ADOPTING EARLY WARNING SYSTEM TO ADDRESS FLASH FLOOD IN THE DEEPLY FLOODED *HAOR* (WETLAND) BASIN IN NORTH-EAST BANGLADESH

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CENTER FOR NATURAL RESOURCES STUDIES (CNRS)

CNRS

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Background Information

- The greater *haor* basin in the northeastern part of the country covering vast area is a flash flood zone;

- A flood, which is caused by heavy or excessive rainfall in a short period of time over a relatively small upstream area, is referred to as flash flood;

- The flood is an annual recurrent problem causing huge loss in financial terms that makes us vulnerable to poverty;

- The extreme flashy character of the hilly rivers and sudden excessive rainfall in the region causes frequent flash floods;

- In the *haor* areas, flash flood comes from the very steep uplands in Meghalayan hills causing immense damage to the standing crops and properties;

(contd.)

Background Information

- In flash flood, water level rises and falls quite rapidly with little or no advance warning;

- Typically, flash flood occurs in areas where the upstream basin topography is relatively steep and the concentration time of the basin is relatively short;

- Bangladesh is considered to be a country miserably affected by recurring floods with devastating dimensions exposing the national economy to the vagaries of nature;

- Complete flood control in the geographical context, particularly in the deltaic form of Bangladesh is not at all a feasible option;

(contd...)

Background Information

- Structural methods of flood protection are neither economically viable nor these are environmentally friendly;

- Therefore, non-structural methods are becoming popular in mitigating flood disaster;

- Non-structural methods of mitigation of flood hazards are very cost effective compared to structural ones (e.g. dams, dikes);

- Among non-structural methods, modern flood forecasting and the use of the real-time data collection systems have increasingly been favored by countries prone to flood events;

(Contd…)

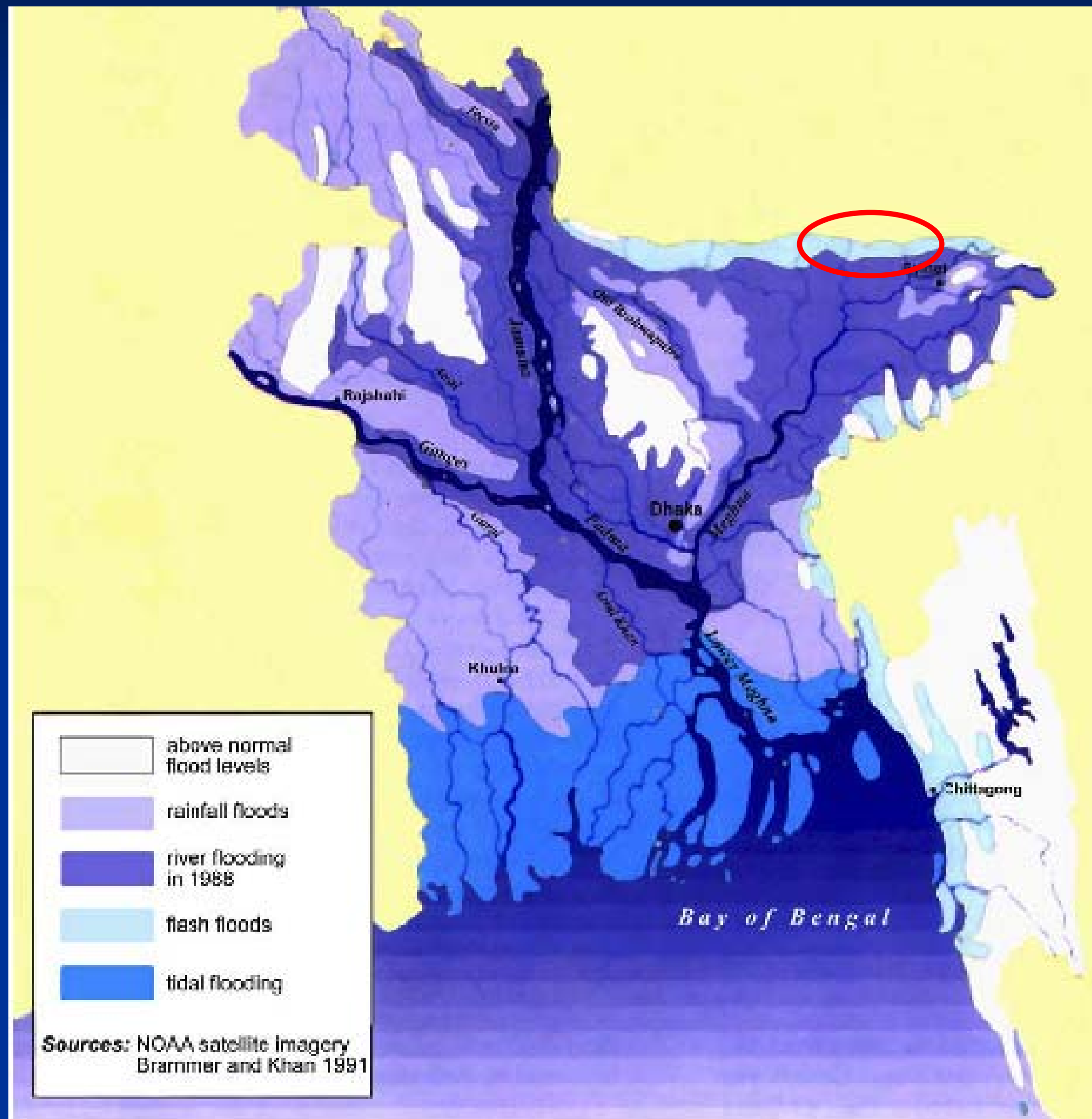
Background Information

- The processes leading to risk has varied territorial circumscription and those do not necessarily coincide with the areas in which risk is expressed or experienced;

- The diffuse and disperse territorial base of risk causation signifies that intervention in favor of risk reduction can not be restricted to the areas where risk is manifested;

- Sometimes this becomes a cross boundary issue demanding a more political solution than that of technological advancements.

Flood Types in Bangladesh



Objectives of the Study

The objective of the people-centered flood early warning systems is to

- develop a early warning model to forecast and empower individuals and communities threatened by the hazards, especially flash flooding; and

- to act in sufficient time and in an appropriate manner to reduce the possibility of crop loss, loss to livelihoods, and damage to property and environment.

Scope and Delimitations of the Study

Varied geo-hydrologic factors involved in the occurrence of flash flooding including

- rainfall - runoff relationship;
- excess saturation of the groundwater storage capacity and evapotranspirative demand;
- Upstream river catchments size, main stream length, and sedimentation load; and
- slope and the bifurcation ratio of the first order stream network to its second order ones, amongst others.

Availability of regular geo-hydrological data is in question. No bilateral agreement exists. Moreover, subject catchments do not have sufficient upstream monitoring points to generate above information regularly.

Scope of EWS in the Government System

Early Flood Warning System is recognized by the government as the National Water Policy states,

"……through its responsible agencies, the Government will develop early warning and flood proofing systems to manage natural disasters like flood and drought….."

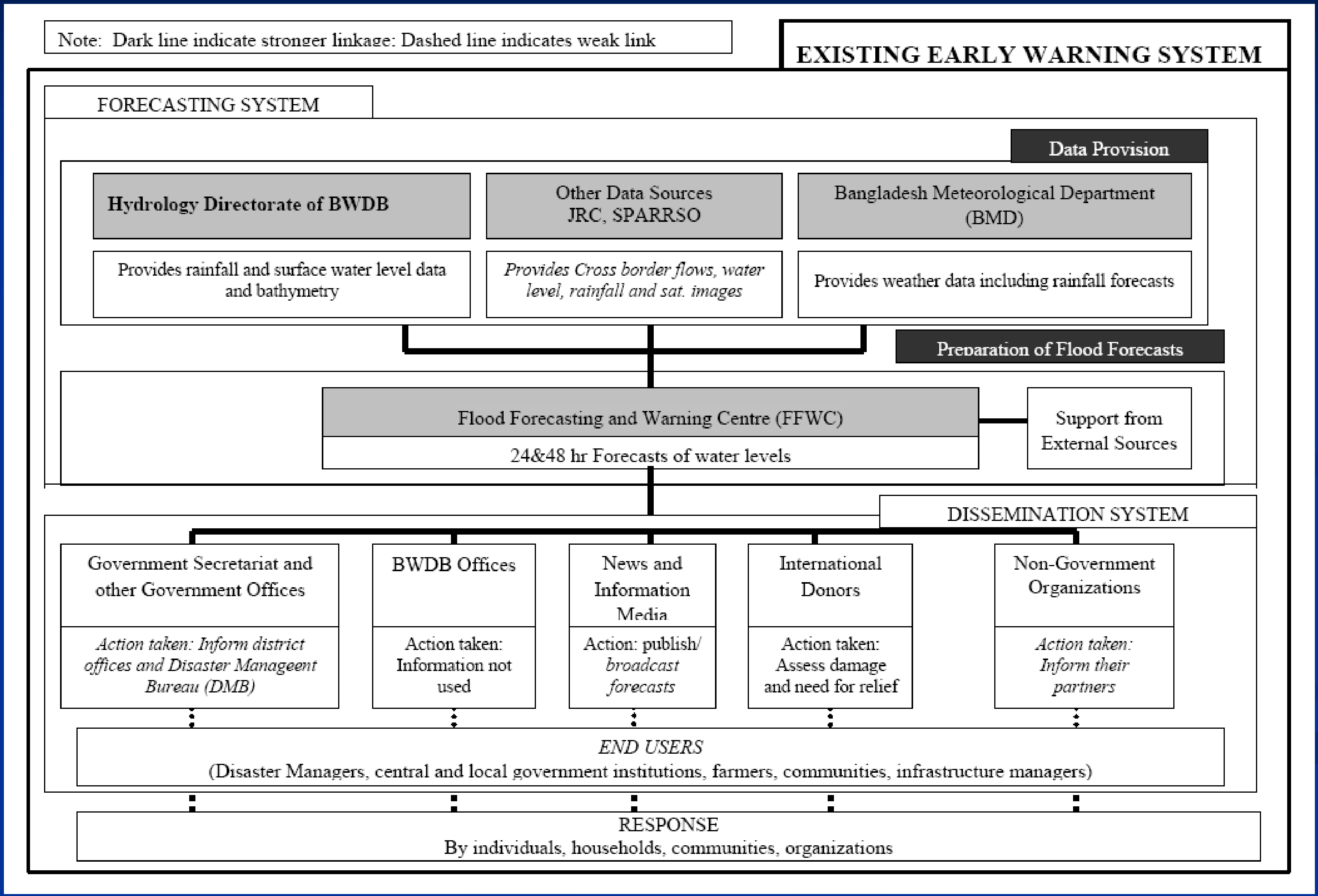
Elements of Early Warning System

Forecasting comprises of data provision and preparation of flood forecasts and warnings.

Dissemination is the process that relays the forecast and warning information to end-users.

Response to warnings requires that the agencies and communities at risk understand and are confident in the forecast and warning information and that they have options to take action to mitigate the impact of floods.

Existing Early Warning System



Systems Evaluation and Suggestions

Technology & Tools

- Improving the upstream boundary condition requires the installation of automatic water and rainfall monitoring stations
- Lead time preferences can be improved significantly with addition of data from weather models and also from river basin models

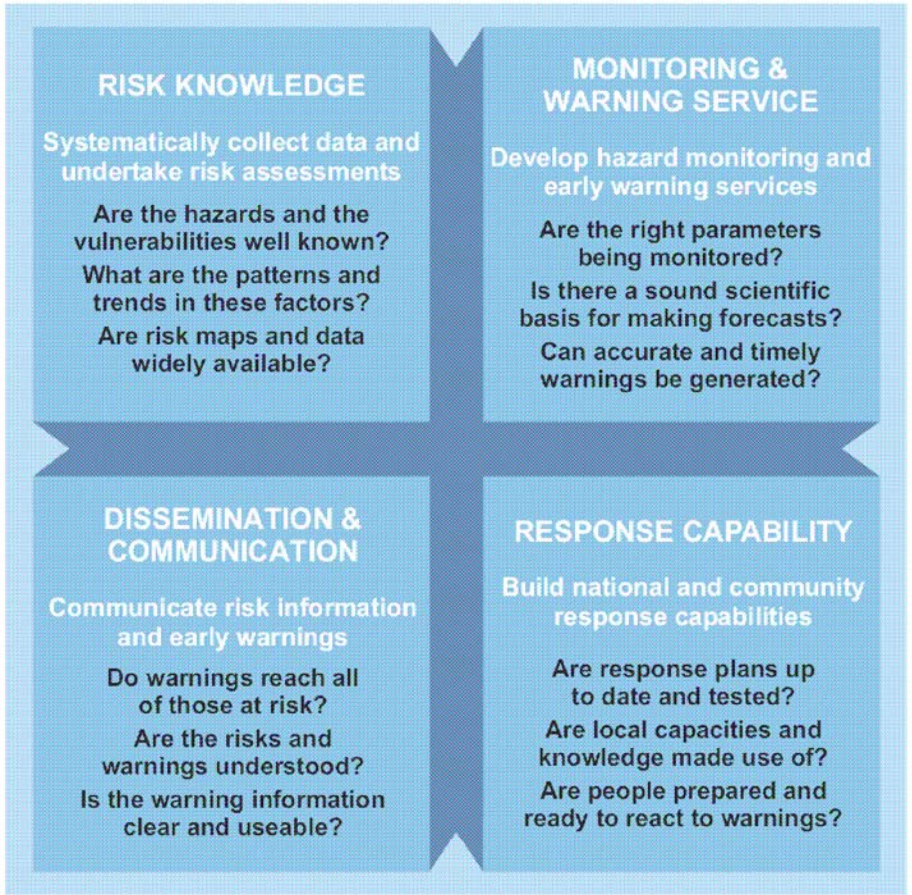
Dissemination

- Lead-time needs to be extended so that forecasts become more useful to the decision makers end users
- Warning messages should be easily understood by end users and preparedness & contingency planning should be promoted

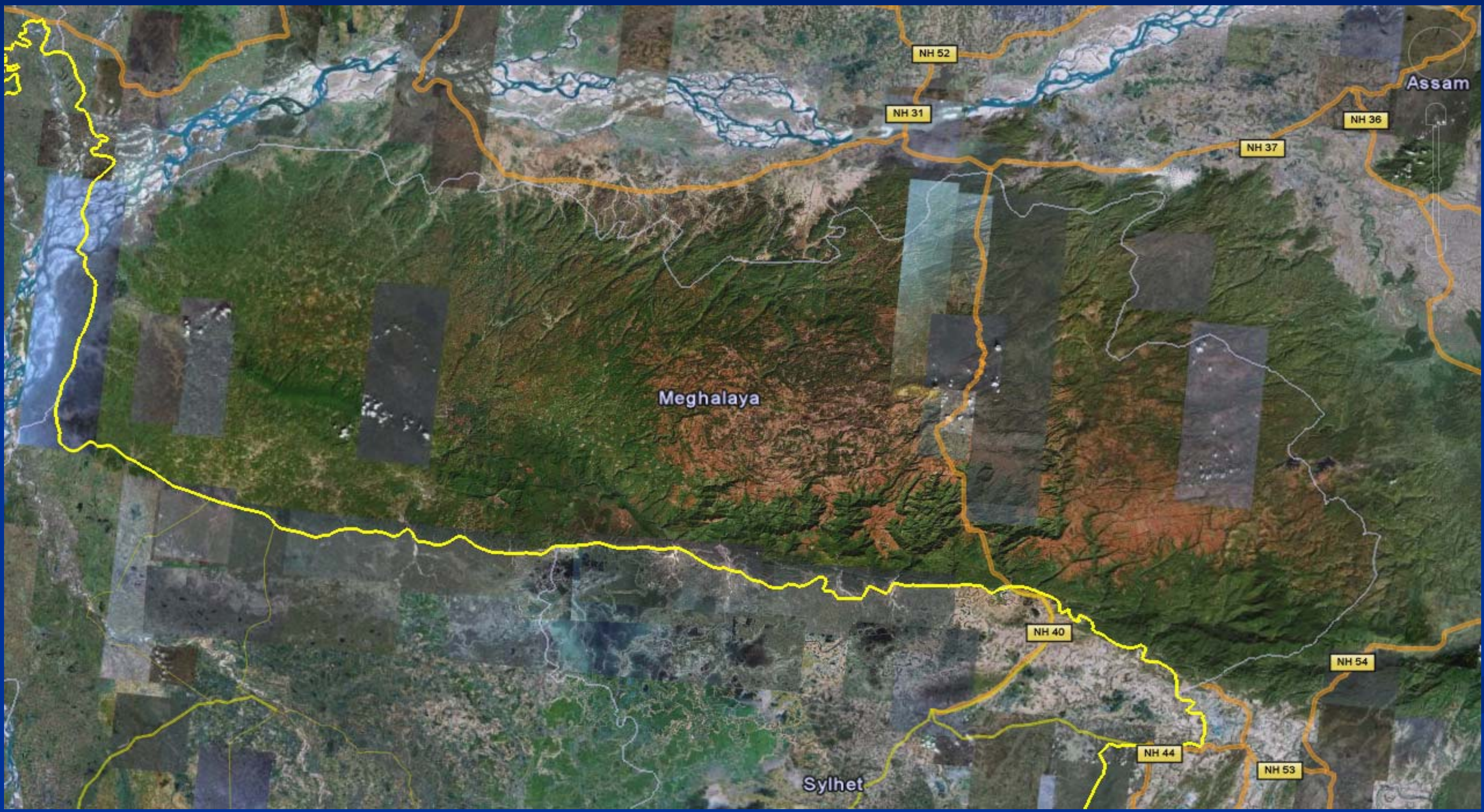
Institutional and Legal

- Lack of clarity about roles & responsibilities of Govt. staffs during floods
- DMB is set up to respond to disasters once they happen rather than to promote disaster awareness
- Mechanism for continuous monitoring and routine feedback should be established for the forecasting and warning system

Guidelines of People Centered Early Warning System



Location of the Field Demonstration Sites



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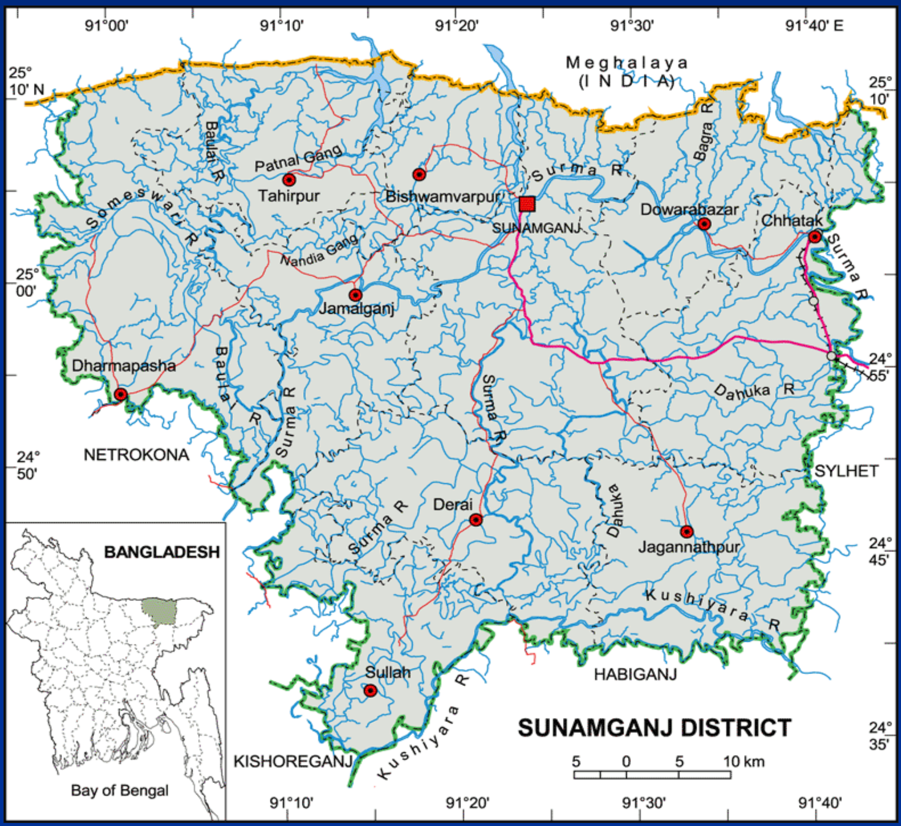
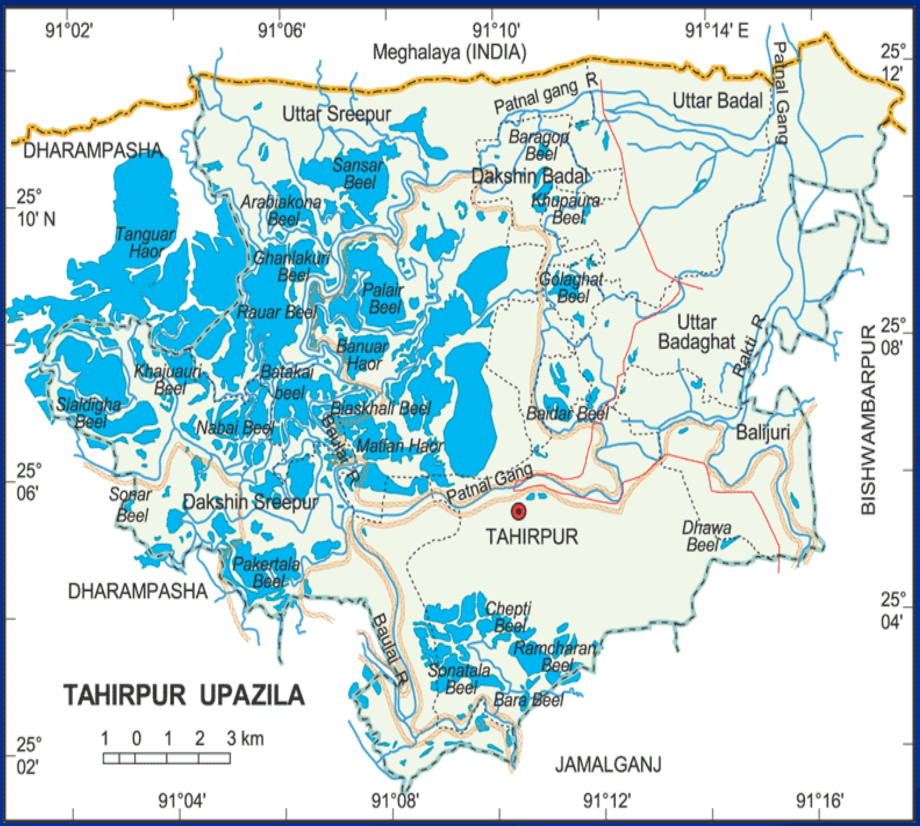


