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Rainfall trend and flood hazard vulnerability: a community based case study of parts of Kamrup Metro District, Assam

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ABSTRACT

Study of hazard vulnerability in various parts of the world is a growing field of research. It is a very intricately linked study in the field of disaster management, with very less amount of local level analysis. It is also an interesting field of research to interrelate the various intricately linked weather parameters with the changing hazard events in various parts of the world at global, regional and local level. At the same time, it is to be acknowledged that dearth of micro level data to justify the weather change and its likely impact on various hazard events in terms of their change is always a big challenge to overcome. From geographic standpoint the challenge is primarily to unfold, how the changing weather have affected the hazard events in terms of their nature and intensity over space in time dimension. This paper is a local level effort to enlighten the issue of existing flood hazard vulnerability of both urban and rural land-scapes with special reference to Kamrup Metro District of Assam. Unfortunately the issue of vulnerability itself is a lesser addressed area of geographic research, at-least at local level in Assam. But study of vulnerability (degree of exposure) is a vital parameter to assess the various underlying characteristics of hazards, including their causes and effects on the existing landscape, so that a better disaster risk reduction strategy can be formulated for the time of disaster. The study is an attempt to highlight the rainfall trend of last 20 years, considering two observation stations of Borjhar and Chanmari at outskirt and core of the city respectively. The analysis is based on some secondary data and information generated from concerned government agencies, from which some relevant components are derived. In addition to that community based hazards calendar is prepared, based on field survey of randomly picked up villages and ward locations (rural and urban respectively) from among the affected places. It has been observed that among the rural vulnerable villages maximum percentage of respondents indicated hazards exposure especially in the month of July, where maximum average rainfall and rainy days are recorded, whereas the urban respondents have wider range of response in the hazard calendar.

Key words: disaster risk, Flood, hazard calendar, rainfall trend, vulnerability.

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INTRODUCTION

A global paradigm shift has been observed, in disaster related studies over the years, which is becoming more of a pro-active approach, coming away from its previous relief centric approach. The focus is now more on reduction of the involved risk element, rather than its management straightaway. With this new effort, identification of the type of hazard and assessment of its degree of vulnerability (level of exposure to hazard risk) is placed as key element, so that an effective risk reduction strategy (space and time bound) can be formulated. Another captivating area of this pro-active approach is involvement of all concerned stakeholders, especially the affected communities, who actually live with the hazards. With increasing global population on one hand and rising demand of natural resource on the other hand, the natural balance in coming under an unprecedented peril. In this dwindle, both natural and man-made hazards are rising like never before, with no any immediate respite. In this connection, study of hazard vulnerability can, not only give some fresh insights to the study of disaster management in specific, but also build up a general consciousness among the concerned stakeholders in totality. The paper has attempted to visualise the nature of temperature and rainfall pattern of the study region, with especial reference to community response towards occurrence of hazard events. Being a monsoon dominated region the community response is primarily concentrated within the rainfall season of May to September (5 months), to see the trend of hazard occurrence during that period.

Food victims perceive a much greater range of choices in dealing with flood lazarel, than the state agents, who deal with it from outside. This is probably why indigenous knowledge application in dealing with the problem of the people can be more effective and meaningful (Mustafa, 2005).

Relevance of study:

Assam as a whole is lying in a belt of perennial flood, caused by its mighty river network of the Brahmaputra and the Barak and their rich network of tributaries. With its location in a tropical monsoon climate, with an average monthly rainfall of 278mm in a spell of just 5 months (May to September, IMD, Guwahati) and its giant sediment carrying river network in an abruptly falling angle, the state is bound to be perished by the perennial flood problem. Not only the river Brahmaputra, but many of its tributaries, especially that of the northern tributaries turns violent during the summer season, causing widespread displacement of people, loss of property, standing crops and even loss of life.

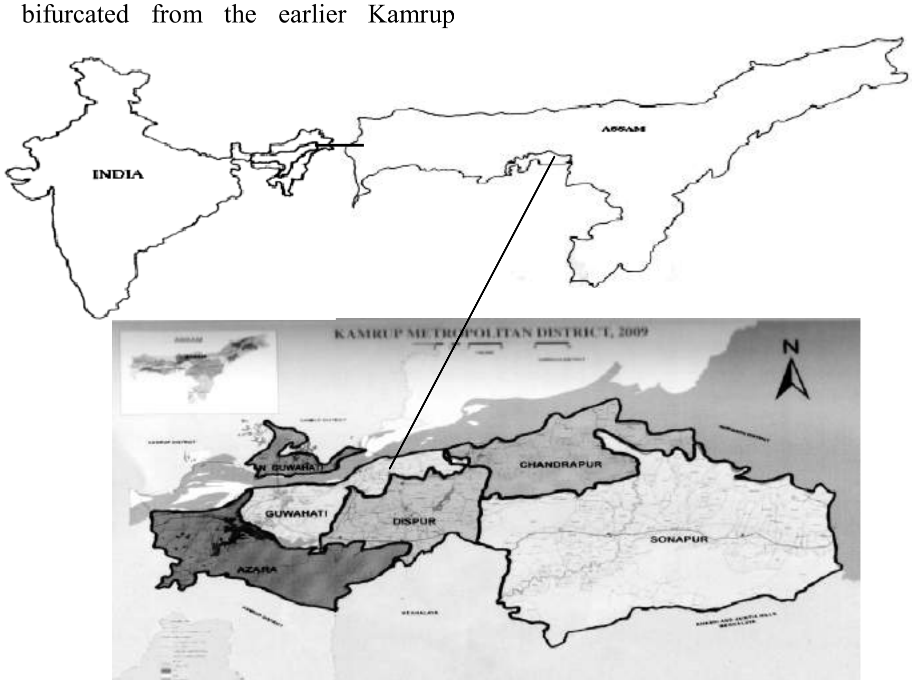
Hazard occurrence is directly related to various short terms weather affect and long term climatic controls, which are ever changing with time. As a result of this change effect, nature and intensity of hazard and their geographic confinement are also bound to change. Its growing attention is also attributed to the fact that it is a kind of interdisciplinary research, that brings together experts from a wide range of fields including climate science, development studies, disaster management, health, social science, policy development, economics so on and so forth. With ever expanding scope of bottom-up approach of disaster management and the paradigm shift from relief centric to response centric approach, community participation in disaster related issues are gaining momentum. In this context vulnerability assessment, involving the community, who actually live and fight with the concerned hazard become a central attraction, so that other necessary assessment related to immediate preparedness and long term mitigation options can be implemented in true spirit. The paper tries to unfold the issue of hazard vulnerability in the context of rainfall trend over a period of time. In this connection a community based hazard calendar is also tried to be prepared, to see how community response are related with the rainfall trend of the study area.

