially the eastern part of Murshidabad district, eastern part of Birbhum district come under this category. Total area of moderate flood coverage is 898.51 sq.km.

Extensive river command area, convergence of meso rivers, deposition of river bed, influx of water from the other river basin etc. are mainly responsible for flood in this zone.

3. Low Flood Zone

In relatively upper part of this river basin specially the western part of Birbhum of West Bengal and eastern part of Dumka district of Jharkhand come under this flood zone. Total areal coverage is 909.57 sq.km. Relatively greater degree of slope, high relief less dense population, less cropping intensity, all are responsible for low flood and marginal flood loss.

4. No Flood Zone

In extreme upper portion of the catchment area where there is no large and broad river, surface flow is more common than any channel flow the occurrences of flood is almost nil or rarely found. For example in the memorable flood history, only during flood year 2000, some portion of no flood zone was marginally affected. Total coverage of this kind of no flood zone is 1554.28 sq.km.

The flood intensity zone on the basis of flood frequency, flood stagnation period and flood height have been presented in fig.10 by using the Composite Score to represent the total flood character.

Table 7: Scale of Integrated Flood Affected Area

Flood zone	Area	% of area to total
Intensive flood zone	207.40km^2	5.81
Moderate flood zone	898.51 km^2	25.17
Low flood zone	909.57 km^2	25.48
No flood zone	1554.28 km^2	43.54

Major Findings:

- The flood level height has increased remarkably in lower catchment area and normally maximum flood height is found in confluence catchment area.
- Due to non-perennial character of river and high slope, upper part of this basin is totally free from flood devastation.
- Flood frequency is increasing since 1978. Now every year macro to meso level floods are experienced by lower catchment dwellers.

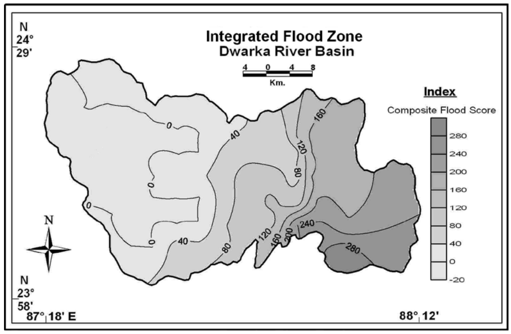

Fig. 10

- There is strong relation between flood in lower catchment area and discharge of water from Deucha barrage. During 2000 flood coverage area and damaging intensity were very high due to the release of huge amount of water from the barrage.
- Out of some memorable flood incidences, flood 2000, flood 1998, flood 2007 are significant. Among them 2000 flood is worst one for its spatial extent, flood height and stagnation period. About 63% area of the whole basin was affected by flood during this period.
- As a flood vector, rainfall is directly linked with mass scale flood but as a specimen of human interference, narrowing down of river course by encroaching lodges, sudden discharges from barrages (Deucha) etc. are also responsible for the cumulative flood devastation in this basin.
- From the comparative study of the flood intensive zone it is expressed that the zone is gradually shifting toward relatively upper reach since 1978. It

indicates that the flood affected area and intensity are spreading upward.

Some Remedial Measures:

I. Dredging of feeder channels will help to free trespassing of the water from Dwarka to Bhagirathi at faster rate.

II. Increasing of the retention capacity of the wetland or wetland areas to hold excess water during flood.

III. Large numbers of sizeable culverts are essential along the road for the passing of the water as it will save the road damage.

IV. Controlled monitoring of water discharge from dam and barrage is necessary during peak monsoon period and the capacity of the storing water must be increased.

V. Encroachment of the settlement areas into the channel must be avoided as the constricted flow is responsible for sudden flood occurrence .

VI. Flood safety room, community hall, common concrete granary etc. may be considered as good step to get rid of much losses.

VII. Village wise flood volunteer group should be organized for urgent and prompt saving of properties during flood.

VIII. Flood warning system should be implemented and revived. At least one river gauge station per each 20 km distance should be established with proper rain gauge system.

IX. Profit –loss calculation should immediately be revised for Deucha barrage to make our future plan more viable.

X. The perception of the basin dwellers should be implied to chalk out the management strategies.

Flood is natural phenomena, so it should not be hampered and tampered. It is high time that people should be concerned about ensuing threats otherwise river can announce rebel against the river tamer and on that days man would have nothing to do rather shameful surrender to river and riverine process. People are living within the flood command area, so they should adjust with flood at any cost.

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