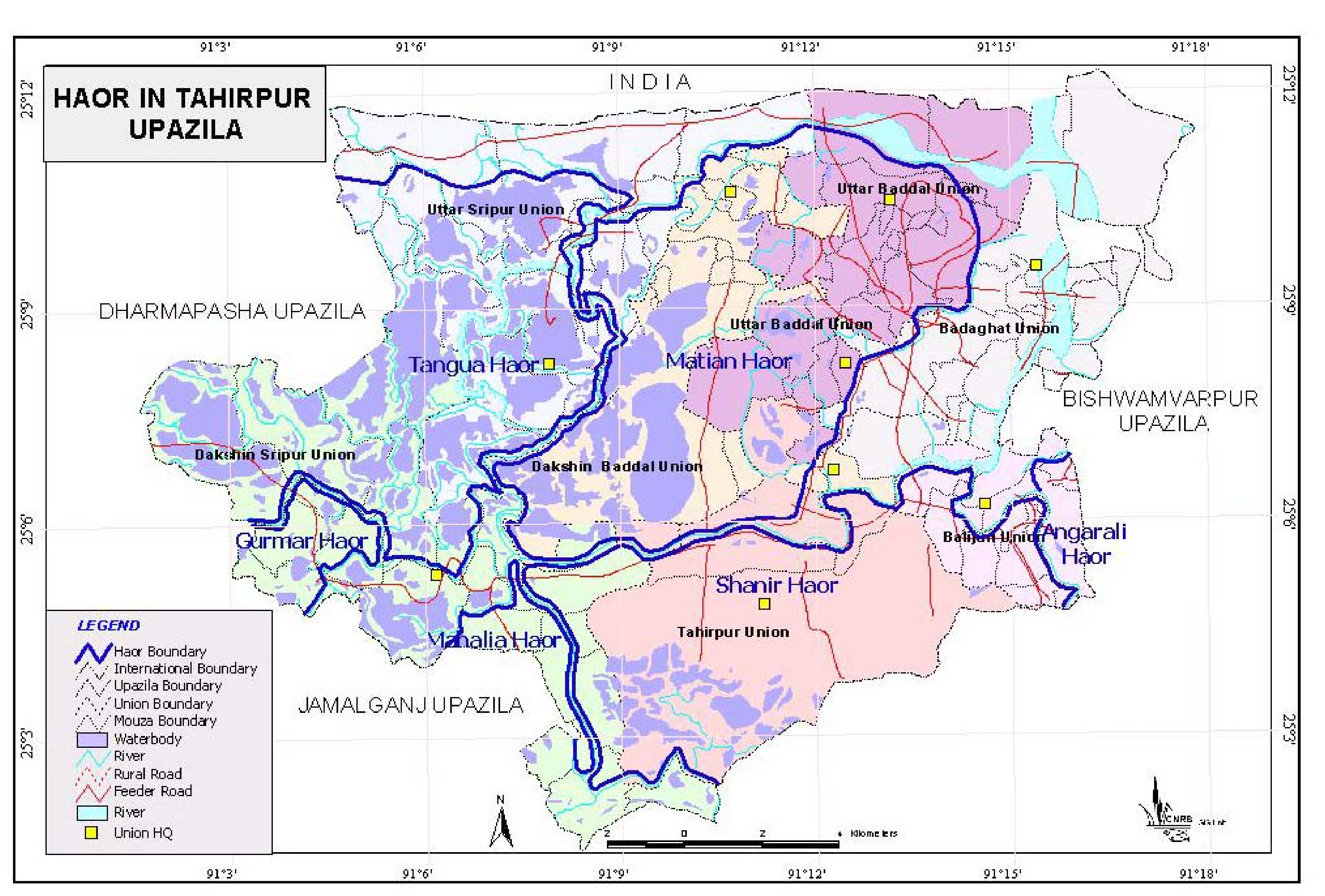


Location of the Upstream Catchments

Mean Annual Rainfall in and around Meghalaya

Sl. No.	Name of Station (Location)	Mean Annual Rainfall (mm)
1	Shillong (Central Meghalaya)	2,271
2	Dhubri (Lower Assam)	2,436
3	Lumding (Upper Assam)	1,161
4	Guwahati (Central Assam)	1,538
5	Silchar (South Assam)	3,018
6	Cherrapunjee (South Meghalaya)	11,131
7	Tura (Far West Meghalaya)	3,500
8	Williamnagar (West Meghalaya)	3,207
9	Nongstoin (Central West Meghalaya)	3,207
10	Baghmara (S-W Meghalaya)	3,698
11	Sylhet (N-E Bangladesh)	7,000
12	Mymensingh (North Bangladesh)	2,432
13	Tangail (Central Bangladesh)	1,440
14	Dhaka (Central Bangladesh)	1,400
N.B.	* Rainfall data based on 30 years normal (1960-1990) ** Projected through interpolation method for 5 years average (1987- 1991) *** Data based on 30 years mean of monsoon season (June - Sept) (1951 - 1980)	
Source:	Climatic Tables Part - I, Indian Meteorological Department (IMD), Pune District Research Laboratories of Different District Head Quarters Bangladesh Meteorological Department, Dhaka (BMD)	

Haors in Tahirpur Upazila



Factors Affecting the Occurrence of Flood

1. Duration of Rainstorms through Monsoon Season
2. Rainfall in Upper Catchments (observed and forecast)
3. Soil Water Holding Capacity and Excess Saturation
4. Soil Infiltration and Evapotranspirative Demand
5. Runoff Generation and Lag Time Preference
6. Water Level and Unit Discharge of Lowland Rivers
7. Local Rainfall and Channel Navigability
8. Crop Calendar and Status of Protection Infrastructures
9. Social and Territorial Aspects of Risk
10. Climate Change and Variability

Is This Flood or Inundation?

Cultivation Practice in Tahirpur Upazila

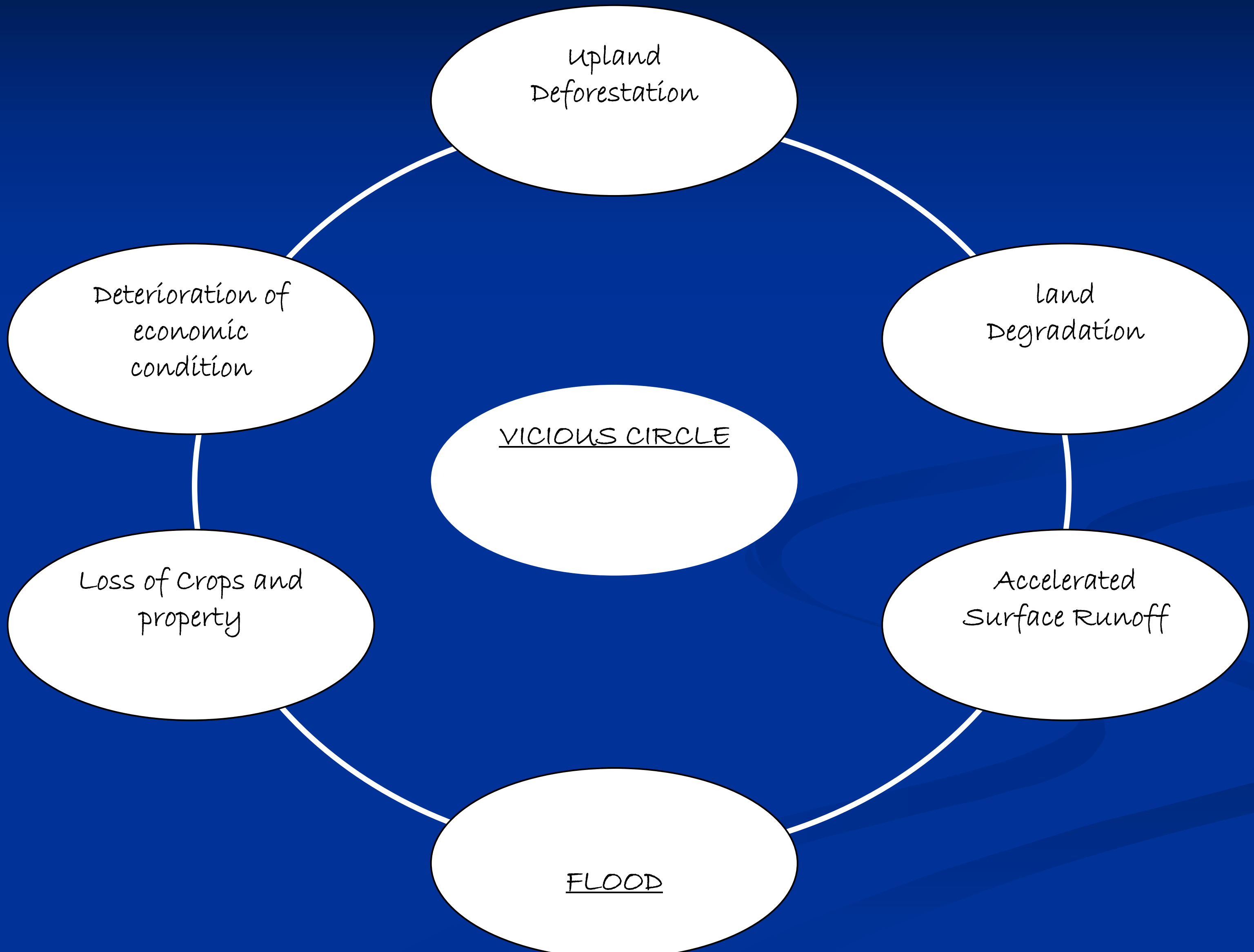
Cropping by Season			Land Area in hector	Percentage (%)
Boro/ Spring Harvest	*Kharip-1*	*Kharip-2*		
Boro	Fallow	Fallow	13,624.60	65.88
Boro/ Wheat	Fallow	T *Aman*	3,023.74	14.62
Mustard	Fallow	T *Aman*	1,1411.08	6.82
Nut	*Aush*	T *Aman*	604.74	2.92
Spices/ Vegetables	egetables	T *Aman*	203.16	0.98
Pulse	Fallow	T *Aman*	400.00	1.93
Mixed	Sugarcane	Sugarcane	400.00	1.93
Mustard/ Linseed	Jute	T *Aman*	406.32	1.96
Sweet potato	Fallow	T *Aman*	406.36	1.97
Vegetables/ Spices	Vegetables	Vegetables	200.00	0.97

Lead Time Preference to Save Different Assets

Assets	Days*		
	1 day	2 day	7 day
Structures			✓
House Contents		✓	
Outside Property			✓
Livestock		✓	
Agriculture			✓
Culture Fisheries			✓

* Indicates lead time required to save 70% or more of the asset.

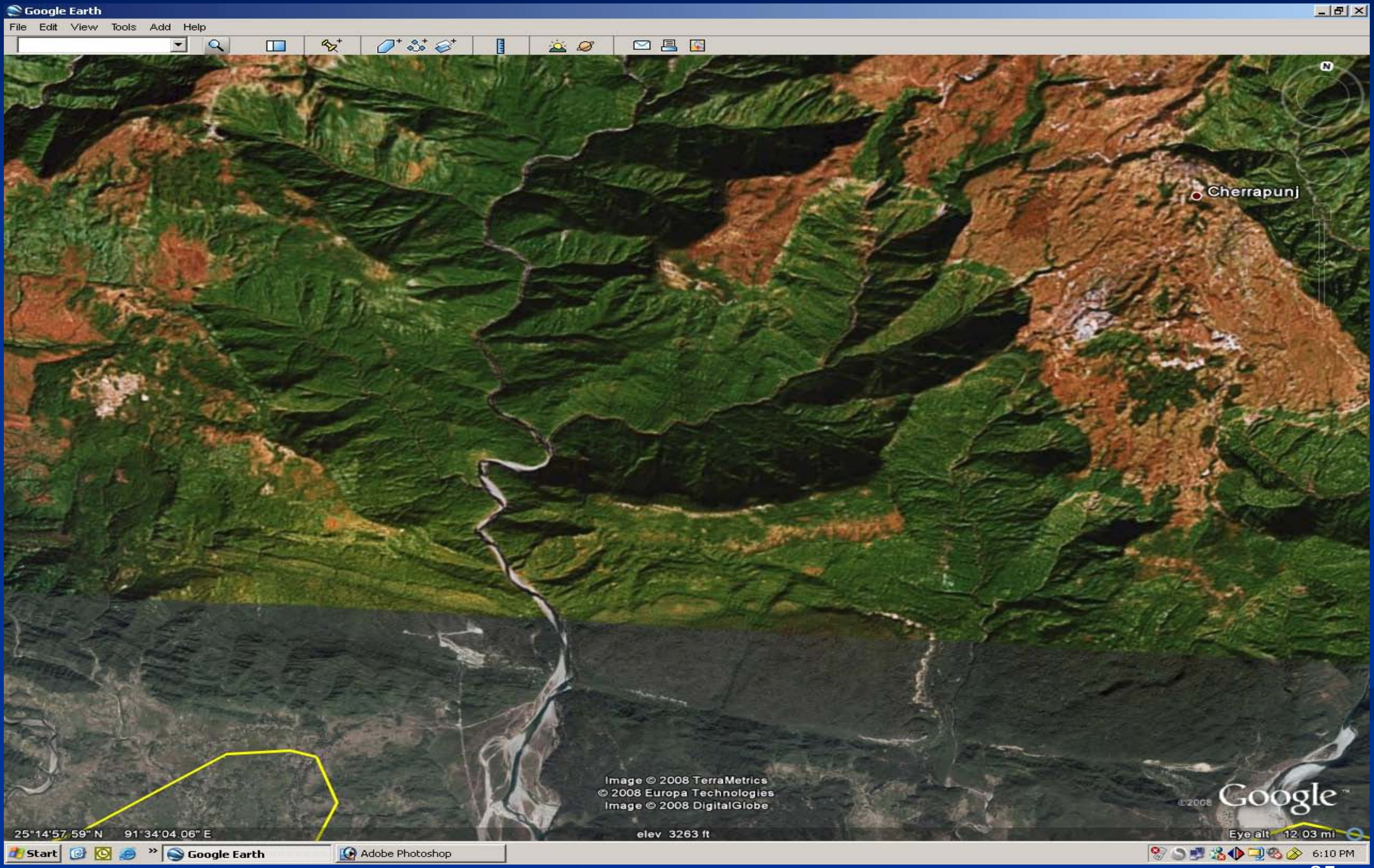
Deforestation and Flood - a General Model



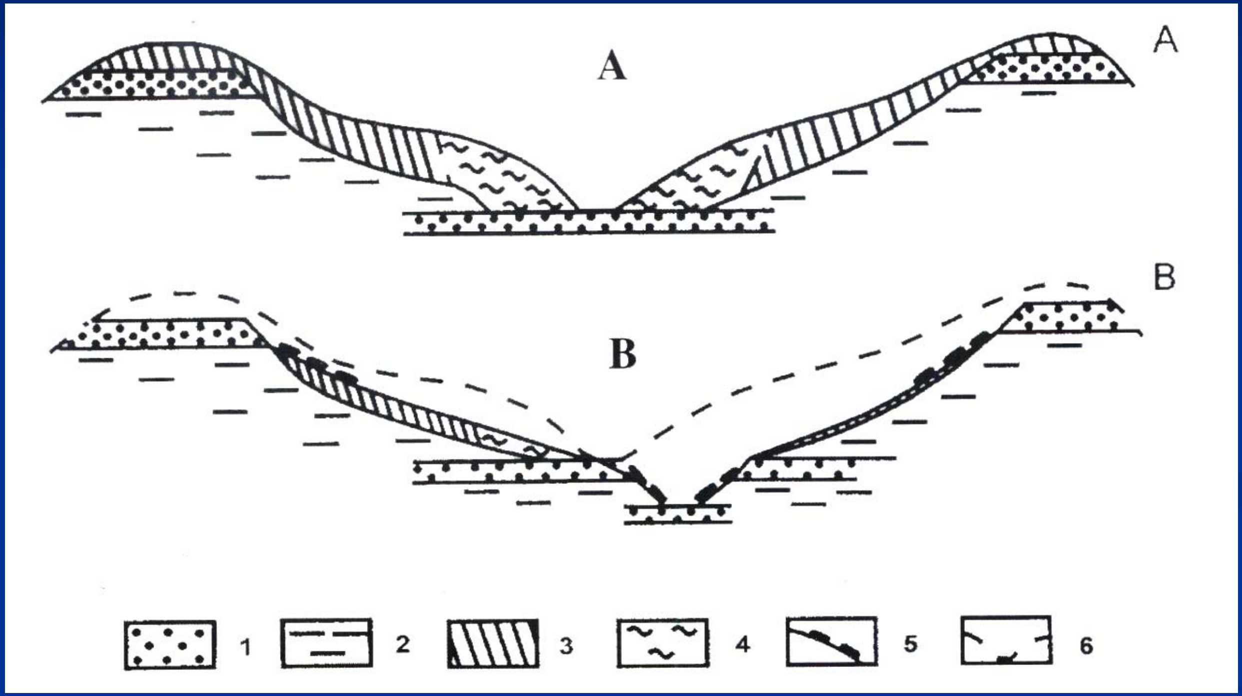
History of Flash Flooding in Sunamganj

Year	Flood water entered the *haor*	Inundating the *boro* crops	Extent of damage	Damaged *boro* crop in hector	Cost of damaged crops in Lac taka
1996	16 March	18 March	75%	29,822	4,102.07
1997	22 May	24 May	15%	9,830	1,278.84
1998	20 May	23 May	40%	11,579	2,365.02
1999	03 May	06 May	45%	10,950	976.65
2000	28 April	30 April	70%	1,355	420.14
2001	27 April	30 April	75%	4,963	1,899.95
2002	14 April	18 April	70 %	21,677	7,058.16
2003	27 May	30 May	20%	20,997	8,666.87
2004	13 April	15 April	90 %	95,402	34,860.40
2005	22 May	25 May	15%	-	-

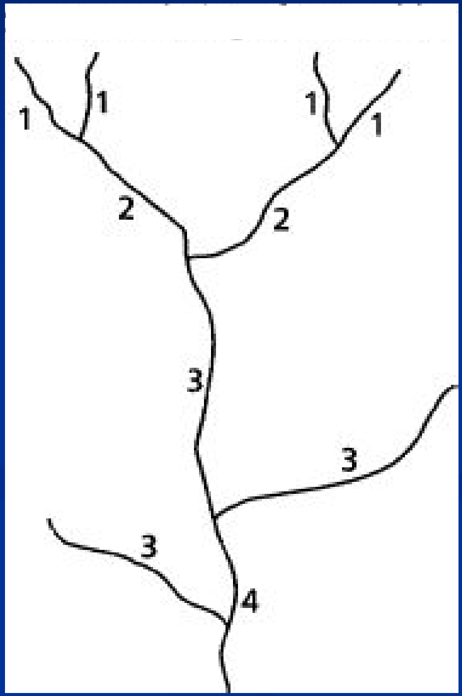
Soil Erosion in Cherrapunjee Catchment



Model of Evolution of a Small Valley

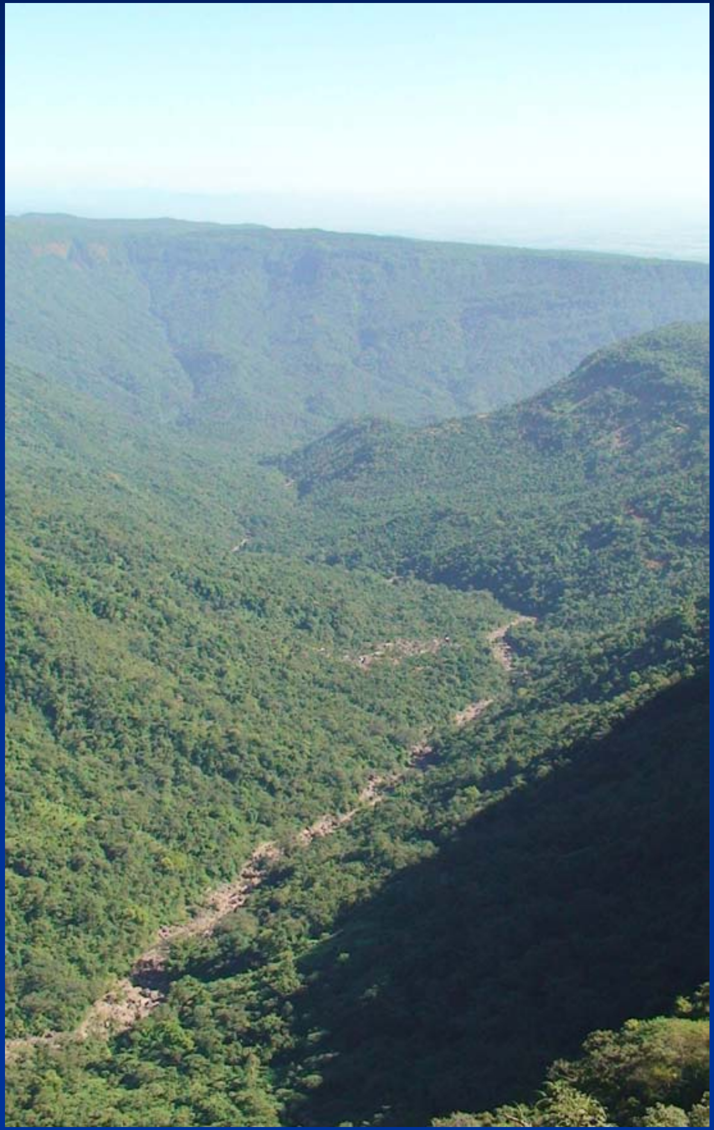


A - before deforestation, B - after deforestation
(1 - resistant sandstone beds, 2 - less resistant sandstones and shales, 3 - regolith of laterithic type, 4 - colluvial deposits (also deeply weathered), 5 - sliding sandstone blocks, 6 - former valleys transact)