The issue of Hazarel Val: and adaptive capa has much to do with sl. Exploration of the local wisdom of those people, who outually live with such a system. The importane of formalizing a monitories network based on local knowledge, as apart of a broder adaptive management framework is highlighters many times by the community themselves. (Ogden and innes)

Study Area:

Ancient Assam was known an Pragjyotis in early times and as kamrupa in late time. The Ahom Kingdom the east of Manas river came to be known as Assam or Asam, after the Ahom and the name Kamrupa has since then restricted to the present district of Kamrup beth Manas and the Baruadi (Rai let Baruak Bahadu—Early History of Kamrupa).

Kamrup Metro District is a newly created district of the state of Assam, since 2003, bifurcated from the earlier Kamrup District. Geographical area of the district is 216.79 sq.km. It is bounded by Kamrup Rural district in three sides of west, north and south, part of Darrang district in north, state boundary of Meghalaya in south, and the district boundary of Morigaon in east. The extension is 25.43 - 26.51^0 north latitude and 90.36 -92.12^0 east longitude (NIC, Kamrup Metro). As the only metro of the region and the gateway to North-East, this part of Assam has gone through radical transformation in demographic and land use pattern over the years. Lying on the south bank of the mighty river Brahmaputra, the region originally belongs to swamp and low-lying landscape surrounded by hillocks on all side. With ever expanding population and expanded urbanization, the region have increasingly witnessed a vast environmental loss, reflected in various form of hazards viz. lost forest, especially on the hill slope and its aftermath like slope failure, hill soil erosion, etc. Urban flash flood is a rising environmental issue of the region, gaining momentum with



Map 1. Map of Study Area

changing land use pattern especially with filling up of the low lying belt, with expanding settlements. The district has witnessed both rural seasonal flood and the issue of urban flash flood. Flood vulnerability of Kamrup Metro District at village level is derived on GIS platform for two case study locations namely: Sonapur and Chandrapur revenue circle. Altogether nine villages (9) from two circles and six (6) urban flood affected locations are selected for case study to highlight community based responses towards hazard occurrence.

Objectives of the study:

The paper is an attempt to highlight the following objectives:

1) Identification of the geographical distribution of the flood vulnerable locations of the study area with special reference to two (2) circles having maximum flood vulnerable villages.

2) Average trend analysis of temperature-rainfall of the study area.

3) Comparative statistical analysis of rainfall trend from two observatory stations of Borjhar and Chandmari.

4) Projection of community based hazard calendar to see the relation between community response towards hazard occurrence and the general rainfall trend of the study area.

METHODOLOGY

Assessment of flood hazard vulnerability and rainfall trend analysis of Kamrup Metro district is based on secondary information, collected from concerned departments and reports etc. Based on the data other relevant derivatives are tried to be measured. In addition to that, assessment of community based hazard calendar is made on the basis of field study of selected case study area, covering both rural and urban locations.

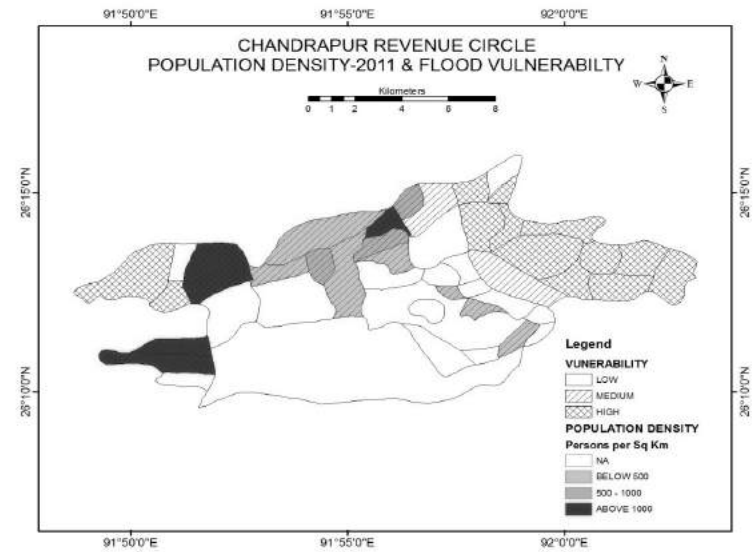
The methodological steps are as follows:

- Preparation of circle level base map, delineating the flood vulnerable zones in it.
- Average trend analysis of temperature and rainfall pattern of the study area in general.
- Trend analysis of rainfall of the study area for a specified time period of 2 decades (1991-2011), in 2 observatory stations.
- Preparation of hazard calendar based on community response in selected case study areas (9 villages from two revenue circles and 6 urban locations) to see how the community response towards hazard occurrence are related with that of trend of rainfall distribution in the study area.
- Development of various carto-statistical models for analysis of findings.

Circle-level flood vulnerability of Kamrup Metro District:

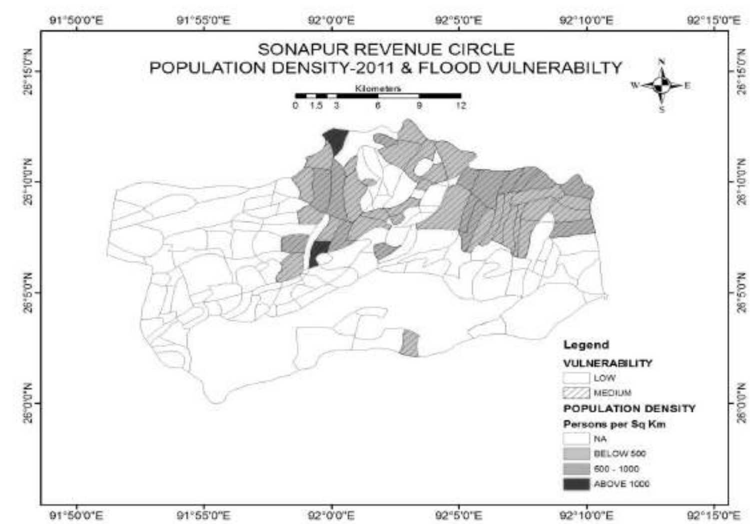
During the monsoon, flood hazard become a seasonal mayhem, especially in the low-lying belts of Assam. Like many other districts, lying along the valley of the mighty river Brahmaputra Kamrup Metro is also been affected by flood during the monsoon period (ASC, 2005). During last couple of decades urban flash flood is growing in terms of frequency, volume and spread, exposing the unplanned growth of the district. Among six (6) revenue circle of the district, the most flood affected are Chandrapur and Sonapur, followed by Azara, whereas few wards falling under Guwahati Municipality are affected by the problem of typical urban flash flood.

Among the circles, in Chandrapur 73% of the villages are identified as flood vulnerable. Out of total forty villages (District Census 1991) twenty nine (29) are identified as flood vulnerable. Looking at the flood vulnerability pattern (Map No: 2), it become clear that most of the affected villages are falling along the bank of Brahmaputra, and low lying belt in between kolong and Digaru.



Map 2. Vulnerability Pattern, Chandrapur Circle, Kamrup Metro District, Assam

On the other hand Sonapur with maximum number of villages also have maximum number of flood vulnerable villages. Out of 145 total villages, forty seven (47) are identified as flood vulnerable, representing 32.41% of the total villages. Looking at the flood vulnerability pattern of the circle (Map: No 3) one can see that most of the vulnerable villages are clustered in the north-east corner, along the bank of river Digaru and Kolong.



Map 3. Vulnerability Pattern, Sonapur Circle, Kamrup Metro District, Assam

The third most flood affected circle under the Kamrup Metro district is the Azara revenue circle, located west of the district. All together ten (10) villages of the circle are identified as flood vulnerable. The circle has 26 villages, affected partially or fully by flood water of river Brahmaputra. Out of that, four are fully affected by flood, falling under flood prone area, while six villages are partially submerged.

In addition to this three most flood affected circles, the other two circles namely North Guwahati Revenue Circle and Guwahati Revenue Circle also have pockets of partially affected flood areas. In North Guwahati, out of 39 villages, Amingaon is fully affected, whereas Tilingaon, Silagrant and North Guwahati are falling under partial flood affect. The Guwahati circle has area under Ulubari, Guwahati and Jalukbari. Parts of this circle are partially affected by problem of artificial flood. In addition to the rural seasonal flood, parts of Kamrup Metro District, falling under Guwahati Municipal Corporation are also increasingly affected by the problem of urban flash flood, which is growing over the years. (Flood Management Plan, Kamrup 2007).

Average trend of temperature-rainfall of the study area:

The climate of Kamrup doesn't differ from rest of the districts of central Assam. It falls under subtropical monsoon climate, with semi dry summer and cold winter. It receives an annual rainfall of about 1500-2600 mm, with a high humidity of about 75%. Annual temperature ranged between 07-38.5 degree C. The average temperature (daily minimum-maximum), rainfall and rainy days of 30 years database (1951-80) as measured by Regional Meteorological Centre, under IMD, Borjhar, Guwahati is shown in Table:1 and illustrated separately by Fig: 1,2 & 3 respectively.

Table 1. Average temperature-rainfall pattern, Kamrup Metro District, Assam

Months	Average temperature (in ^{0}c)		Average Rainfall (in mm)	Average number of rainy days
	Daily minimum	Daily maximum		
January	9.8	23.6	11.4	1.2
February	11.5	26.4	12.8	1.3
March	15.5	30.2	57.7	4.6
April	20.0	31.5	142.3	9.0
May	22.5	31.0	248.0	14.3
June	24.7	31.4	350.1	16.1
July	25.5	31.8	353.6	16.8
August	25.5	32.1	269.9	13.9
September	24.6	31.7	166.2	10.3
October	21.8	30.1	79.2	5.3
November	16.4	27.4	19.4	1.5
December	11.5	24.6	5.1	0.4