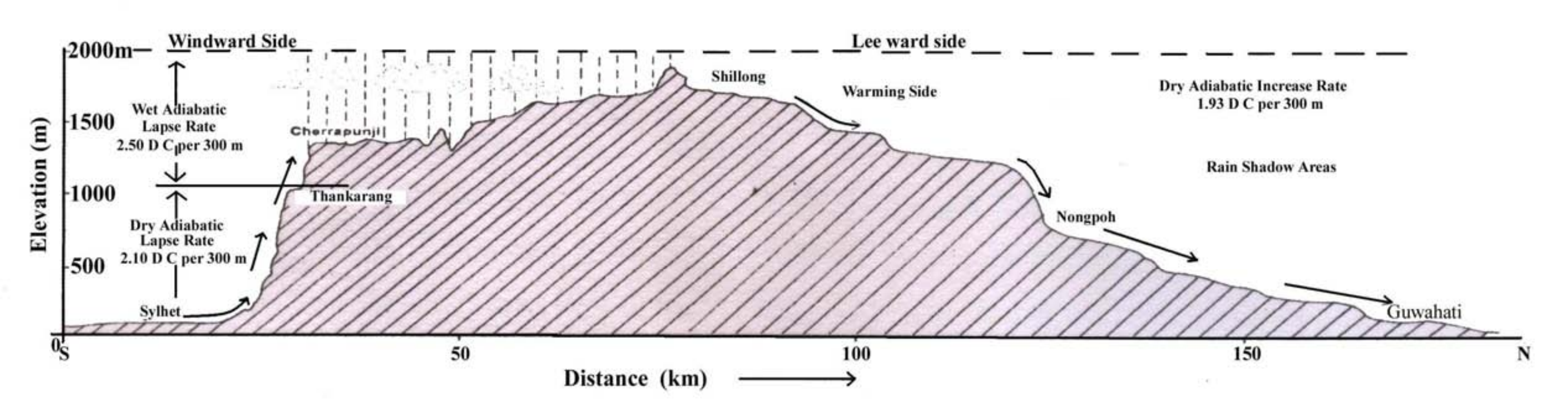
Stream Ordering

Model of Evolution of a Small Valley



Model of Evolution of a Small Valley

Geo-hydrological Characteristics of the Plateau



- The plateau represents the extremely high rainfall where deforestation and extensive land use practices have accelerated the process of water circulation leading to complete degradation of soils and vegetal cover.

- Bengal Plains at lower elevations receive less than 2500 mm rain annually, while Cherrapunjee and Mawsynram areas nearer the edge of the plateau get an average annual precipitation ranging from 8,000 to 24,000 mm.

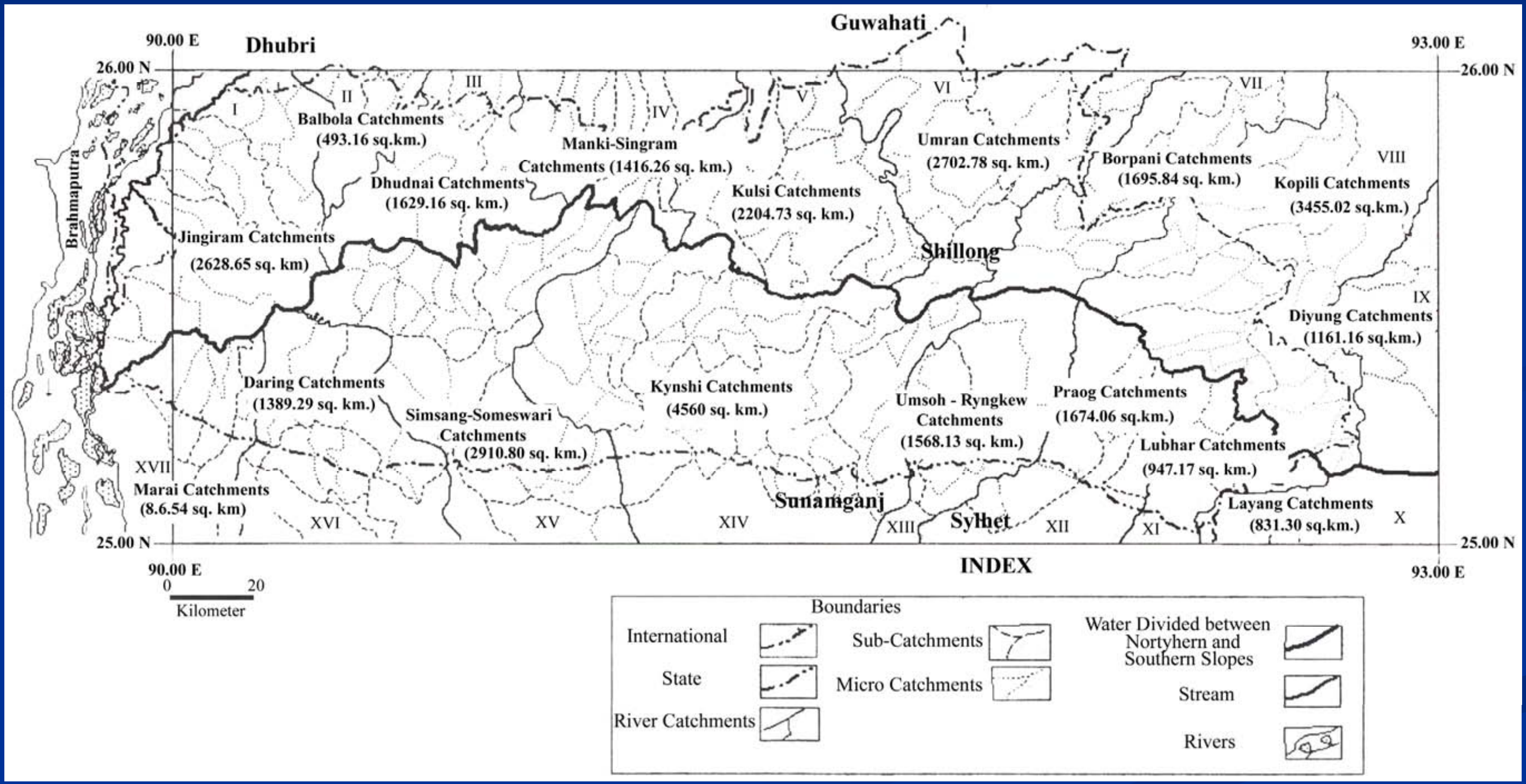
- The highest daily rainfall was recorded 1,563 mm on 16 June 1995 in Cherrapunjee, the other extremes are: 14 June 1876-1036 mm, 12 July 1910-998 m, 5 June 1956- 974 mm, 15 June 1995- 930 mm

Spatial Gradient of Mean Annual Rainfall

Places	Rainfall Differences (mm)	Linear Distance (km)	Spatial Gradient (mm/km)
Cherrapunjee – Shillong	8,860	40	221.50
Cherrapunjee – Sylhet	8,699	45	193.31
Cherrapunjee – Jowai	4,831	55	87.84
Cherrapunjee - Mawsynram	2,60	14	18.57
Mawsynram – Dhubri	8,984	180	49.91
Mawsynram – Tura	7,920	147	53.88
Mawsynram – Baghmara	4,420	91	48.57
Shillong – Guwahati	733	60	12.21

Spatial Gradient (Cherrapunjee - Sylhet)

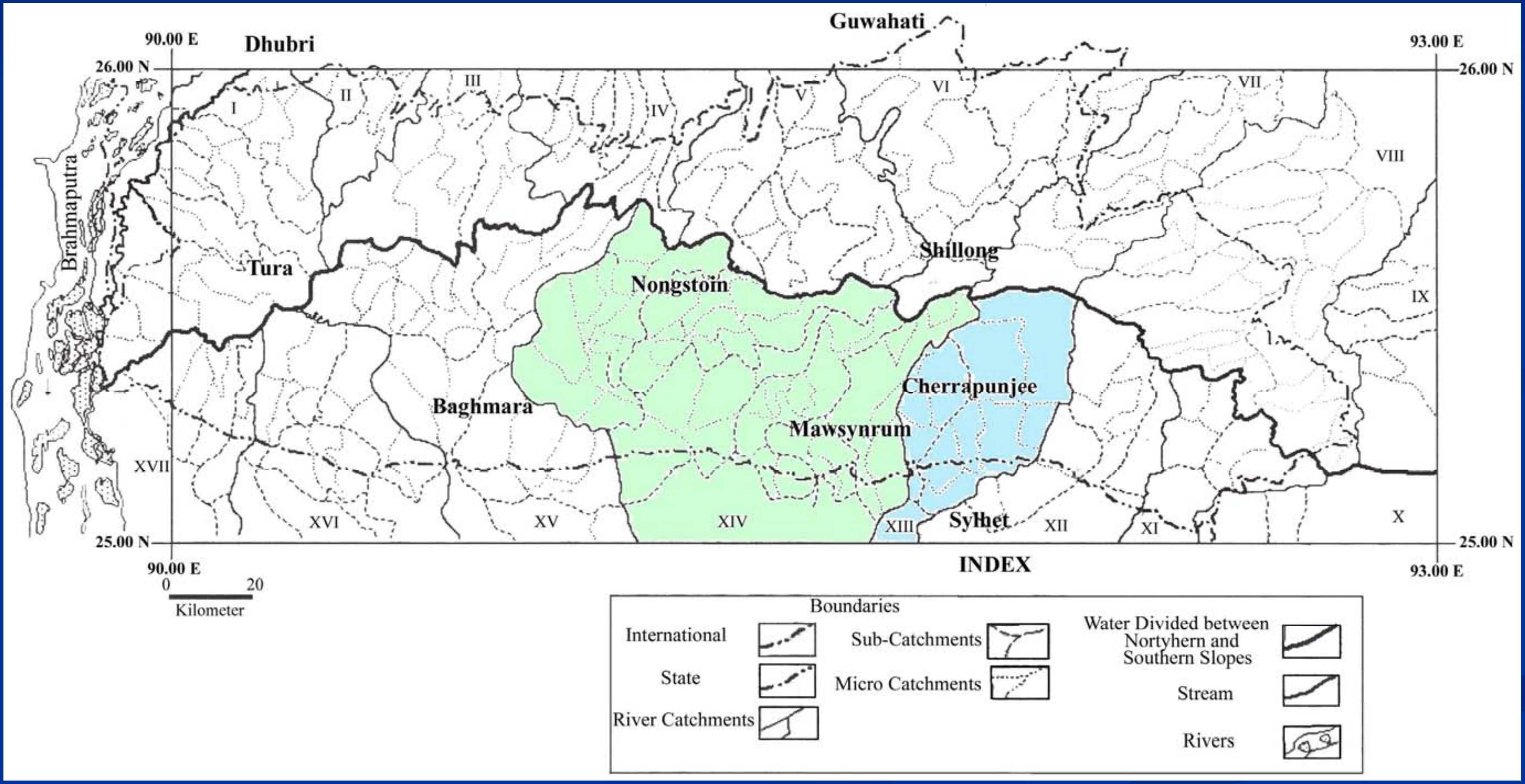
Identification of Geohydrological Units



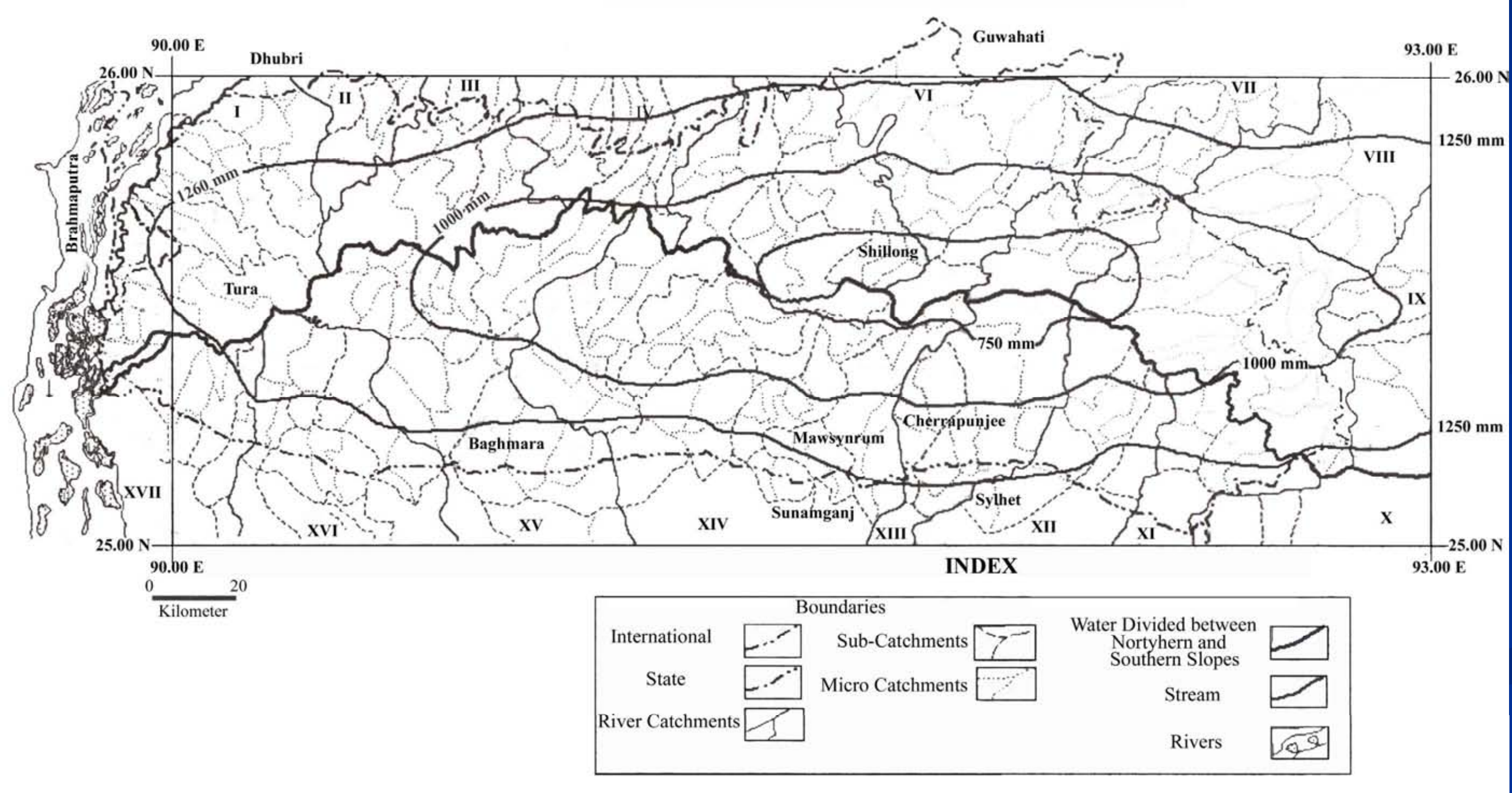
Ordering and Size of Geo-hydrological Units

Higher Order	Name of the Higher Order Catchments	Area (sq. km.)	Middle Order Catchment		Lower Order Watershed and Inter Catchments	
			Total No	Average Size (sq. km.)	T. No	Average Size (sq. km.)
I	Junjiram	2628.65	4	657.16	19	138.35
II	Balbola	493.16	2	246.58	5	98.63
III	Dhudnai	1629.16	2	814.58	8	203.64
IV	Manki-Singram	1416.26	4	354.06	13	108.94
V	Kulsi	2204.73	4	551.18	19	116.04
VI	Umran	2702.78	3	900.93	13	207.91
VII	Borpani	1695.84	3	565.28	13	130.45
VIII	Kopili	3455.02	5	691.00	26	132.88
IX	Diyung	1161.16	3	387.05	7	165.87
X	Layang	831.30	3	277.10	3	277.10
XI	Lubhar	947.17	2	473.58	7	135.31
XII	Praog	1674.06	3	558.02	8	209.26
XIII	Umsoh-Ryngkew	1568.13	2	784.06	9	174.23
XIV	Kynshi	4560.22	6	760.04	41	111.22
XV	Simsang-Someswari	2910.80	4	727.71	25	116.41
XVI	Daring	1389.29	3	463.09	12	115.77
XVII	Marai	806.54	2	403.27	7	115.22
Total		32,074.30	55	583.17	235	136.49

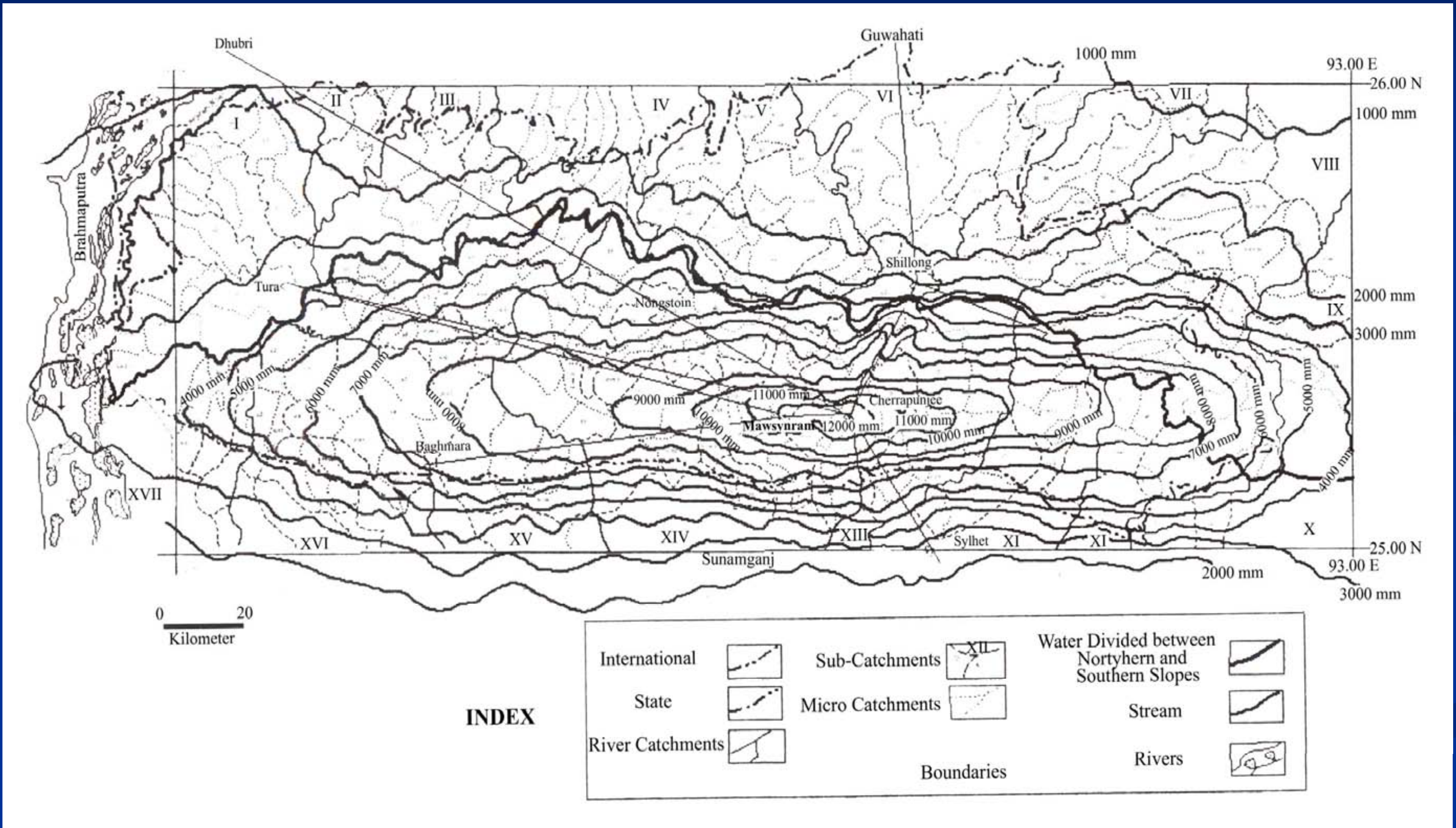
Meghalaya Plateau – Target Catchments



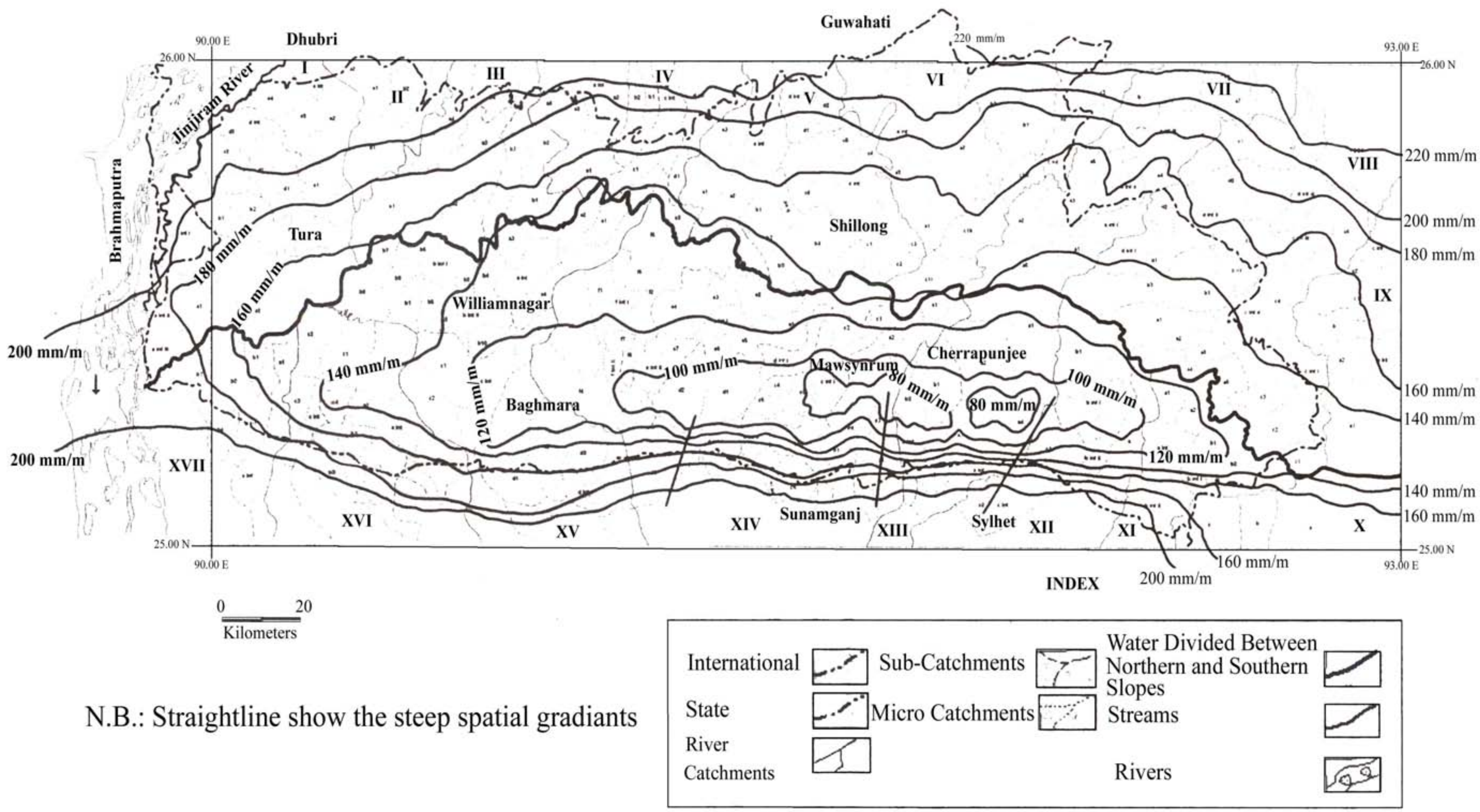
Meghalaya– Mean Annual Evapotranspiration