Source: Regional Meteorological Centre, Guwahati-1951-1980

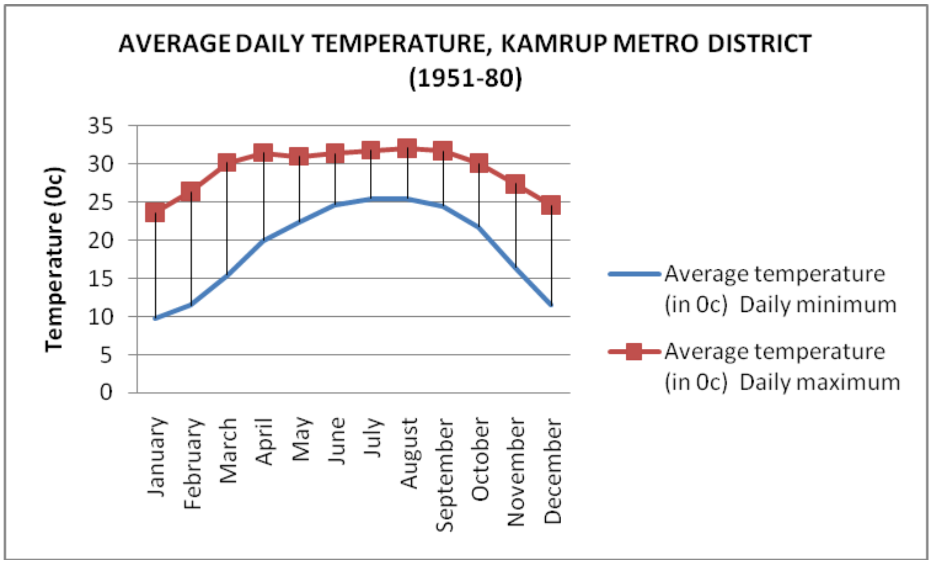


Figure 1. Average daily temperature (minimum-maximum), Kamrup Metro District

As shown in Fig: 1 during the winter season, the gap between minimum and maximum remains high. Minimum temperature is observed in the month of January 9.8^{0}c, during which maximum remains more than double the minimum at 23.6^{0}c. However with the advancing monsoon, during the summer season temperature continuously raised in the study area, that never falls below 30^{0}c (March to September), indicating creation of low pressure in the region.

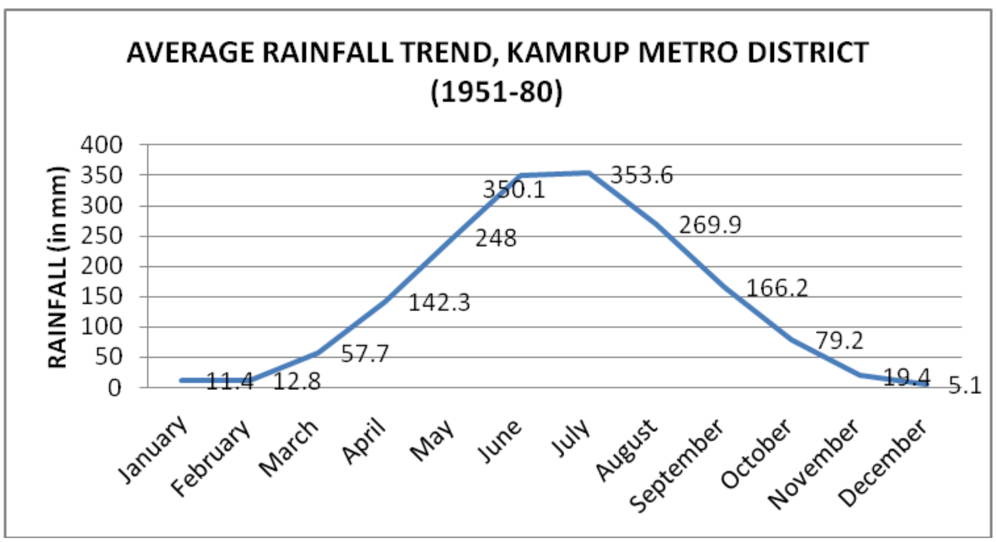


Figure 2. Average rainfall trend, Kamrup Metro District

The average rainfall trend of Kamrup Metro District during the observed time periods, have indicated a typical summer monsoon character of rainfall. From the month of April, with beginning of pre-monsoon phase till the month of August there is a continuous rise in rainfall, extended till the month of September. The rainfall trend is further supported by average number of rainy days during the same time period, represented by Fig: 3 Month of July, being the pick of the monsoon also have the highest number of average rainy days (16.8). Month from May to August have the highest numbers of rainy days in a calendar year.

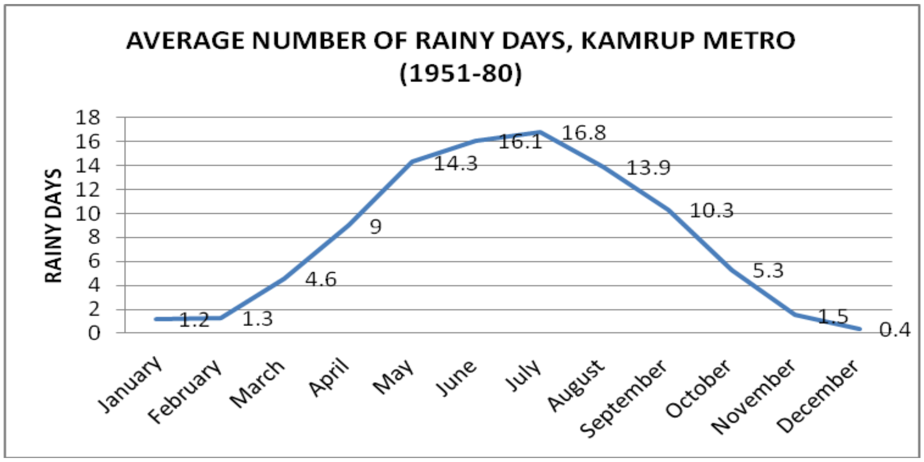


Figure 3. Average numbers of rainy days, Kamrup Metro District

Comparative statistics of rainfall of the study area:

Sufficient database on micro-level rainfall distribution pattern is required for effective rainfall analysis and projection of possible flood inundation. The official data are derived from the observation station of IMD at Borjhar airport, which is located at the western periphery of the city and in the office of the Chandmari Water Resource Department, located in the city centre. A comparative trend analysis of both the stations is presented in the following discussion, which will give us a general idea on hazard timing of the surrounding area of Guwahati metro. The analysis has covered 24 years of data (1991-2014) recorded in two stations of Borjhar and Chandmari.

Table 2. Total & Mean Rainfall (In mm), Guwahati Station at Borjhar Airport (1991-2011)

Data is derived from the original data generated at Borjhar Airport
TIME RERIOD: 1991-2011 (21YEARS)

	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	MEAN
1991	19.7	7.9	54.3	130	520.7	206.8	222.6	347.2	177.2	312.3	0	11.7	2010.4	167.533
1992	9.9	32.7	19.3	103.1	270.9	414.1	367.1	373.4	185.9	55.3	7	16.5	1855.2	154.6
1993	76.1	61.3	83.3	102.5	319.6	487.3	343.7	378.7	242.8	24.8	0	0	2120.1	176.675
1994	19.4	30	121.3	156.4	170.9	350	199.8	315.8	28.2	149.1	6.7	0	1547.6	128.967

	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	MEAN
1995	10.4	13.5	41.3	132	156.9	426	580.3	362.6	371.6	30.2	37.9	3.7	2166.4	180.533
1996	10.2	31.3	36.3	28.5	447.4	207.6	329.6	183.1	121.2	164.5	0	0	1559.7	129.975
1997	14.3	20	30.1	171.9	208	219.1	212.6	212.5	224.2	12.1	3.3	29	1357.1	113.092
1998	0.5	12.2	103.2	149.1	140.8	164.4	260.8	284.3	213	192.5	7.1	0	1527.9	127.325
1999	0	0	13.2	25.8	360.9	292.7	348.5	384.6	189	129.8	44.3	0.9	1789.7	149.142
2000	4.6	22.8	45.3	220.2	366.9	365	201.2	373.3	159.5	43.2	1.7	0.6	1804.3	150.358
2001	2.1	16.4	19.4	257.2	302	343	240.3	177.4	205.4	185.6	14.8	0	1763.6	146.967
2002	14.6	4.5	85.8	276.6	214.7	396.2	295	182.3	113.6	31.7	54.5	0	1669.5	139.125
2003	6.2	48	120.6	249.3	166.5	543.2	333.9	231.1	159.4	182.8	21.4	12.6	2075	172.917
2004	10.7	8.4	10.9	551.5	126	205.1	391.6	65.1	89.8	354.4	3.7	0.6	1817.8	151.483
2005	16.6	3.8	150.6	134.2	284.5	104.6	175.1	803	78.1	126.9	0	1.4	1878.8	156.567
2006	0	11	18.1	201.3	290.3	153.7	247.2	162.7	88	119.9	15.9	6.7	1314.8	109.567
2007	0	96.1	29.8	286.6	96.2	294.2	284.5	122.4	315.9	118.7	32.2	0	1676.6	139.717
2008	35.3	3.5	124.2	153.6	108.5	319	273.2	249.6	101.9	97.4	8	5.2	1479.4	123.283
2009	4	0	43.6	65.6	143.2	118	388.3	325.2	180.7	196.3	7.3	6.7	1478.9	123.242
2010	0.4	0	50	369.7	356	468.6	309.1	213.2	252.8	121	1.8	2.2	2144.8	178.733
2011	14.6	23.4	53.6	26.5	132.7	231	190.9	388.1	227.2	7.2	0	1.5	1296.7	108.058

Source: IMD, Borjhar Airport

Table 3. Total & Mean Rainfall (In mm), Guwahti Station at Chandmari Water Resource Department (2005-2014)

Data is derived from original data generated at Chandmari Water Resource department

TIME PERIOD: 2005-2014 (10 YEARS)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	MEAN
2005	22.9	0	93.4	229.1	272.5	87.2	195.3	391.2	85.6	141.5	5.6	0	1524.3	127.025
2006	0	3.8	0	197.1	160.8	148.3	167.9	89.6	63.4	60.9	22.3	0	914.1	76.175
2007	0	96.4	17.8	191	177.3	208.4	259.5	80.5	39.5	31	0	0	1101.4	91.7833
2008	0	0	0	0	136.5	348.8	167.4	302.6	192.4	88.9	12.7	0	1249.3	104.108
2009	0	0	41.1	43.3	114.3	109	280.9	235.6	65.4	42.38	0	0	931.98	77.665
2010	0	0	0	415.3	179.9	311	126.7	75.9	148.5	36.1	0	0	1293.4	107.783
2011	16.5	20.2	48.2	42.1	93.5	142.1	115.2	155.8	142.9	103.1	5	5	889.6	74.1333
2012	6.4	3.3	2.8	159.2	123.5	479.1	208.3	196.9	148.5	34.8	0	0	1362.8	113.567
2013	0	9.7	15.7	82.9	280.2	164.4	205.5	29.7	126.5	151.8	0	0	1066.4	88.8667
2014	5	20	6.9	16.2	199.4	332.6							580.1	48.3417