Meghalaya Plateau –Mean Annual Rainfall

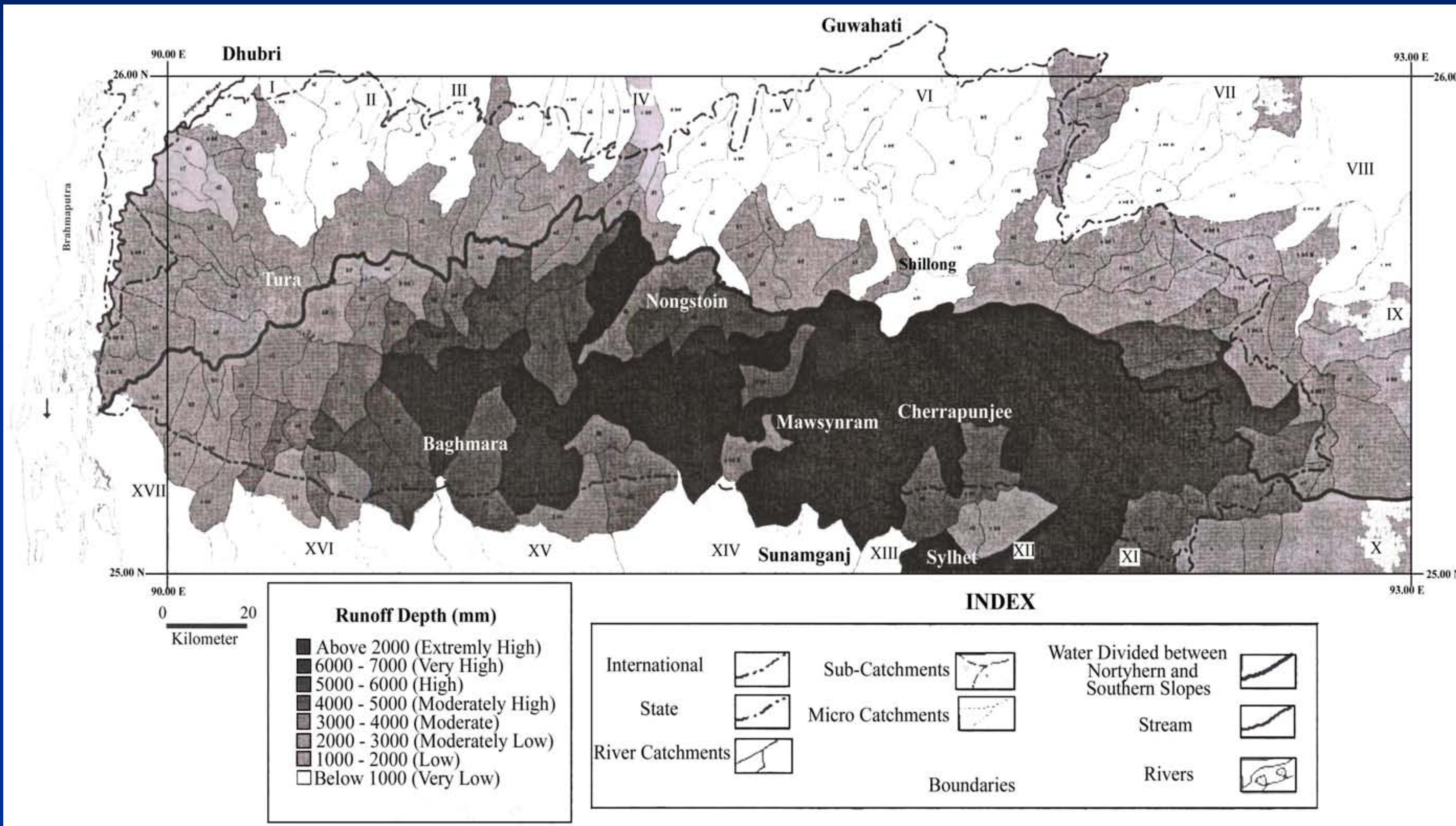


Meghalaya- Mean Annual Water Holding Capacity

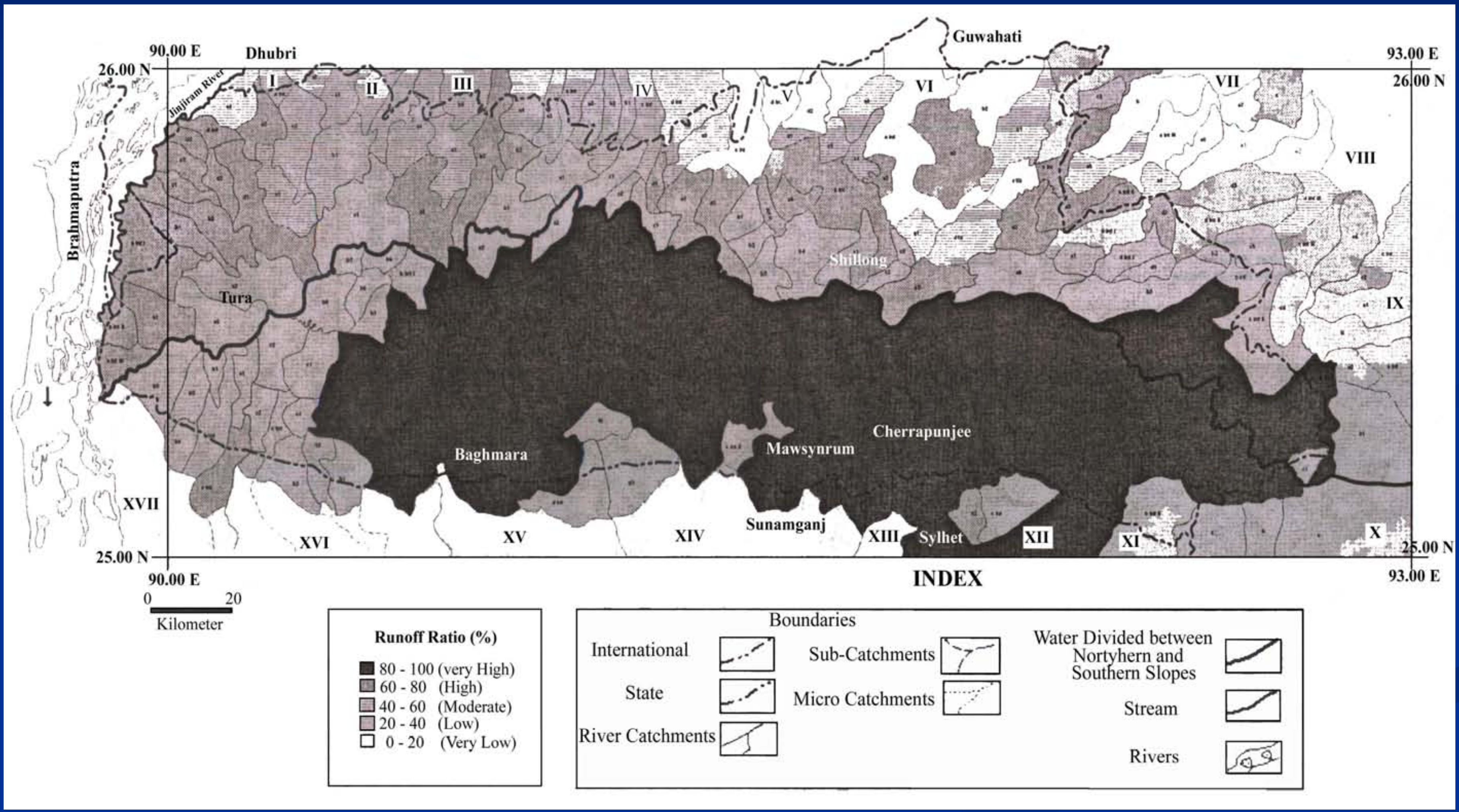


N.B.: Straightline show the steep spatial gradiants

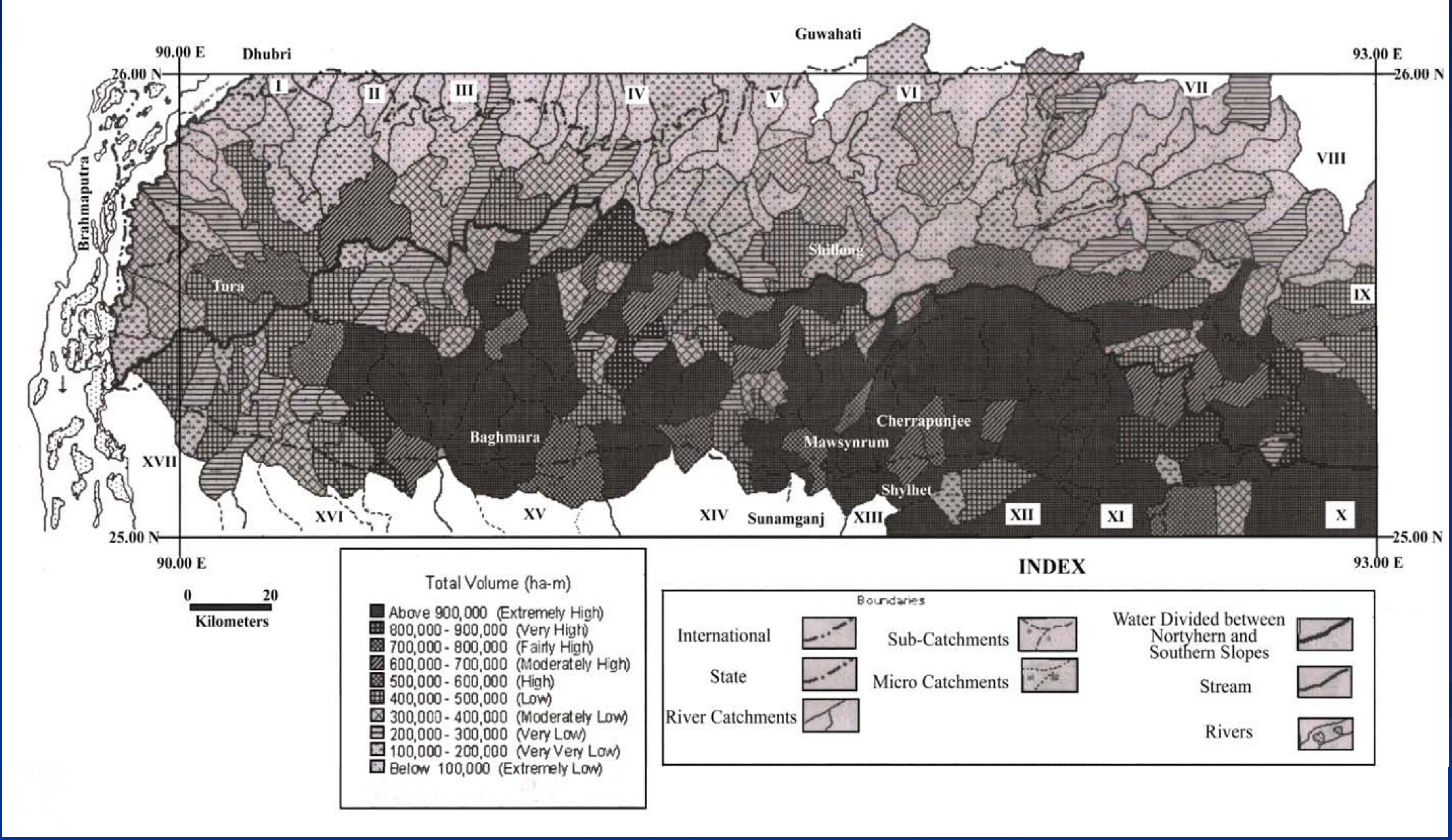
Meghalaya Plateau – Mean Annual Runoff Depth



Meghalaya Plateau – Mean Annual Runoff Ratio



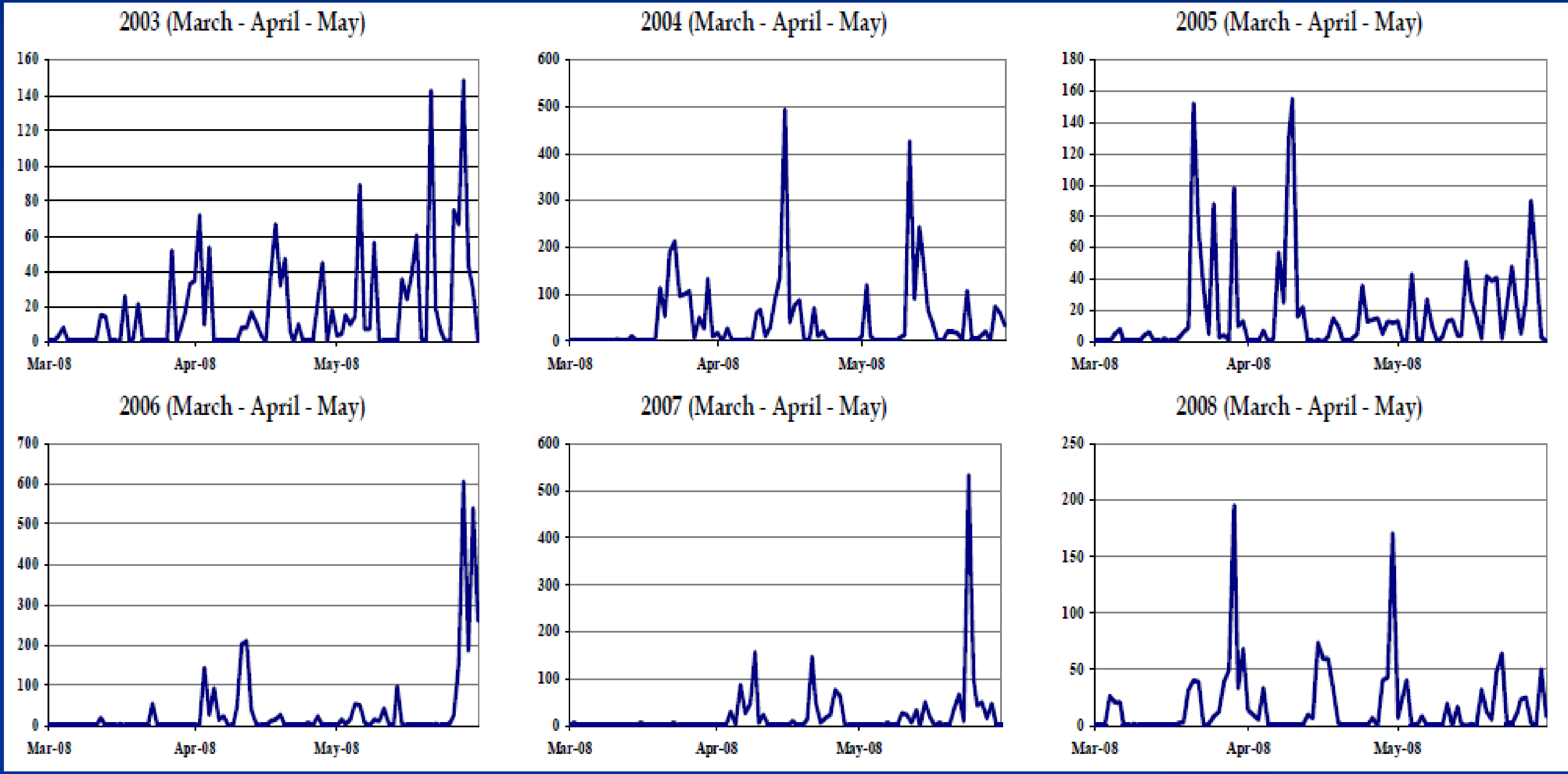
Meghalaya Plateau – Volume of Surface Runoff



Meghalaya Plateau – Volume of Surface Runoff

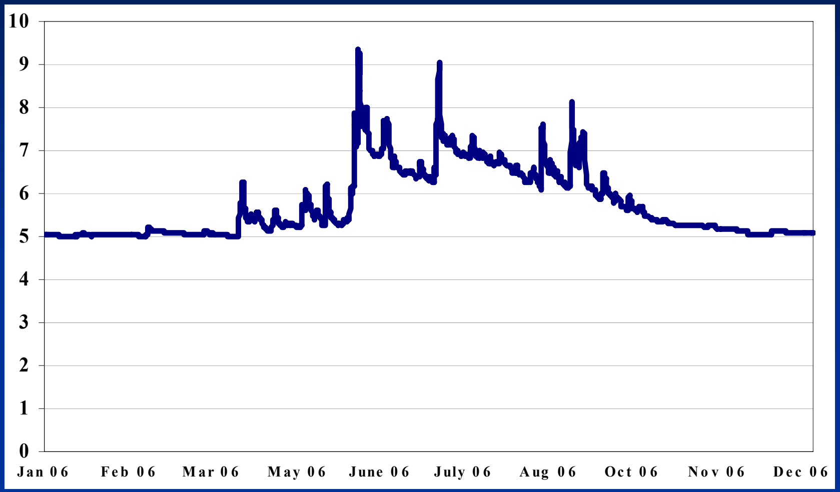
Year	Flood water entered the *haor*	Inundating the *boro* crops	Extent of damage in %	Last 3 days cumulative rainfall (mm)	Maximum Daily Rainfall (mm)	Maximum Daily Rainfall (mm)
1997	22 May	24 May	15%	600	22 May	449.4
1998	20 May	23 May	40%	738	23 May	390.4
1999	03 May	06 May	45%	818	4 May	560.6
2000	28 April	30 April	70%	867.9	30 April	686.6
2001	27 April	30 April	75%	600	22 April	449.4
2002	14 April	18 April	70 %	389.9	17 April	192.1
2003	27 May	30 May	20%	290.4	28 May	148.8
2004	13 April	15 April	90 %	716.5	14 April	492.2
2005	22 May	25 May	15%	94.5	24 May	48.5

Rainfall Records in Cherrapunjee Catchment

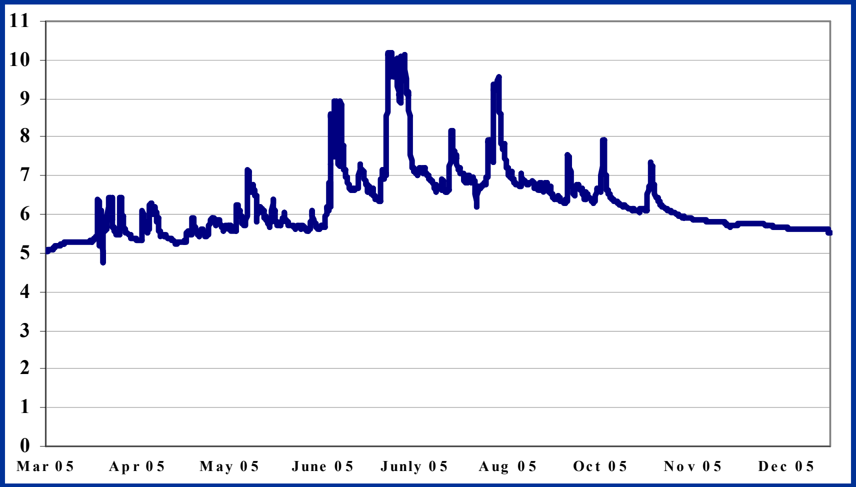


River Gauge Level at Jadukata River Section

2007 (Jan - September)



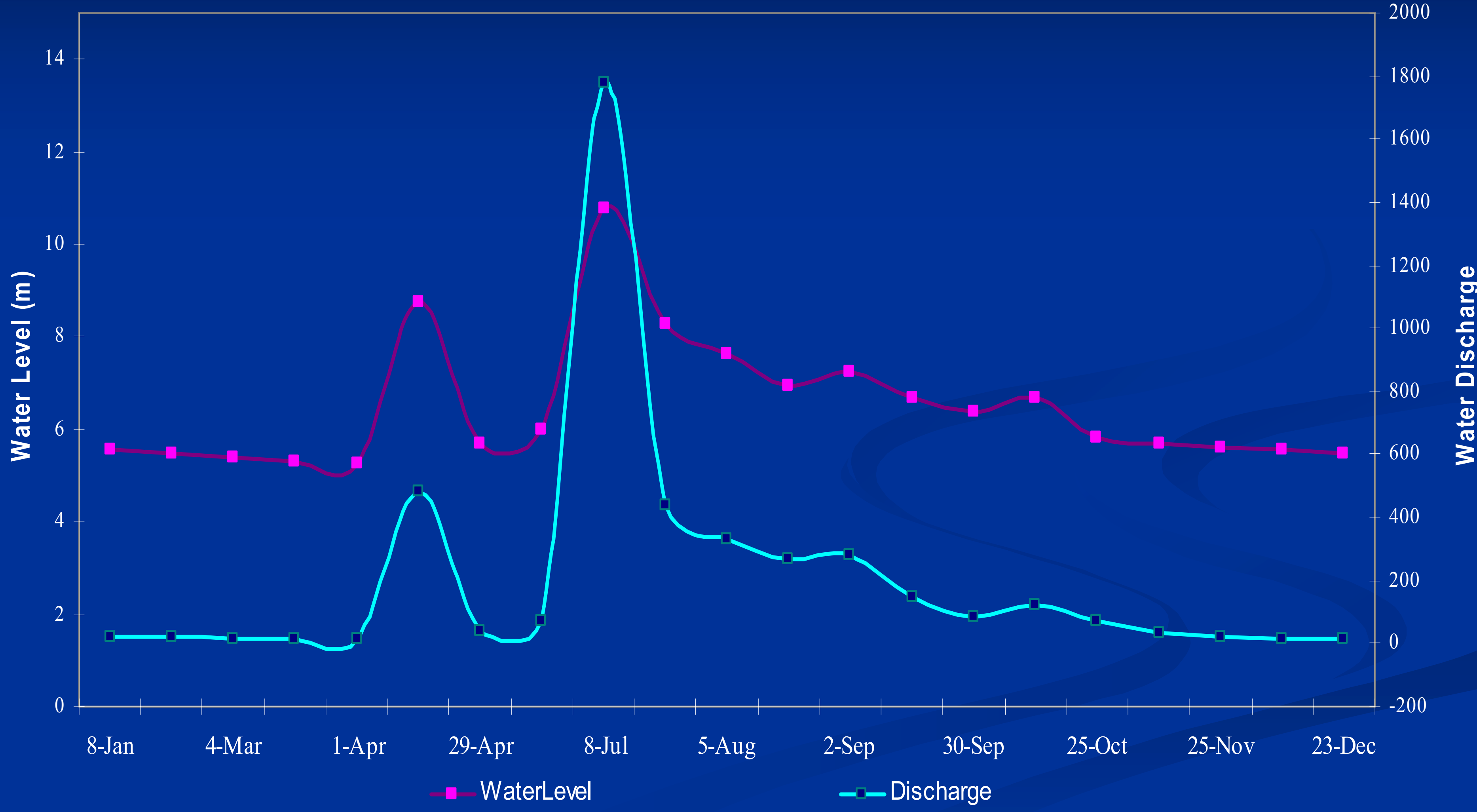
2006 (Jan - Dec)



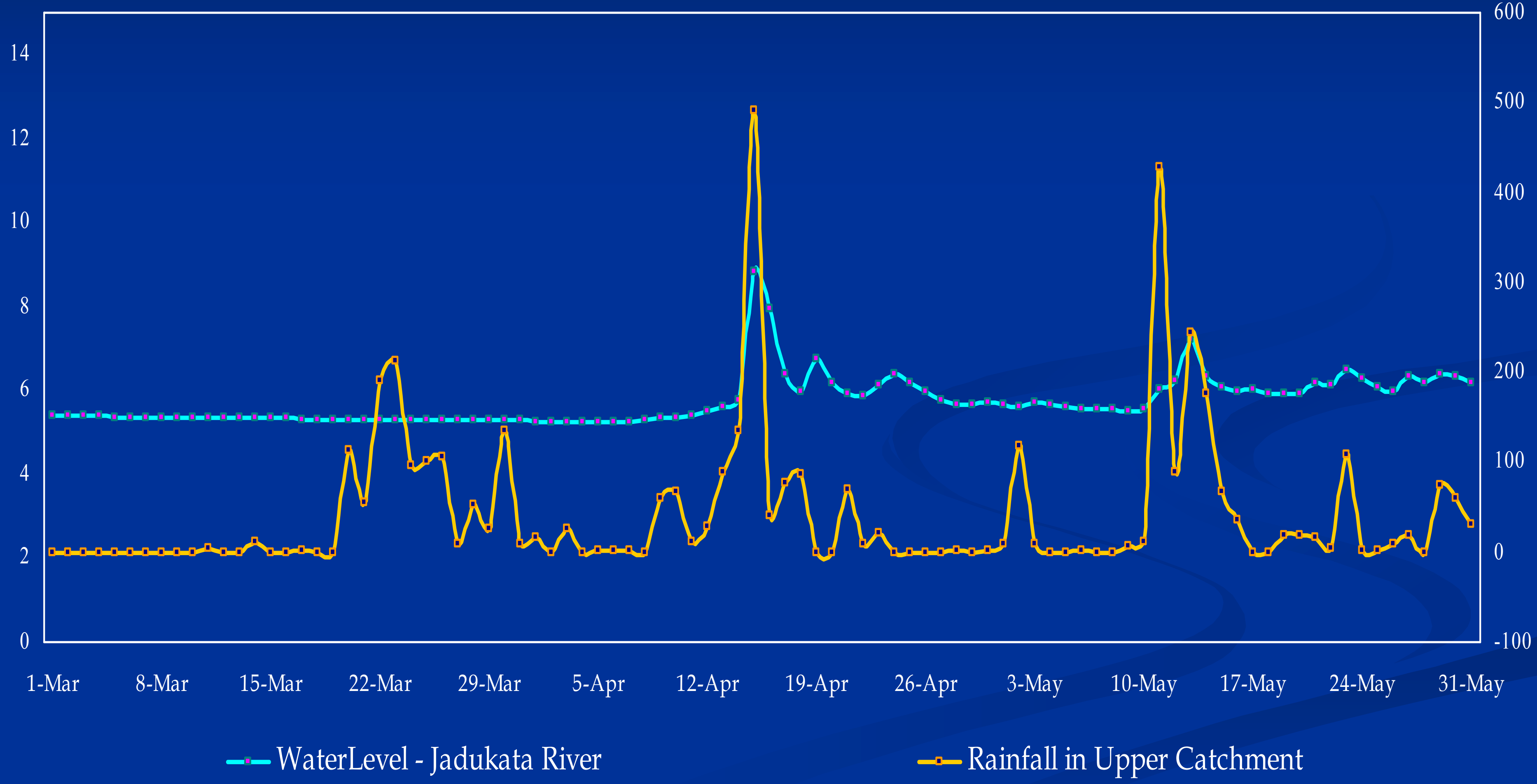
2005 (Jan - Dec)

2004 (Jan - Dec)

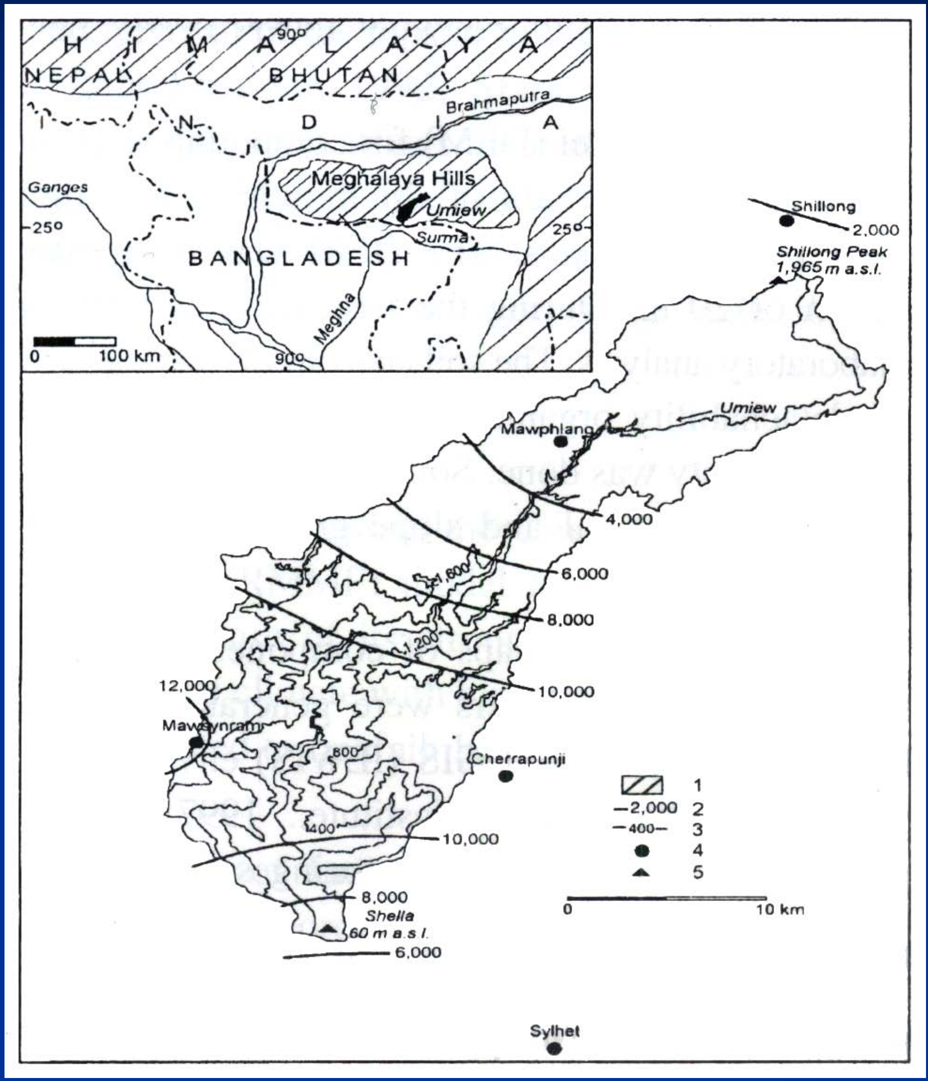
Water Level and Discharge of Jadukata River (2004)



Water Level and Rainfall (Cherrapunjee) in 2004



Location and Characteristics of Umiew Catchment



Area – 45.89 sq km, Runoff Depth - 7240.25 mm, Total Runoff – 339495 m ha, Stream Length – 3218.69 km,

The catchment is drained by the Umiew River (80 km. long), which is the right bank tributary of the Surma River flowing in Bangladesh.

The river is characterized by strong attitudinal gradients, varying between 60 m and 1965 m a.s.l.

LEGEND

1 - mountains and uplands
2 - isohyets with average annual rainfall (mm) for the period 1999-2000
3 - contours every 400 m
4 - rainfall stations
5 - elevations (m a.s.l)

Runoff Yield Assessment

Direct Runoff and Unit Hydrograph for 1.0 cm of Effective Rainfall
over Watershed for 97 Days Rainstorm (23rd June - 29th September 2004)

Time (days)	Total Runoff Ordinates (l/s)	Base Flow Ordinates (l/s)	Direct Runoff (col2 - col3) (l/s)	Unit Hydrograph (l/s per cm of Pnet)
(1)	(2)	(3)	(4)	(5)
0	500	500	0	0
5	250	250	0	0
10	855	240	615	5.19
15	1730	180	1550	13.07
20	2250	100	2150	18.05
25	2500	100	2400	20.25
30	2750	100	2650	22.36
35	2250	110	2140	18.05
40	2100	120	1980	16.71
45	1500	185	1315	11.09
50	1250	250	1000	8.44
55	1100	265	835	7.04
60	1100	285	815	6.03
95	540	540	0	0

Runoff Yield Assessment

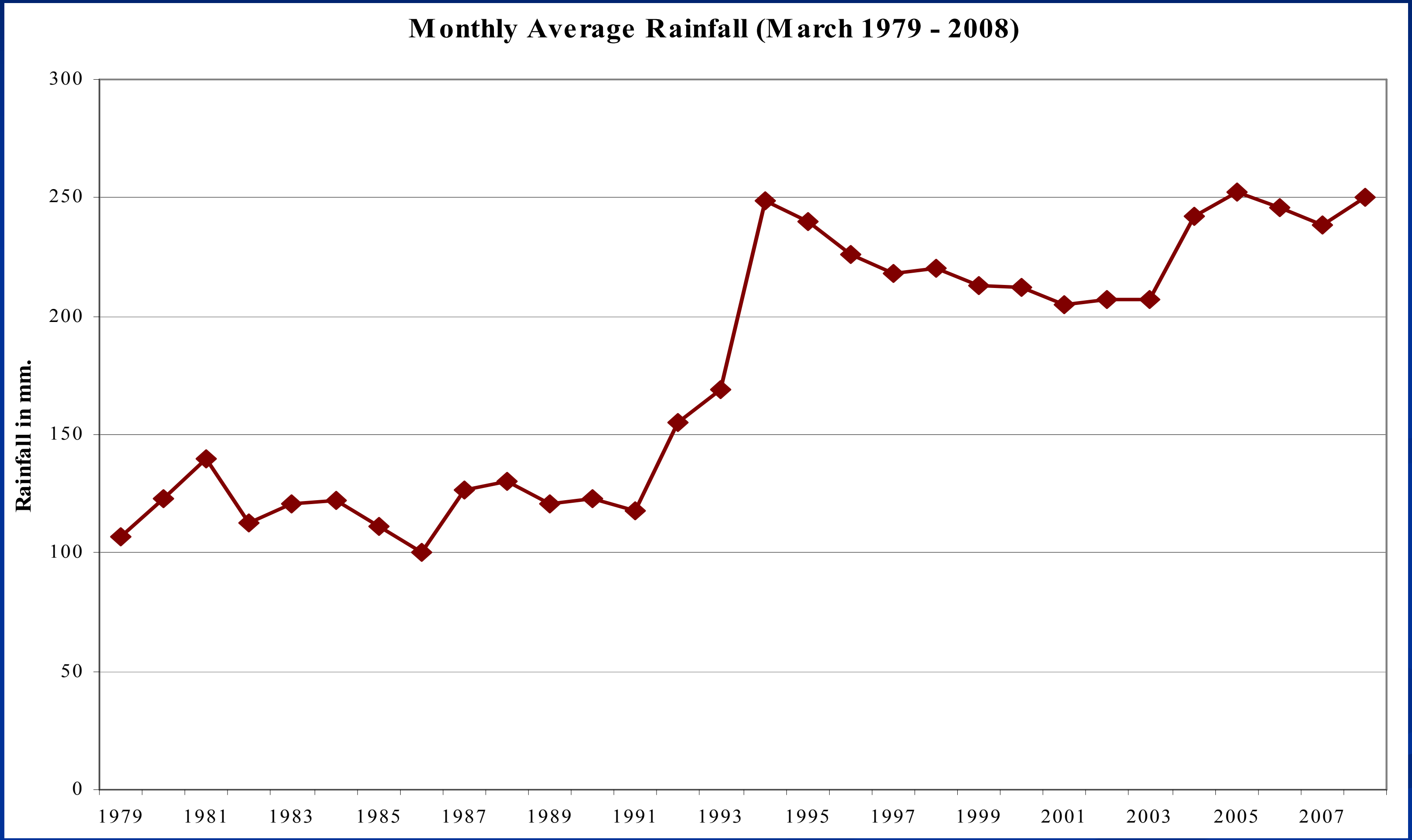
Direct Runoff and Unit Hydrograph for 1.0 cm of Effective Rainfall
over Watershed for 158 Days Rainstorm (12 June - 31 December 2005)

Time (days)	Total Runoff Ordinates (l/s)	Base Flow Ordinates (l/s)	Direct Runoff (col2 - col3) (l/s)	Unit Hydrograph (l/s per cm of Pnet)
(1)	(2)	(3)	(4)	(5)
0	500	500	0	0
5	250	250	0	0
10	900	250	650	5.63
15	1000	210	790	6.36
20	2200	200	2000	16.11
25	3500	190	3310	26.66
30	4400	100	4300	34.64
35	3700	120	3580	28.83
40	1750	180	1570	12.65
45	1250	230	1020	8.21
50	1000	250	750	6.04
55	750	265	485	3.90
60	700	350	350	2.82
65	650	450	200	1.61

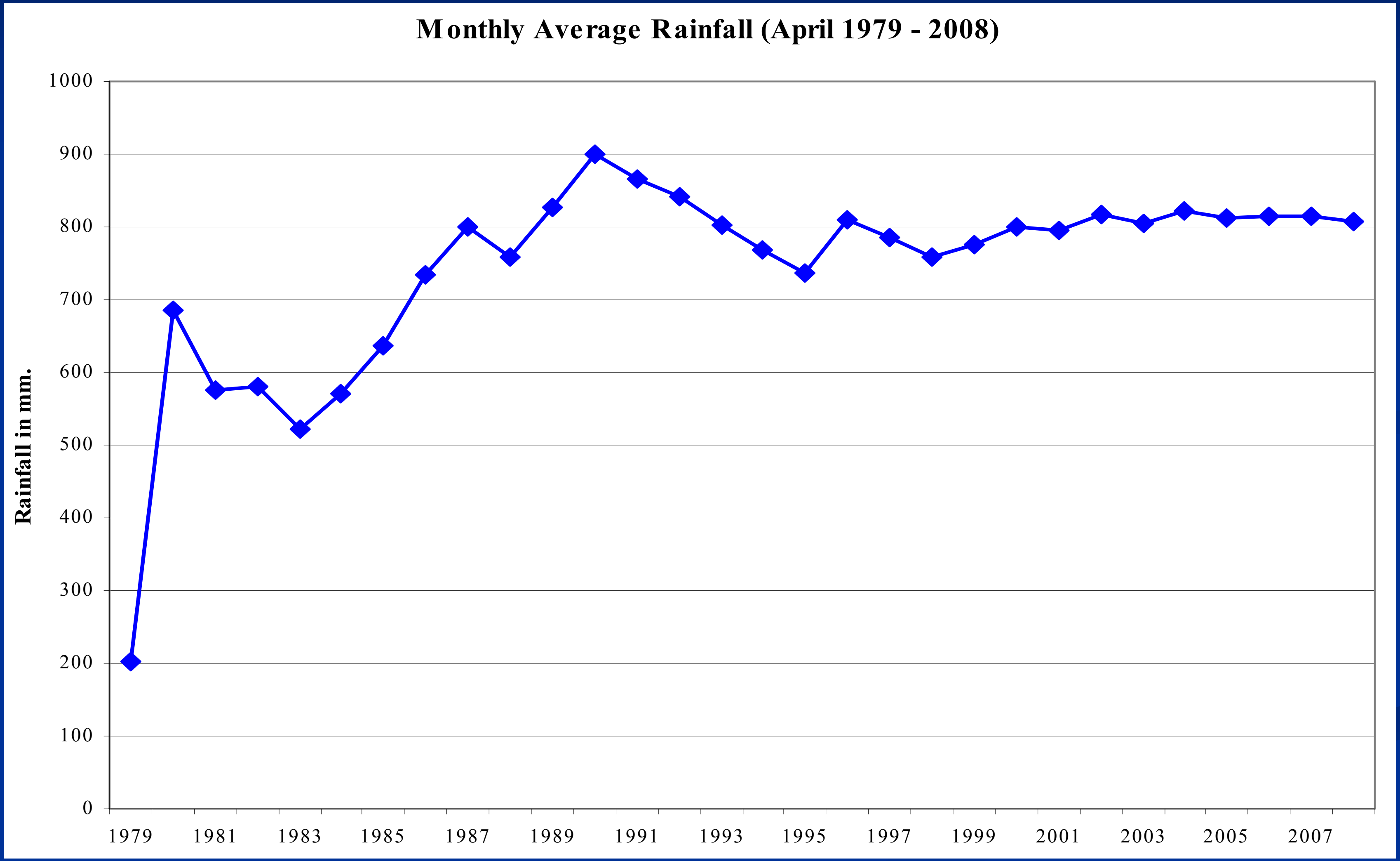
Runoff Yield Assessment

1. Runoff is an independent factor in flood modeling;
2. Higher runoff ratio because of full saturation of groundwater storage capacity;
3. Lesser infiltration and percolation rates during post monsoon time;
4. The small size catchments area which reduces catchments lag time to run water fast to the mouth of the watershed;
5. Rainfall is sometimes delayed which creates its uneven distribution pattern. For example, about 20 percent share of monsoon rain reduced in the N-E India in 2005 because of delayed onset of monsoon;
6. Direct runoff is calculated through subtracting base flow originates from the flow discharge and then the unit hydrographs for 1.0 cm of effective rainfall (i.e. often called net rainfall, an amount after subtracting initial abstraction from total rainfall) ;