Source: Raingauge Station, Water Resource department, Chandmari

Based on the above two tables the spatial differences of monthly and mean rainfall at two separate stations of Borjhar and Chandmari are prepared in a series of Figures (Fig 4.1 to Fig 4.7 for monthly and Fig: 5 for annual) as indicated below. It has highlighted the differences of rainfall pattern from core to periphery of the metro (monthly and mean in mm)

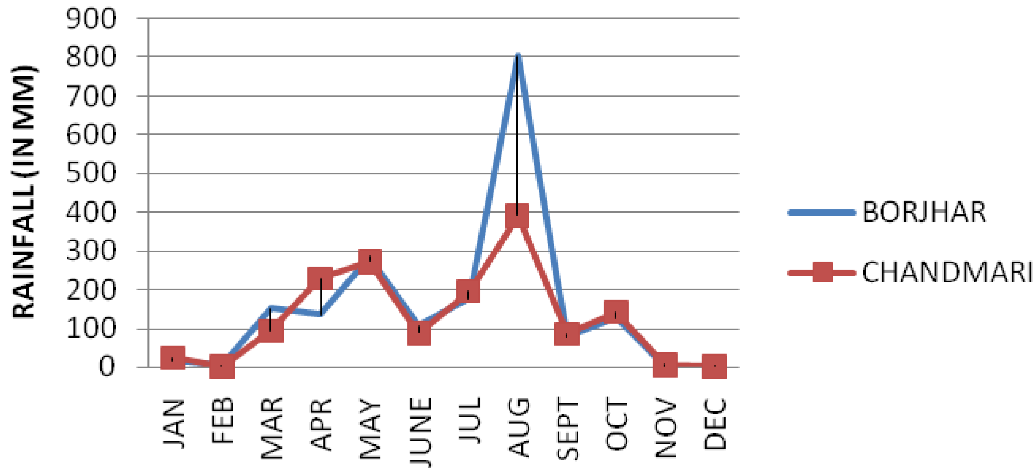


Figure 4.1. Total Rainfall Comparison, Kamrup Metro, 2005

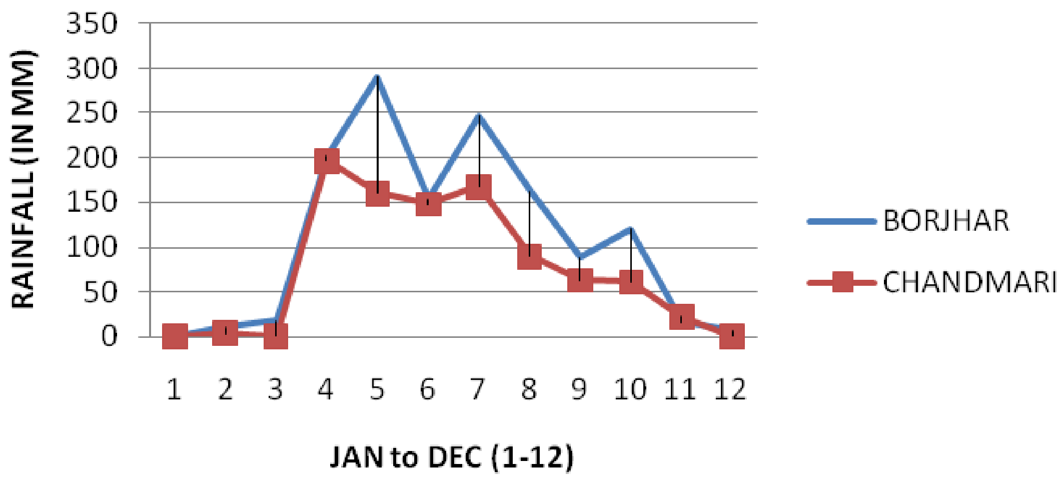


Figure 4.2. Total Rainfall Comparison, Kamrup Metro, 2006

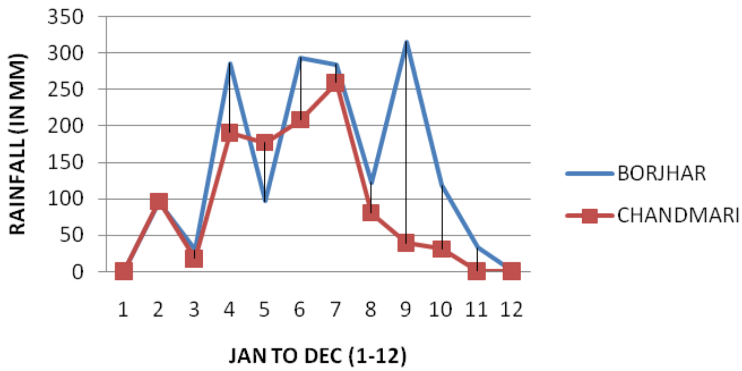


Figure 4.3. Total Rainfall Comparison, Kamrup Metro,

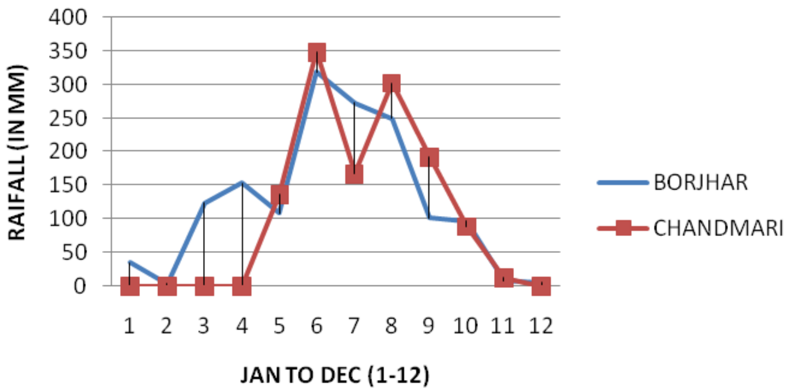


Figure 4.4. Total Rainfall Comparison, Kamrup Metro, 2008

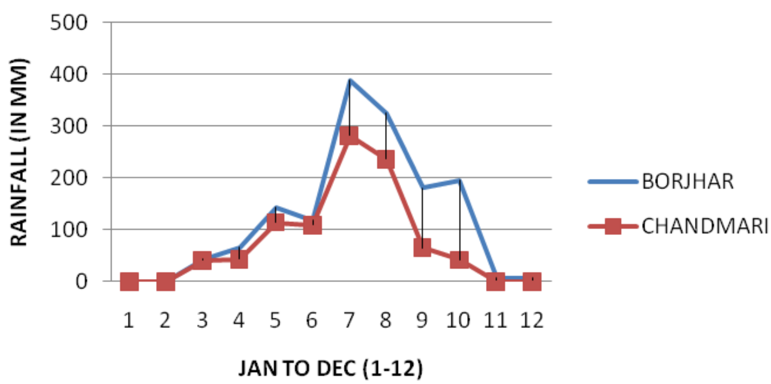


Figure 4.5. Total Rainfall Comparison, 2009