Climate Change and Variability



Climate Change and Variability



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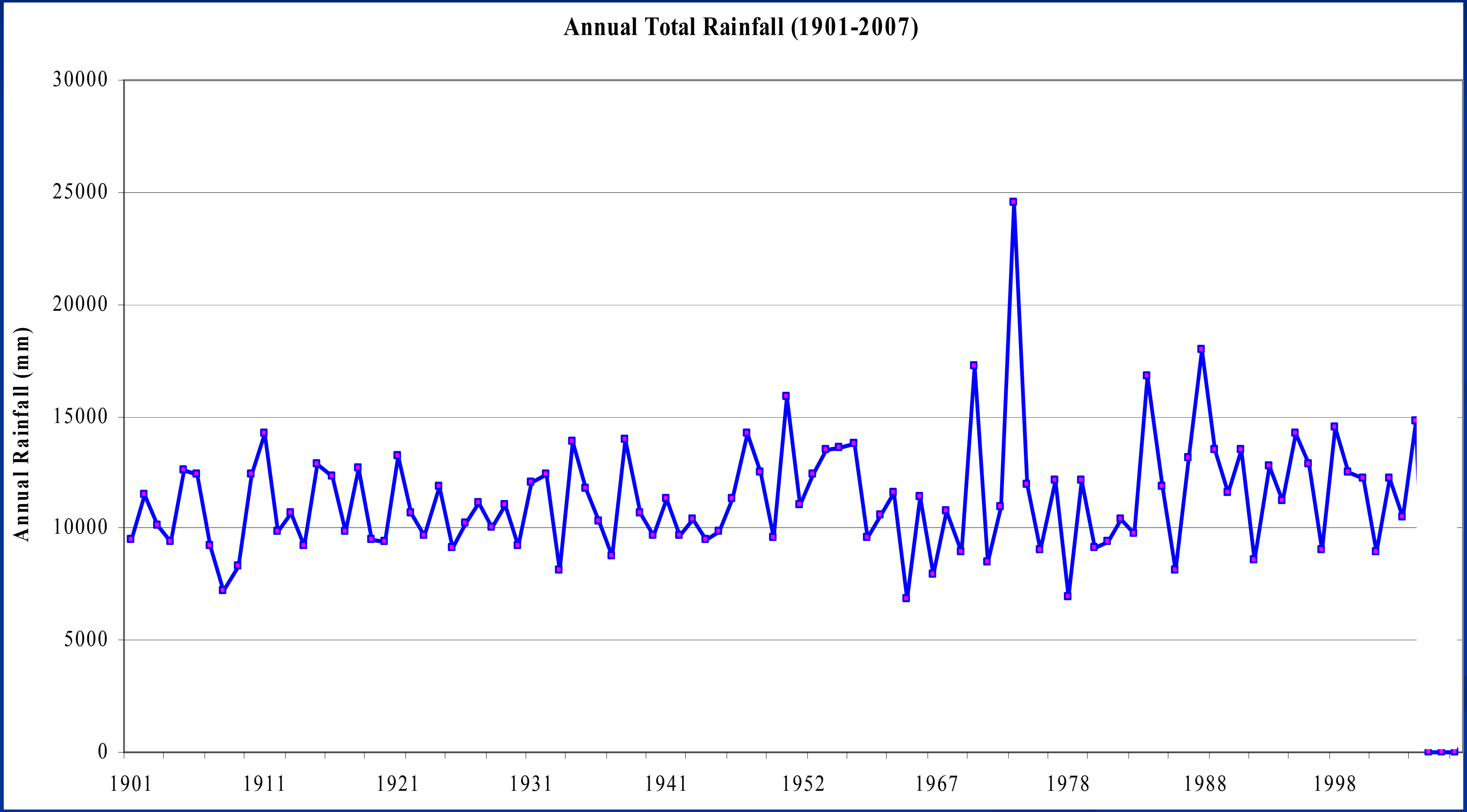
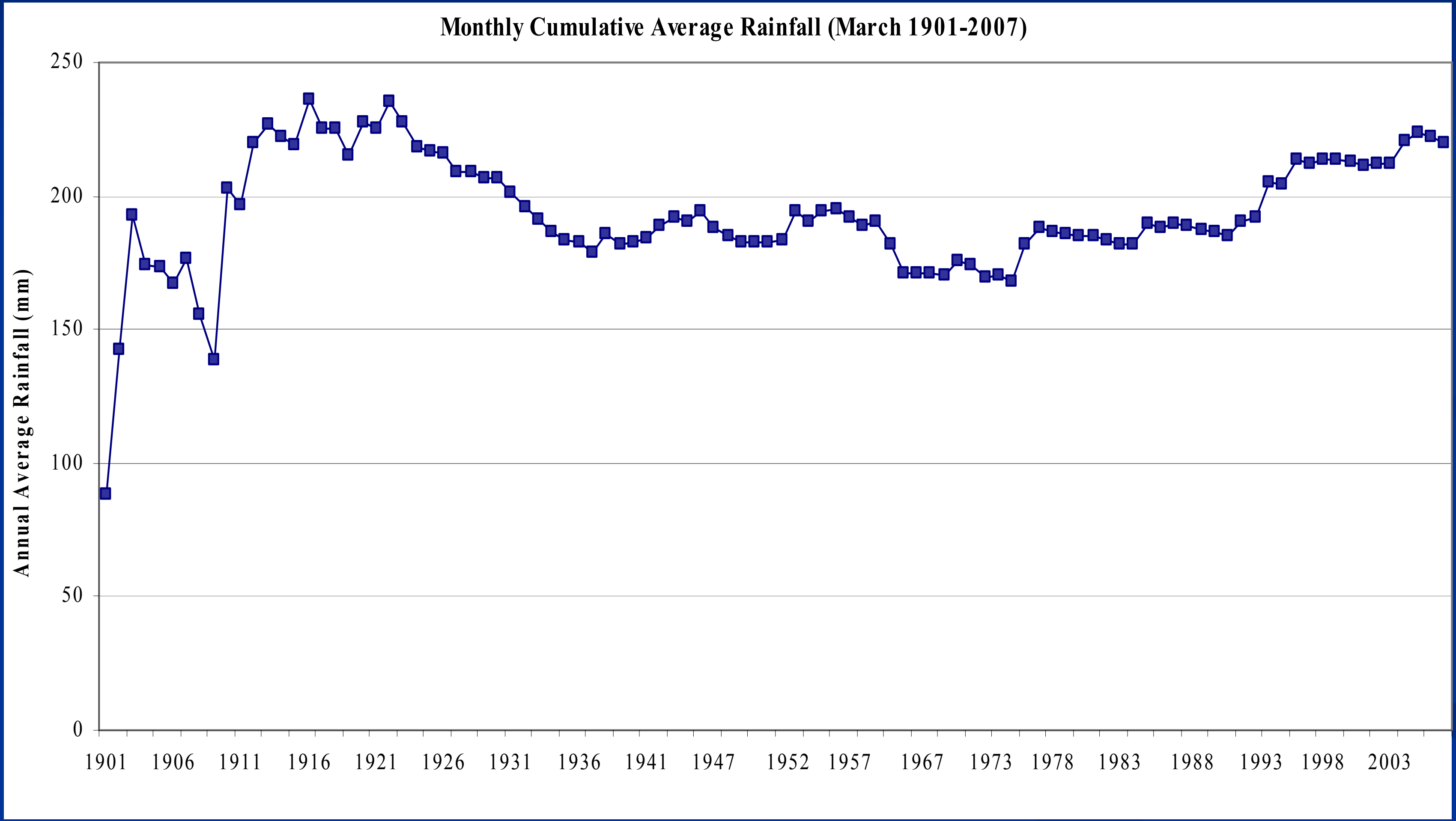
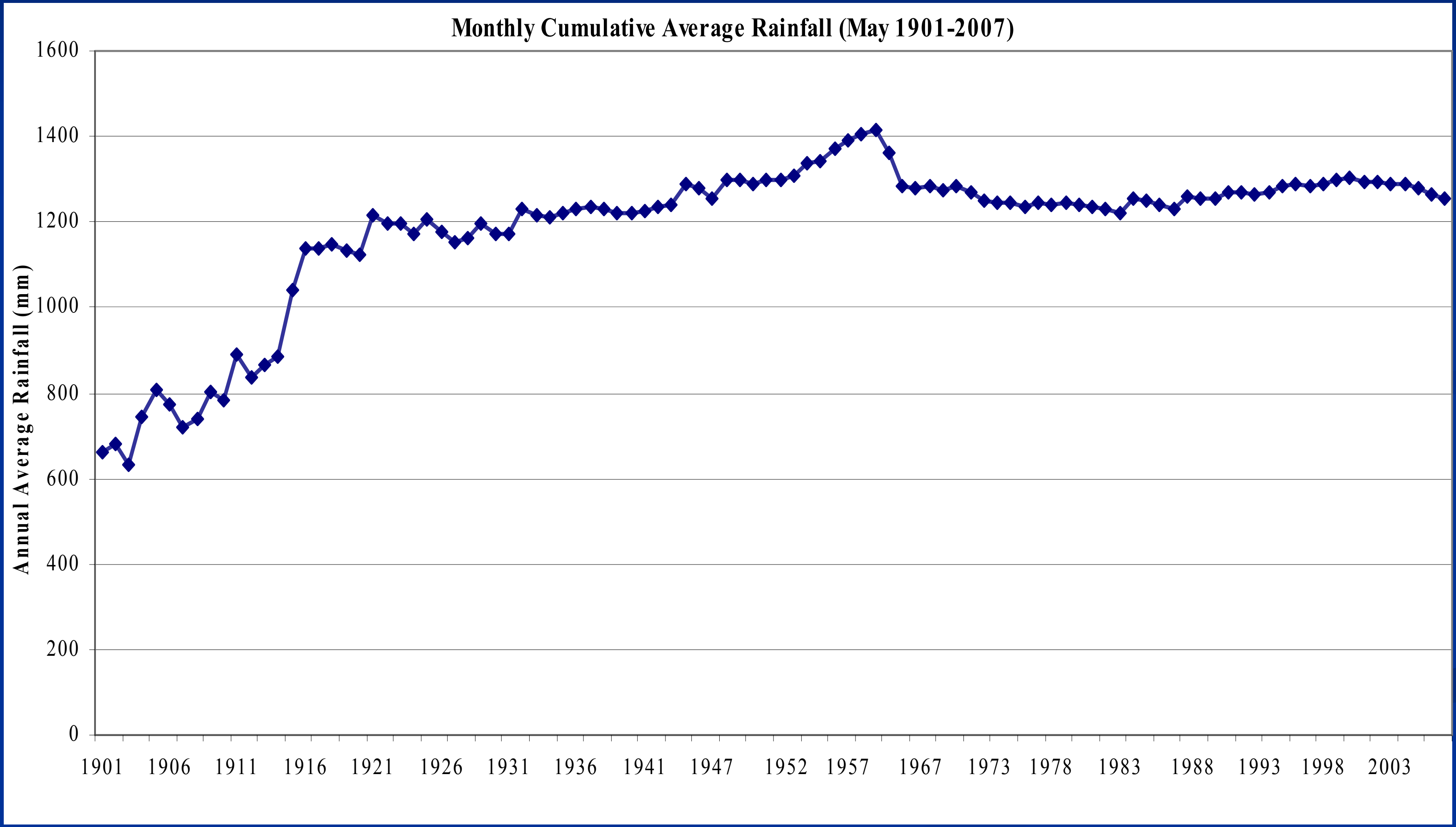


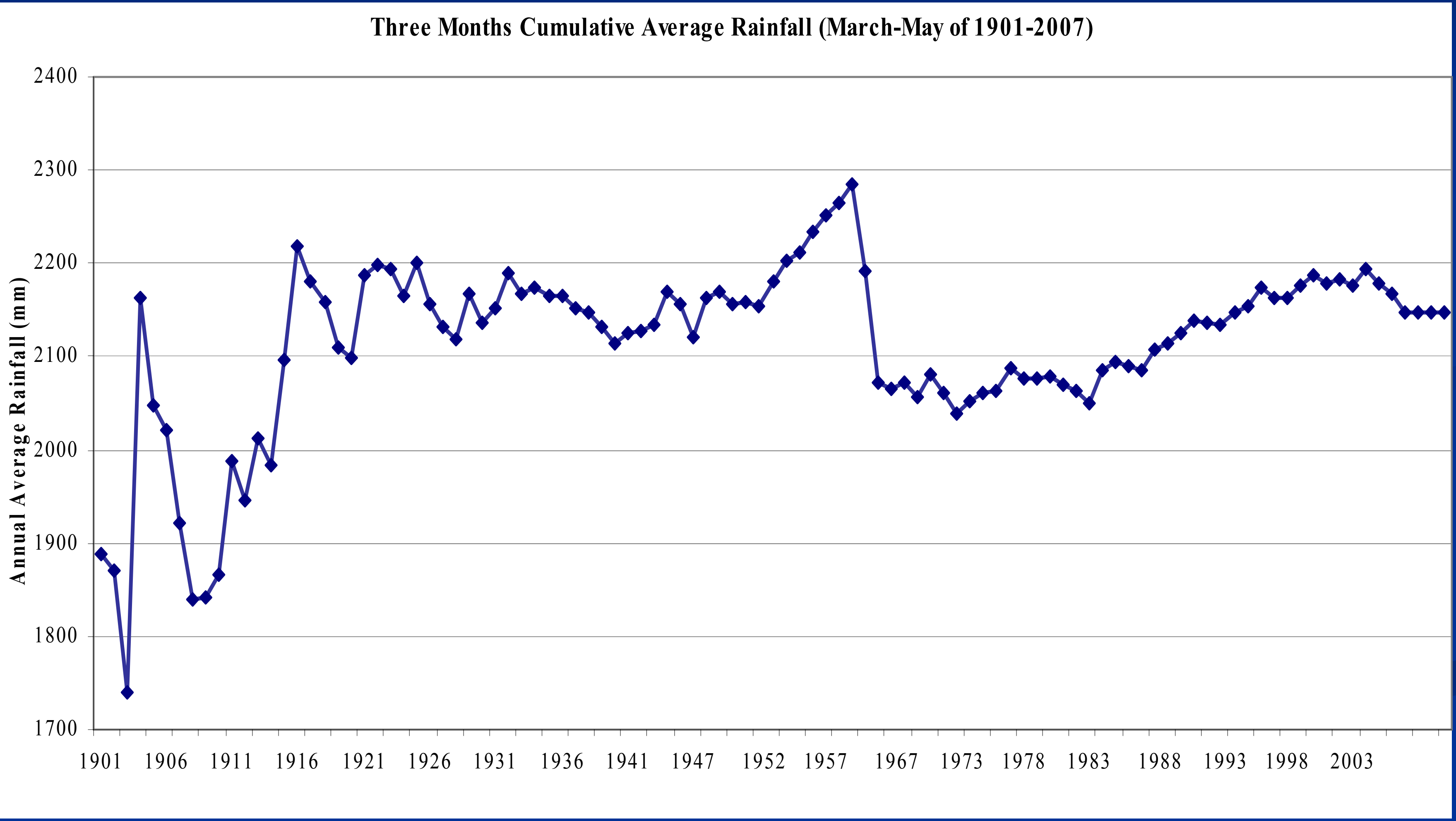
Climate Change and Variability



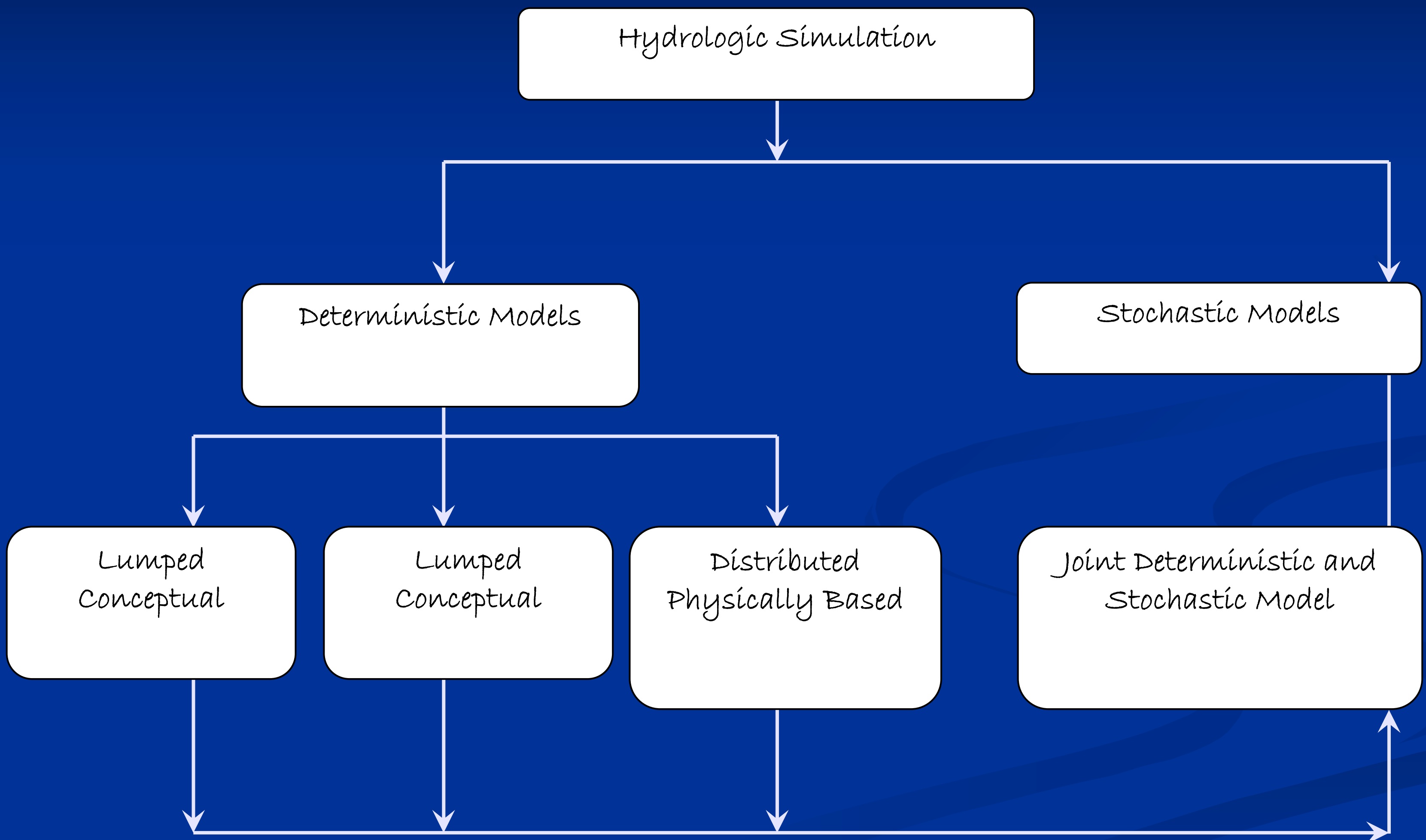
Climate Change and Variability



Climate Change and Variability



Modelling Approaches and Techniques



Empirical Model – Catchments Lag Time Calculation

1. Catchments Lag (t_p in hours) - the time duration between the centroid of the unit rain);
2. It is directly related to the interaction of total length of longest water course (L in km) with the length of water course from its outlet to the point inside the center of catchments (L_{ca} in km);
3. It is inversely related to overall slope of the water course;
4. Geo-morphological parametric relationship in its log form:

$$t_p = ct \{(L * Lca)^n / s^{0.5}\}$$

Where ct and n are coefficients, ct is proportionality coefficient for catchments parameters and calculated by Linsely, et al. (1958) as 1.715 for the mountain region, 1.03 for foot hills, and 0.05 for valleys. For Indian conditions, Mutreza (1986) reported the coefficient values as ct = 1.13 and n = 0.2769 for mountain and hill areas.

Empirical Model – Catchments Lag Time Calculation

5. Equation for catchments lag time for Kynshi River Catchment may be written as,

$$tp = 1.13 \{(L * Lca)0.2769/s0.5\}$$

6. Lag time for Sub Catchment is 13.34 hours, for the higher order catchment is 22.77 to 27.57 hours, and 3 - 4 hours for valley lag (Laurergarh to Tahirpur);

7. Total Lag time calculated is 40 to 45 hours for Kynshi Catchment during shorter rainstorms of post monsoon seasons after full saturation of soil conditions

8. Using the same equation, Catchments Lag time for Umsoh-Ryngkey Catchments is calculated 23 to 25 hours after full saturation of soil conditions .

Lumped Conceptual Model

The approach allows to some extent the introduction of spatial variability hydrological parameters (and responses). The modeling criteria's are:

1. Saturation status of groundwater storage capacity;

2. Antecedent (3 days cumulative) rainfall observations at Meghalaya Plateau;

3. Successive (3 days cumulative) rainfall forecasts at Meghalaya Plateau;

4. Observed river gauge readings at different nodal points of the longest water course from its outlet to the point inside the center of catchments;

5. Condition of flood protection infrastructure and vulnerability status; and

6. Local rainfall forecast (next 3 days cumulative).

Factors affecting the Hydrological Events

Sl	Factors Affecting	Maximum Value
1	Saturation status of groundwater storage capacity	Yes / Not*
	** If saturated (YES), flood may happen; If not saturated (NOT) or within first 10 days from the start of the monsoon rain, no such risk for next 3 days and no need to proceed further for that day. But keep notes of the next 5 days forecasted rainfall.*	
2	Rainfall observations at Meghalaya Plateau (last three days cumulative)	40
3	Rainfall forecasts at Meghalaya Plateau (next three days cumulative)	40
4	Observed river gauge readings at different nodal points of the longest water course from its outlet to the point inside the center of catchments	10
5	Condition of flood protection infrastructure and vulnerability status	05
6	Local rainfall forecast (next 3 days cumulative)	05

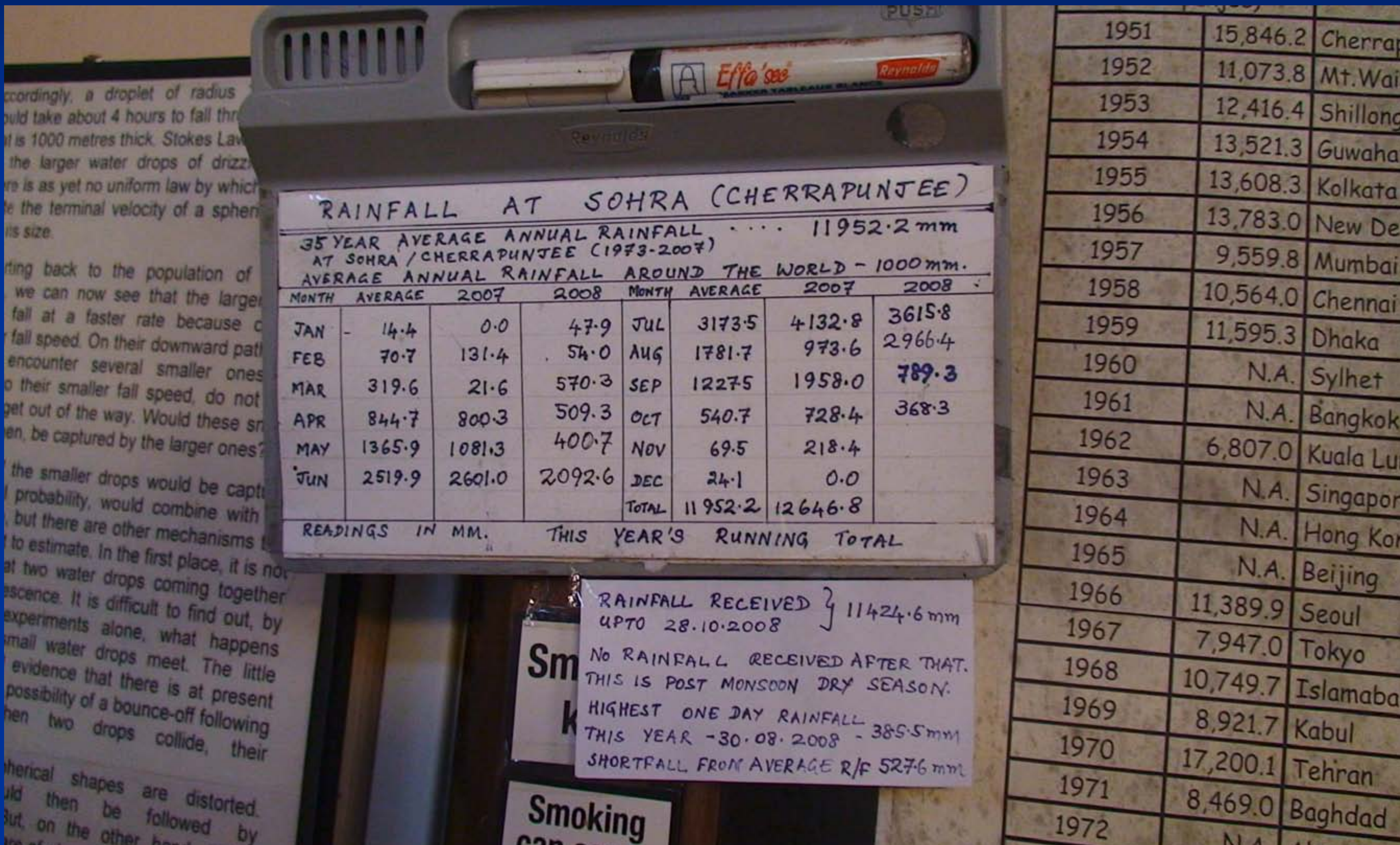
Extent of Flood and Respective Warning Message

Sl	Flood Category	Total Value	Flood Warning Message
1	Extremely High	Above 80	Crop loss is certain –forced harvesting (as much as they can) recommended without further delay
2	Highly Flooded	70 to 80	Crop loss is almost certain, – urgent repairing of embankments and forced harvesting of mature crops recommended
3	Moderately flooded	60 to 70	Crop loss may happen – maintenance and close monitoring of the embankments recommended
4	Low Flood	50 to 60	Regular maintenance, monitoring and guarding of the embankments recommended
5	Flood Free	Less than 50	Regular monitoring and guarding of the embankments recommended

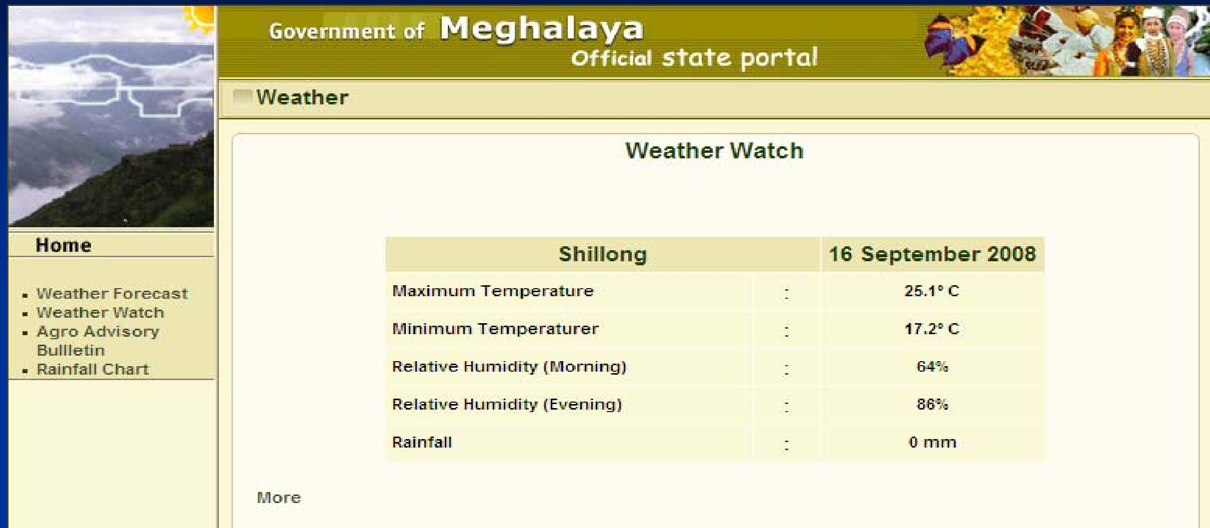
Rainfall Observations (last 3 days cumulative)

Sl. No	Rainfall Category	Rainfall Observation (last 3 days cumulative)	Weighted Value
1	Extremely High	Above 300 mm	40
2	Very High	200 to 300 mm	35
3	High	150 to 200 mm	30
4	Highly Moderate	125 to 150 mm	25
5	Moderate	100 to 125 mm	20
6	Moderately Low	75 to 100 mm	15
7	Low	50 to 75 mm	10
8	Very Low	Less than 50 mm	5

Rainfall Observations (last 3 days cumulative)



Sources of Rainfall Observations Data



Government of **Meghalaya**
Official state portal

Weather

Home

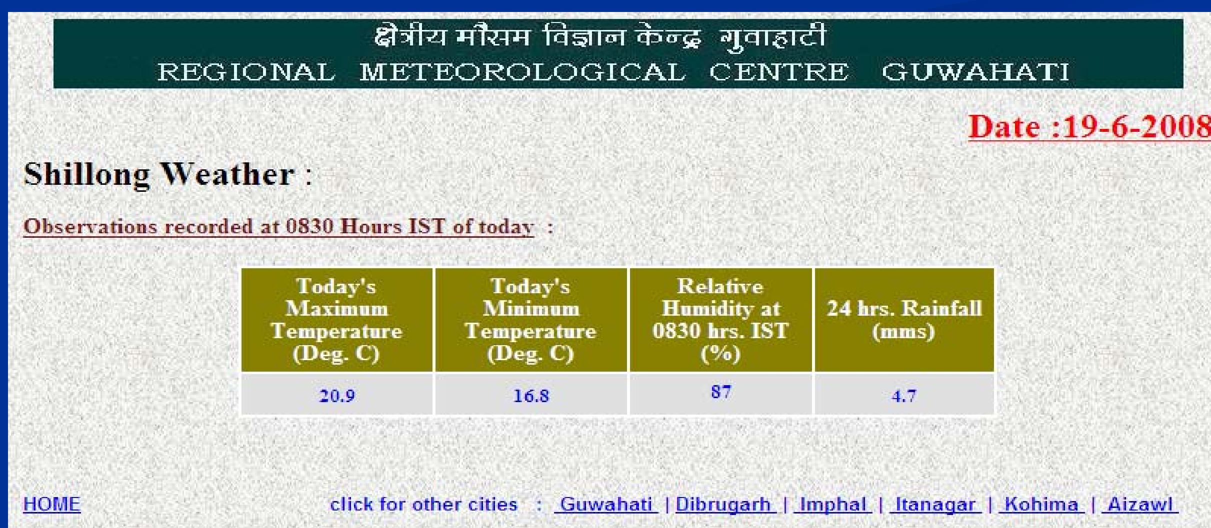
- Weather Forecast
- Weather Watch
- Agro Advisory Bulletin
- Rainfall Chart

Weather Watch

Shillong		16 September 2008
Maximum Temperature	:	25.1° C
Minimum Temperaturer	:	17.2° C
Relative Humidity (Morning)	:	64%
Relative Humidity (Evening)	:	86%
Rainfall	:	0 mm

More

http://meghalaya.nic.in/weather/watch.asp



क्षेत्रीय मौसम विज्ञान केन्द्र गुवाहाटी
REGIONAL METEOROLOGICAL CENTRE GUWAHATI

Date :19-6-2008

Shillong Weather :

Observations recorded at 0830 Hours IST of today :

Today's Maximum Temperature (Deg. C)	Today's Minimum Temperature (Deg. C)	Relative Humidity at 0830 hrs. IST (%)	24 hrs. Rainfall (mms)
20.9	16.8	87	4.7

HOME click for other cities : Guwahati | Dibrugarh | Imphal | Itanagar | Kohima | Aizawl

http://education.vsnl.com/rmcguwahati/shlfc.html

Sources of Rainfall Observations Data

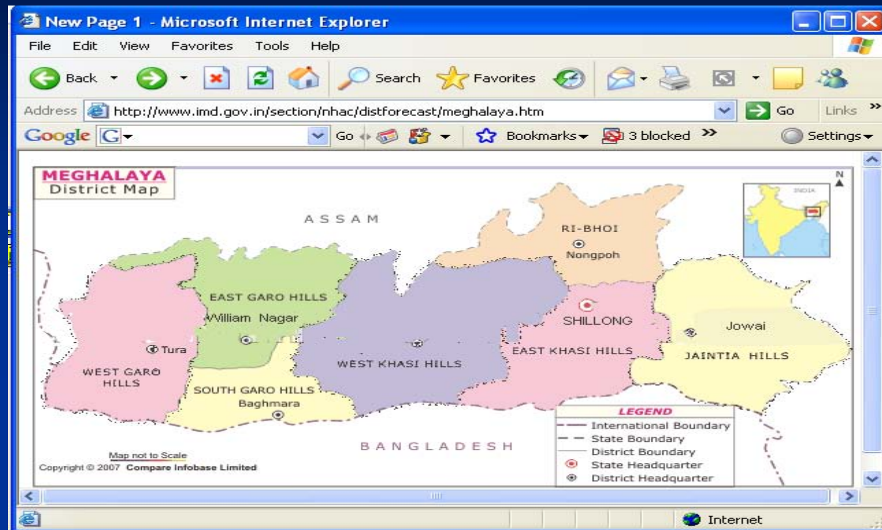
Day	Temp °C		Rainfall in mm	Total Rainfall for the year till Date	Air Pressure in mb		Wind Speed
	Min	Max			Morning	Evening	
1	2	3	4	5	6	7	8
16th Sep 2008, Tue	19.7	24.0	0.0	10868.5	865.6	864.9	04 k/h
15th Sep 2008, Mon	21.7	28.2	0.0	10868.5	866.1	862.7	03 k/h
14th Sep 2008, Sun	17.6	27.2	47.2	10868.5	867.3	864.0	02 k/h
13th Sep 2008, Sat	19.2	26.6	0.0	10821.3	867.1	863.9	01 k/h
12th Sep 2008, Fri	18.8	26.0	0.0	10821.3	867.7	864.1	00 k/h
11th Sep 2008, Thu	18.9	24.6	30.8	10821.3	868.1	864.7	01 k/h
10th Sep 2008, Wed	17.6	25.6	0.0	10790.5	868.1	864.3	01 k/h
09th Sep 2008, Tue	18.1	24.0	0.0	10790.5	868.6	864.8	01 k/h
08th Sep 2008, Mon	18.5	24.2	0.0	10790.5	868.2	865.0	01 k/h
07th Sep 2008, Sun	17.2	23.8	0.0	10790.5	868.0	864.6	00 k/h
06th Aug 2008, Sat	17.3	21.5	11.6	10790.5	867.8	865.3	00 k/h
05th Sep 2008, Fri	16.5	21.2	133.6	10788.9	868.4	865.1	02 k/h
04th Sep 2008, Thu	17.5	22.4	64.9	10655.3	869.2	865.8	02 k/h
03rd Sep 2008, Wed	17.5	20.6	215.3	10590.4	868.4	866.2	03 k/h
02nd Sep 2008, Tue	18.2	22.0	51.3	10375.1	868.9	865.9	03 k/h

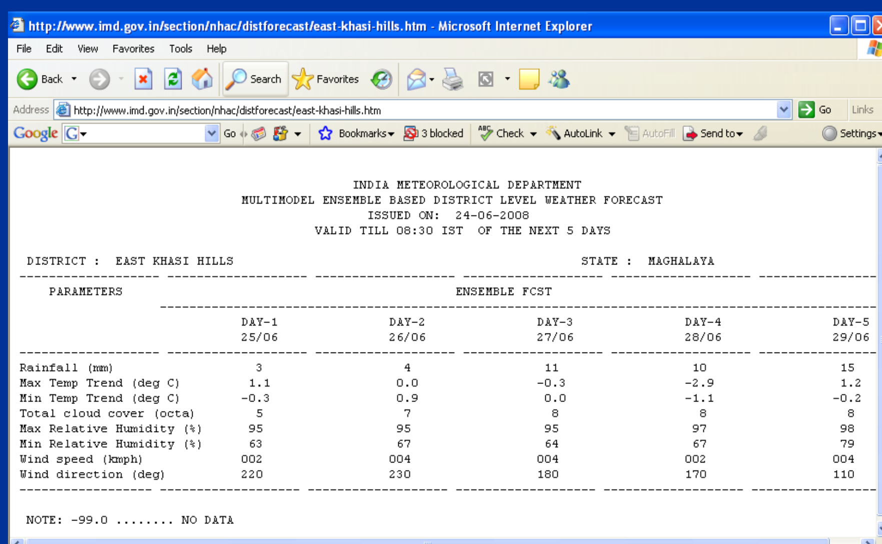
http://www.cherrapunjee.com/current_status_02.php

Rainfall Forecasts (next 3 days cumulative)

Sl. No	Rainfall Category	Rainfall Forecasts (next 3 days cumulative)	Weighted Value
1	Extremely High	Above 300 mm	40
2	Very High	200 to 300 mm	35
3	High	150 to 200 mm	30
4	Highly Moderate	125 to 150 mm	25
5	Moderate	100 to 125 mm	20
6	Moderately Low	75 to 100 mm	15
7	Low	50 to 75 mm	10
8	Very Low	Less than 50 mm	0

Sources of Rainfall Forecasts Data





INDIA METEOROLOGICAL DEPARTMENT
MULTIMODEL ENSEMBLE BASED DISTRICT LEVEL WEATHER FORECAST
ISSUED ON: 24-06-2008
VALID TILL 08:30 IST OF THE NEXT 5 DAYS

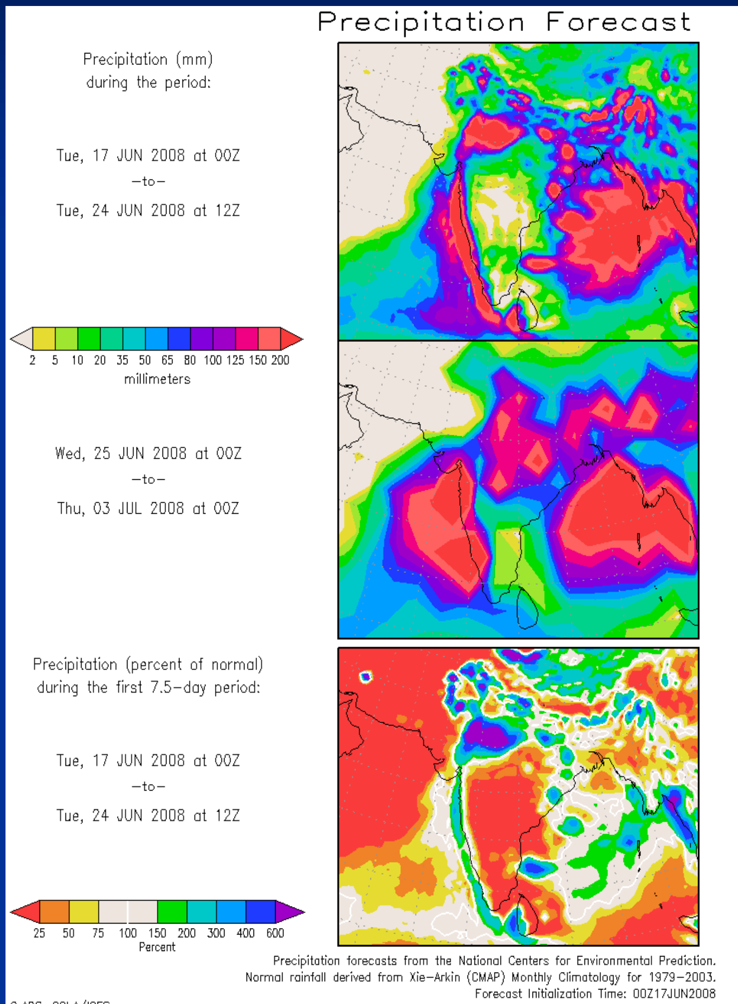
DISTRICT : EAST KHASI HILLS STATE : MAGHALAYA

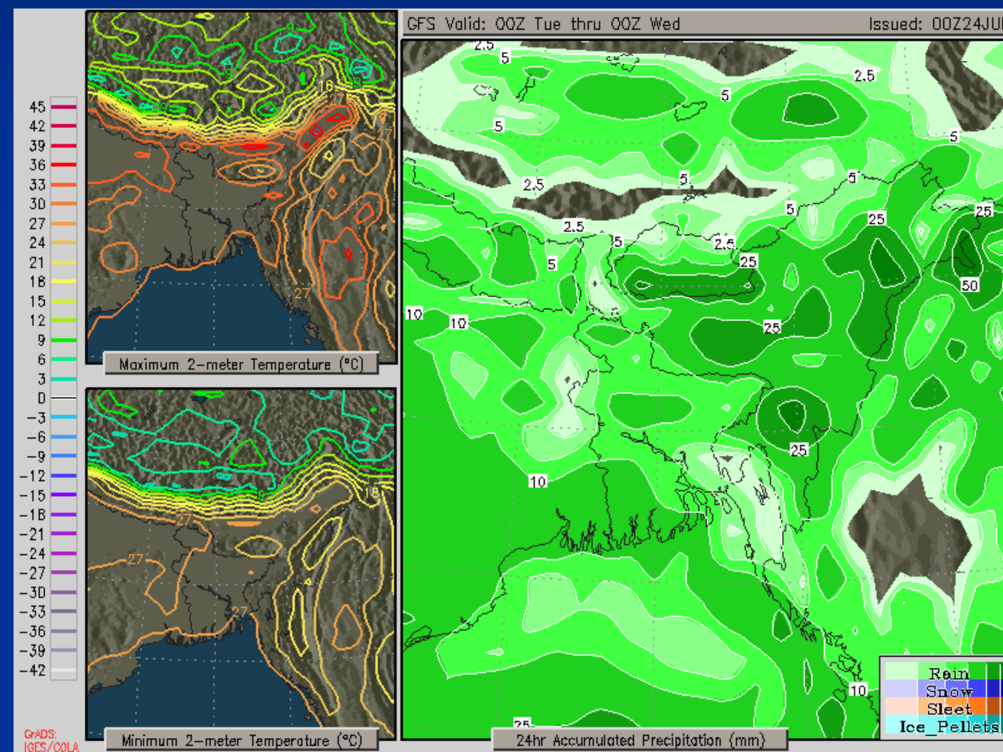
PARAMETERS	ENSEMBLE FCST				
	DAY-1 25/06	DAY-2 26/06	DAY-3 27/06	DAY-4 28/06	DAY-5 29/06
Rainfall (mm)	3	4	11	10	15
Max Temp Trend (deg C)	1.1	0.0	-0.3	-2.9	1.2
Min Temp Trend (deg C)	-0.3	0.9	0.0	-1.1	-0.2
Total cloud cover (octa)	5	7	8	8	8
Max Relative Humidity (%)	95	95	95	97	98
Min Relative Humidity (%)	63	67	64	67	79
Wind speed (kmph)	002	004	004	002	004
Wind direction (deg)	220	230	180	170	110