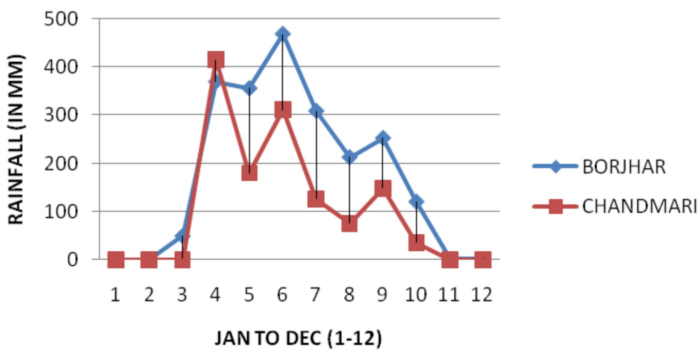


Figure 4.6. Total Rainfall Comparison, Kamrup Metro, 2010

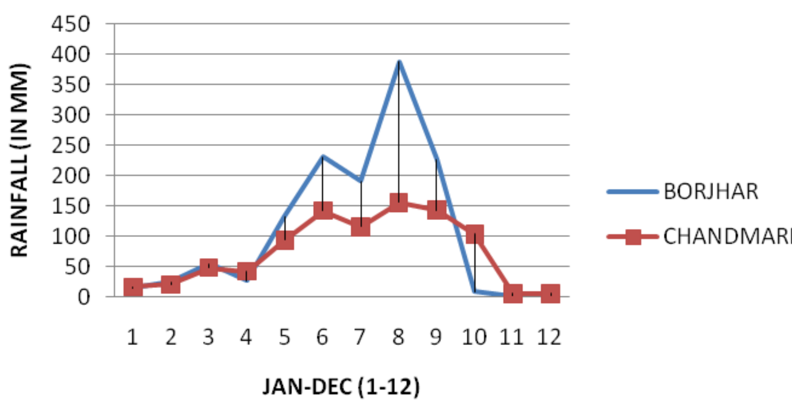


Figure 4.7. Total Rainfall Comparison, Kamrup Metro, 2011

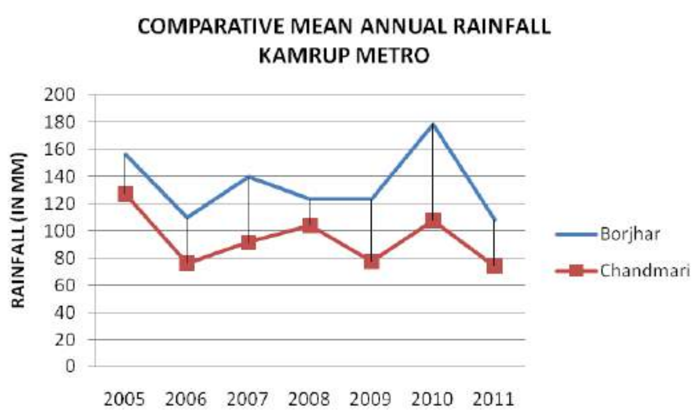


Figure 5. Comparative Mean Annual Rainfall (in mm), Borjhar & Chandmari Station

Community Based Hazard Calendar:

The community based hazard calendar is prepared during field study of selected flood vulnerable villages from two circles of Sonapur and Chandrapur and few urban locations frequently inundated by urban flash flood. All together 9 villages and 6 urban locations are selected for the purpose to assess the community response regarding months of hazard occurrence during the 5 months period of monsoon (May to September), which is summarised in table: 4 (rural) and 5 (urban) and supported by their graphical trend in Fig: 6 and 7 respectively.