NOTE: -99.0 .... NO DATA

http://www.imd.gov.in/section/nhac/distforecast/east-khasi-hills.htm

Alternate Sources for Rainfall Forecast Data

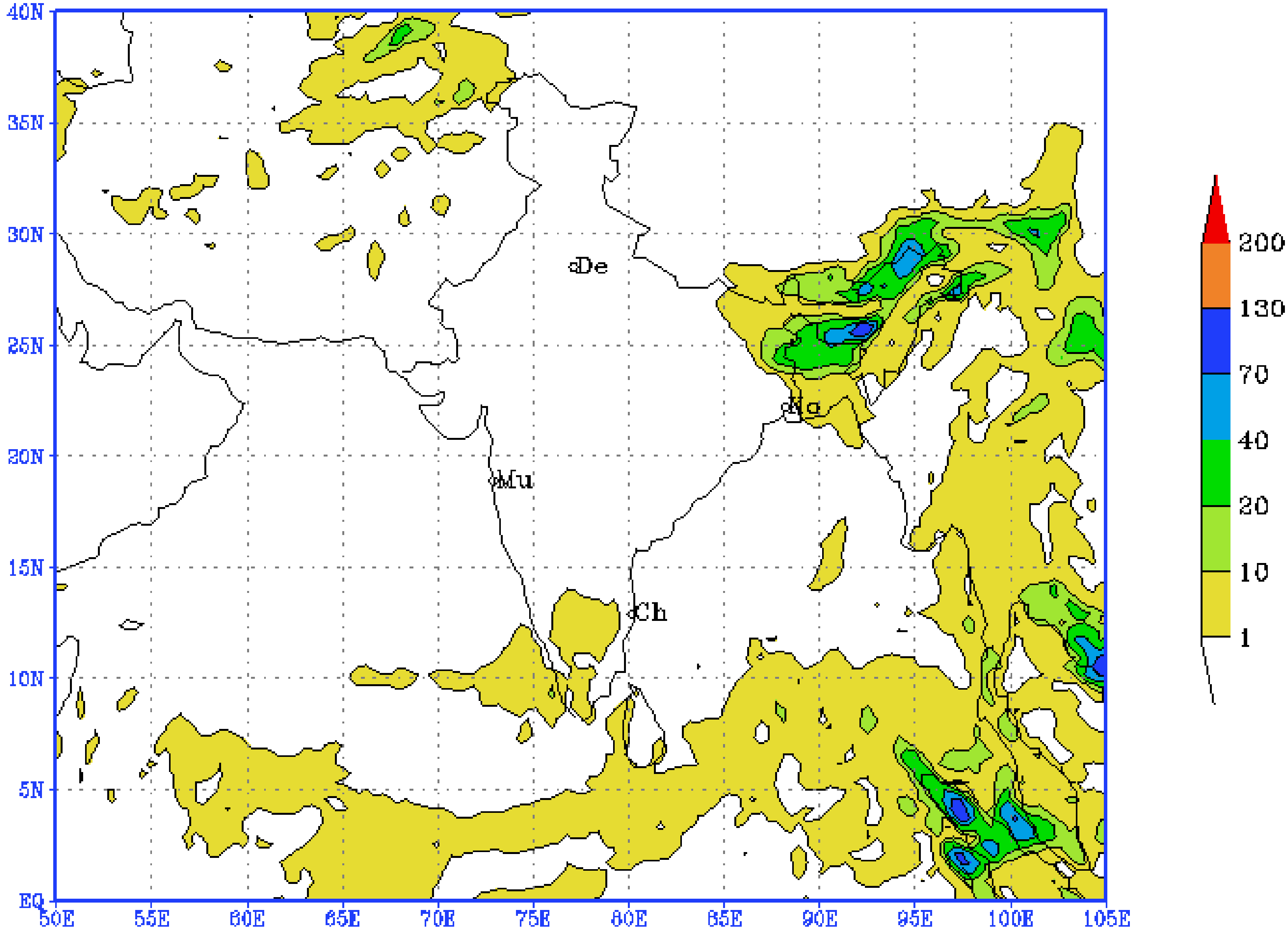




http://www.monsoondata.org/wx/prec.html

IMD MM5 24 hours Rainfall (mm) Forecast

based on 00 UTC 01-05-2009 valid for 03 UTC (08:30 IST) of 02-05-2009



(Background does not depict political boundary)

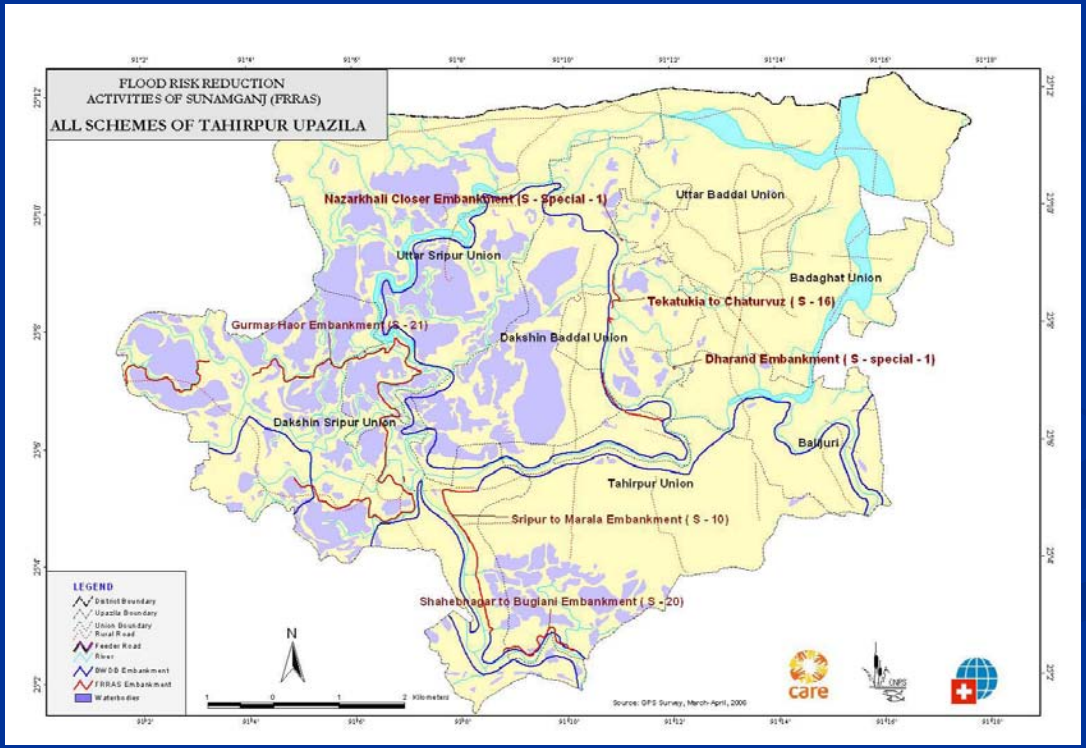
Water Level Readings of Jadukata River

Sl. No.	Water Level	River Gauge Data	Weighted Value
1	Extremely High	Above 8.00 meter	10
2	High Level	7.00 to 7.90 meter	6
3	Moderate Level	6.00 to 6.90 meter	4
4	Low Level	5.00 to 5.90 meter	2
5	Flood Free Level	Less that 5.00 meter	0

Data Source: Water Level Monitoring Station (station number 131), Bangladesh Water Development Board (BWDB), of Laurergarh – Shoktirkhola point of jadukata river.

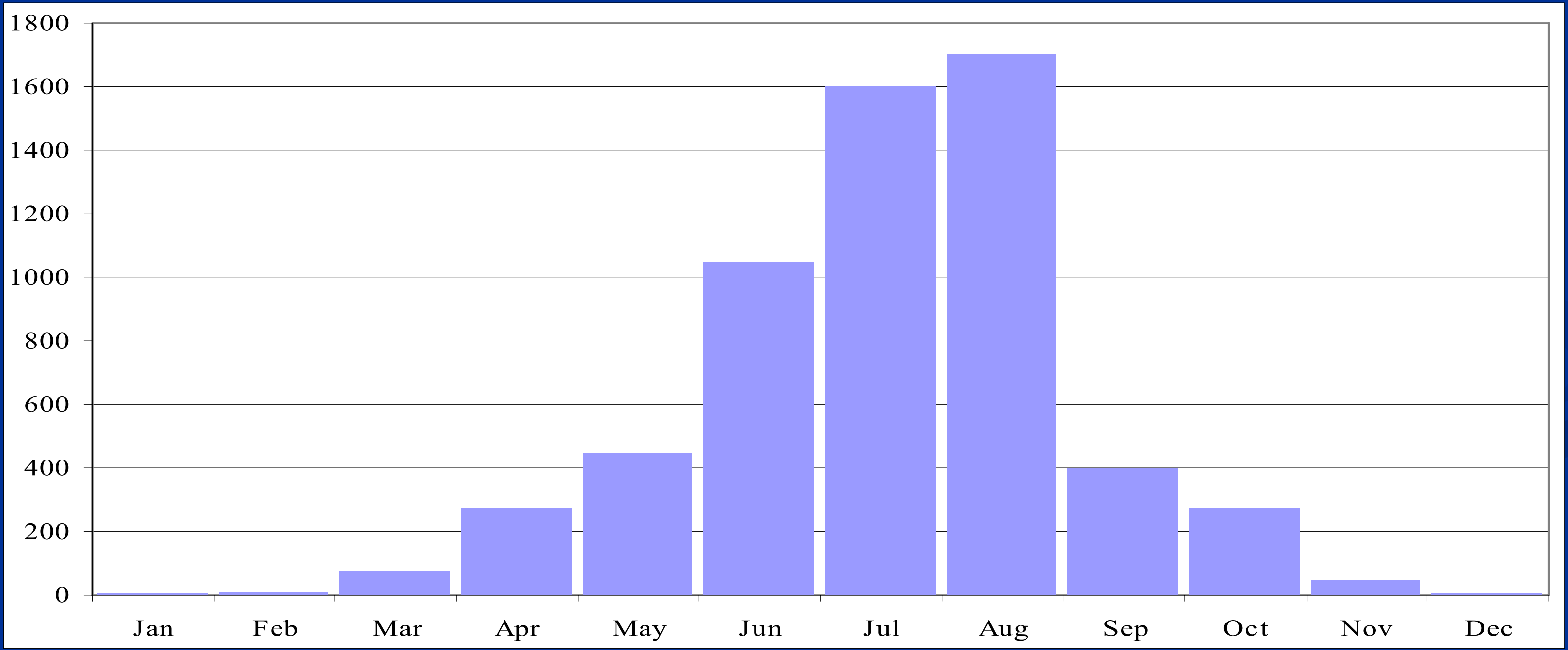
Structural Measures to Flood Protection

Sl.	Structural Strength	Weighted Value
1	Very Good Condition	0
2	Good Condition (needs regular monitoring)	1
3	Fairly Good Condition (requires some repairing)	2
4	Vulnerable (immediate reaping works)	3
5	Critically Vulnerable (external support for repairing)	5

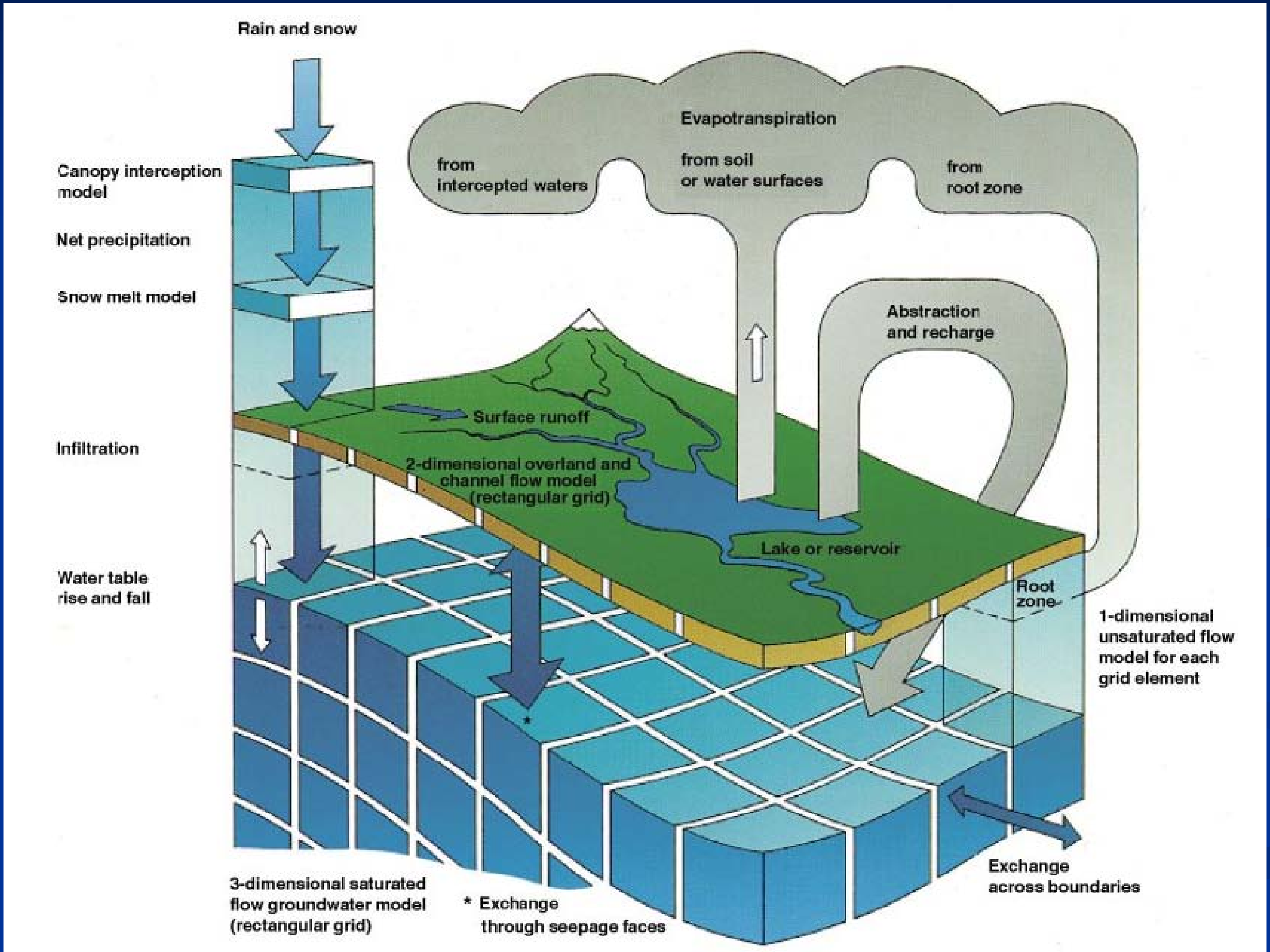


Local Rainfall Observations (last 3 days cumulative)

Sl	Rainfall Category	Rainfall Observation (last 3 days cumulative)	Weighted Value
1	Extremely High	Above 200 mm	5
2	Very High	175 to 200 mm	4
3	High	150 to 175 mm	3
4	Moderate	100 to 150 mm	2
5	Low	50 to 1oo mm	1
6	Very Low	Up to 50 mm	0



Physically-Based Distributed Model



Example of a Physically-Based Distributed Model

Computer Based Simplistic Model Template for EW

TEMPLATE FOR FLOOD FORECASTING

(A) DECLEARATION OF INDICATOR VERIABLES

OBSERVED RAINFALL MEGHALAYA	FORECASTED RAINFALL	RIVER GAUGE LEVEL	CONDITION OF EMBANKMENTS	OBSERVED RAINFALL- SYLHET
Extremely High flood, above 300 mm rain, 40 points	Extremely High flood, above 300 mm rain, 40 points	Extremely High Level, above 8.00 meter, 10 points	Very Good Condition, 0 point	Extremely High flood, above 200 mm rain, 40 points
Very High flood, 200 to 300 mm rain, 35 points	Very High flood, 200 to 300 mm rain, 35 points	High Flood Level, 7.00 to 7.90 meter, 6 points	Good Condition (needs regular monitoring), 1 point	Very High flood, 175 to 200 mm rain, 35 points
High flood, 150 to 200 mm rain, 30 points	High flood, 150 to 200 mm rain, 30 points	Moderate Flood Level, 6.00 to 6.90 meter, 4 points	Fairly Good Condition (requires some repairing), 2 points	High flood, 150 to 175 mm rain, 30 points
Highly moderate flood, 125 to 150 mm rain, 25 points	Highly moderate flood, 125 to 150 mm rain, 25 points	Low Flood Level, 5.00 to 5.90 meter, 2 points	Vulnerable (immediate reaping works), 3 points	Highly moderate flood, 125 to 150 mm rain, 25 points
Moderate flood, 100 to 125 mm rain, 20 points	Moderate flood, 100 to 125 mm rain, 20 points	Flood Free Level, less that 5.00 meter, 0 points	Critically Vulnerable (external support for repairing), 5 points	Moderate flood, 100 to 125 mm rain, 20 points
Moderately Low flood, 75 to 100 mm rain, 15 points	Moderately Low flood, 75 to 100 mm rain, 15 points			Moderately Low flood, 75 to 100 mm rain, 15 points
Low flood, 50 to 75 mm rain, 10 points	Low flood, 50 to 75 mm rain, 10 points			Low flood, 50 to 75 mm rain, 10 points
Flood Free, less than 50 mm rain, 5 points	Flood Free, less than 50 mm rain, 5 points			Flood Free, less than 50 mm rain, 5 points

(B) GENERATION OF WARNING MESSAGES

FLOOD CATEGORY	WARNING MESSAGES
Extremely High Flood, above 80 points	Crop loss is certain –forced harvesting (as much as they can) recommended without further delay
High Flood, 70 to 80 points	Crop loss is almost certain, – urgent repairing of embankments and forced harvesting of mature crops recommended
Moderate Flood, 60 to 70 points	Crop loss may happen – maintenance and close monitoring of the embankments recommended
Low Flood, 50 to 60 points	Regular maintenance, monitoring and guarding of the embankments recommended
Flood Free, less than 50 points	Regular monitoring and guarding of the embankments recommended

(C) INPUT DATA

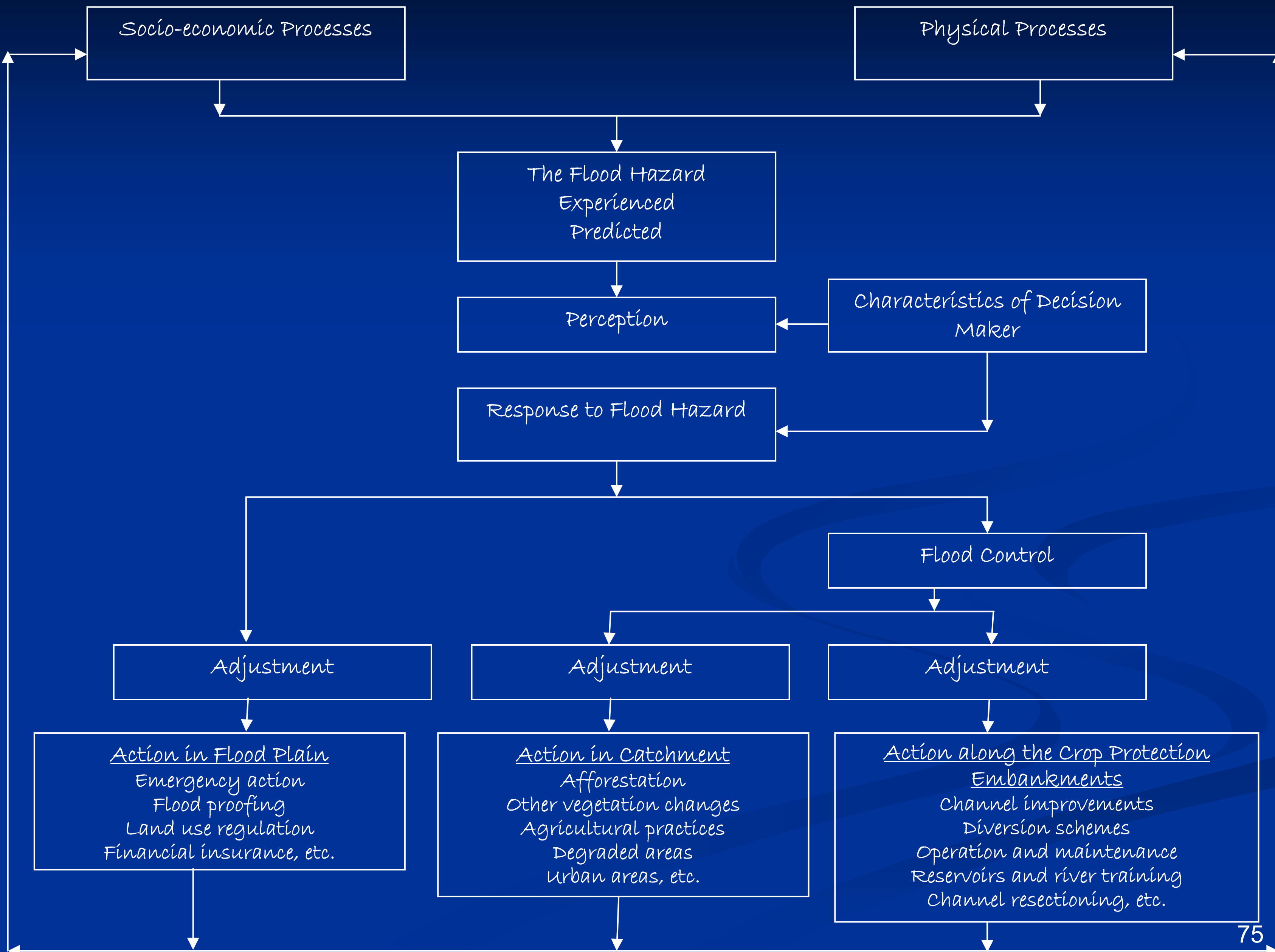
Observed Rainfall in Meghalaya	Forecast Rainfall in Meghalaya	River Gauge Level at Jadukata	Condition of Embankments	Observed Rainfall in Sylhet
130	180	7	2	90

(D) PROCESSING OF WARNING MESSAGES

High Flood - Crop loss is almost certain, – urgent repairing of embankments and forced harvesting of mature crops recommended

Computer Based Simplistic Model Template for Flood Early Warning

Human Response to the Flood Hazards



Warning Generation Dissemination System