Table 4. Community based rural hazard Calendar

	(% of respondent)				
VILLAGES	**May**	**June**	**July**	**August**	**September**
RAJABARI	9.8	39.4	45.9	4.9	0
TATIMARA	0	11.1	61.1	22.2	5.6
UTTAR DIMORIA	14.3	21.4	64.3	0	0
KOLONGPARA	0	22.2	77.8	0	0
KASUTALI	0	17.6	82.4	0	0
DURUNG	5.9	29.4	58.8	5.9	0
MURKATA	5.7	28.6	57.1	8.6	0
AMARAPATHAR	8.7	21.7	65.3	4.3	0
SONAPURPATHAR	7.1	28.6	64.3	0	0

(Field observation of first 2 villages is from Chandrapur and the rest of 7 villages from Sonapur Circle)

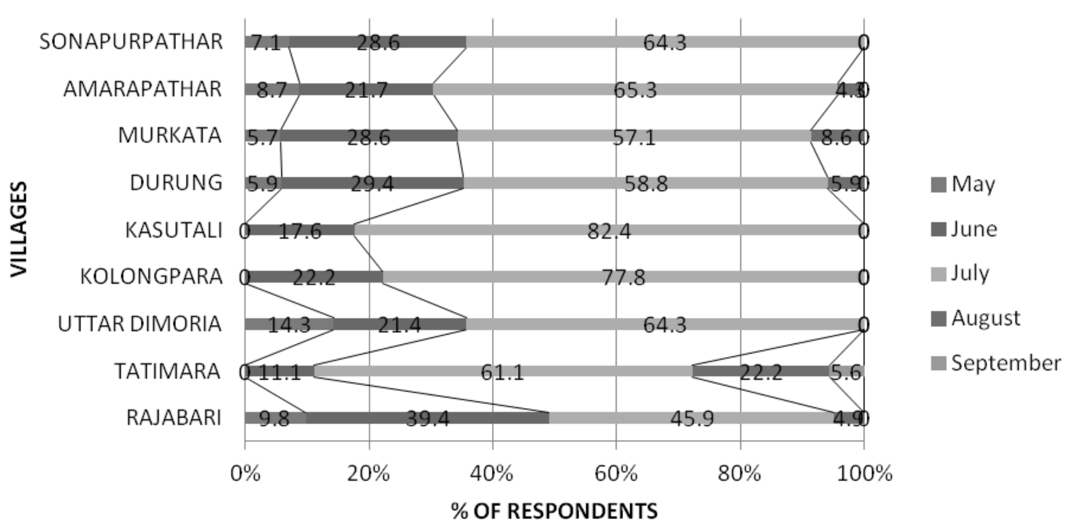


Figure 6. Rural Community Based Hazard Calendar, Kamrup Metro, Assam

Table 5. Community based urban hazard Calendar

(% of respondent)					
Urban locations	May	June	July	August	September
PUB-SARANIA	2.3	2.3	62.8	30.3	2.3
RAJGARH	0	30.4	43.5	17.4	8.7
ZOO ROAD (NABIN NAGAR)	5	5	55	25	10
JONALI	13.8	24.1	34.5	20.7	6.9
BHASKAR-NAGAR	19.4	27.8	30.6	16.7	5.5
SUNDARPUR	24.4	24.4	29.3	17	4.9

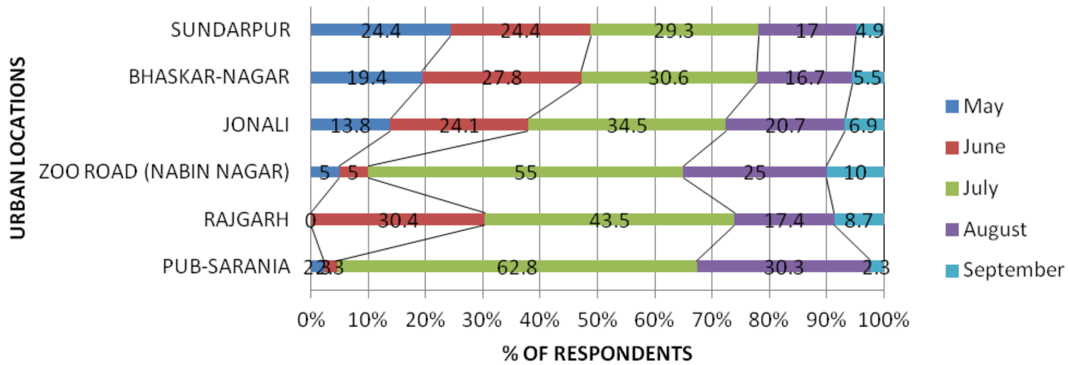


Figure 7. Urban Community Based Hazard Calendar, Kamrup Metro, Assam

CONCLUSION

In flood risk management, flood vulnerability assessment is a vital component. Its quantitative analysis require scientific study of many of the underlying component of physical, climatic, demographic and socio-economic background, which directly or indirectly affect the vulnerability status. This paper is an attempt to highlight the issue of vulnerability, in terms of geographical location, covering both urban and rural scenario of a district. The thrust of the paper is to visualise the general trend of a single component of seasonal rainfall of the study area and how it is related with the hazard calendar prepared from community response.

Certain observations have been made from the thrust of the study as follows:

* Flood vulnerability is a study of level of hazard exposure, which is location specific. Out of six revenue circles of the district, affected villages are mostly confined to two circles of Chandrapur and Sonapur.

* 30 years average trend of rainfall and rainy days (1951-80) of the study area have clear indication of their increasing trend during the monsoon season (May-to-September), which is highest in July in both cases (353.6 mm and 16.8 days respectively).

* Monthly and mean annual rainfall of the study area have indicated greater records at the outskirt of the city (IMD, Borjhar Airport) than at the city core (Chandmari Water Resource Department). More observatories at micro level is required to get better rainfall picture for

pre-hazard preparedness.

* Community Based Hazard Calendar have shown maximum of respondents in the month of July in both rural and urban cases of the study area. The urban calendar have more spread-out % of respondents of the season, while the rural calendar is mostly confined to the month of July. It is indicative of hazard awareness of the community.

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