FLOOD HAZARD ZONATION
IN
MANIPUR VALLEY

FINAL REPORT

***Submitted to* :**

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C O N T E N T S

Introduction

Manipur Valley (Imphal Valley) located in the central part of the State is nearly oval shaped valley. It virtually comprises of four districts viz. Imphal East, Imphal West, Bishnupur and Thoubal districts. The total geographical area of the valley is 1900 sq. km. that falls within the parallels N 24°16′ to N 25°2′ and meridians E 93°41′ to E 94°9′. It is approximately 60-65 km. long and 30-35 km. wide. Physiographically the terrain is an elevated plain surrounded from all sides by structural hills of disang formation.

Flood is a primary natural hazard in the area during monsoon season damaging the crops and properties of the people. Flash flood occurred almost every year during rainy season due to poor drainage condition. The primary causes of flood in Manipur Valley are heavy run off and less infiltration in degraded watersheds in the upper reaches of the rivers during rainy seasons in the valley.

Manipur Valley is traversed by the major rivers viz., Imphal, Iril, Thoubal, Sekmai, Wangjing, Khuga, Chakpi, Nambul etc. which either fall directly into or indirectly connect (through lakes) with Imphal river which later on known as Manipur river. Thus Manipur Valley is oriented with the Manipur River system. The total catchment area of the Manipur river system is 6332 sq. km., which is the study area of the project.

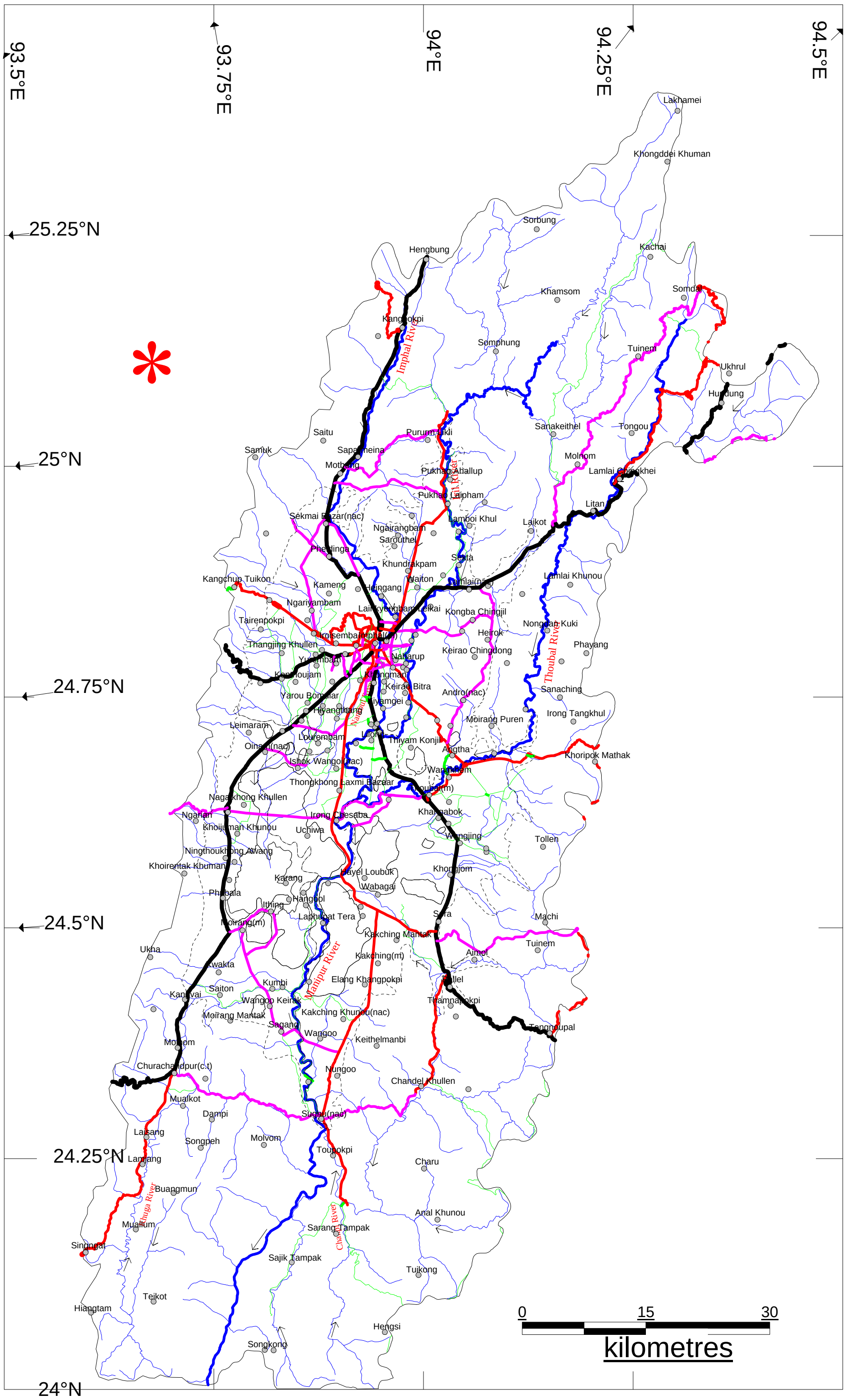
The climate of the study area is sub-tropical monsoon type. The rainy season of the area is quite long starting sometimes in the early part of May and continues up to the middle of October.

Annual rainfall varies from 895 mm to 2135 mm in the valley and up to 3148 mm in the hilly area. Minimum temperature varies from 1° to 10°C and maximum temperature 27° to 36°C. Forest types found in the area are tropical moist deciduous and subtropical pine forests.

Manipur Valley is made up of alluvium of fluvio-lacustrine origin. They are usually dark grey to black in colour. The principal constituents are clay, silt and sand.

Usually almost all the hillocks within the valley and hill ranges within the study area are made up of Disang shales. The Disangs are dark grey to black splintery shales. However, Barials are found in the western hill ranges of the study area and some hillocks inside the Valley have Barail cappings. The Barials are grey to brownish colour sandstone of fine to medium grain size.

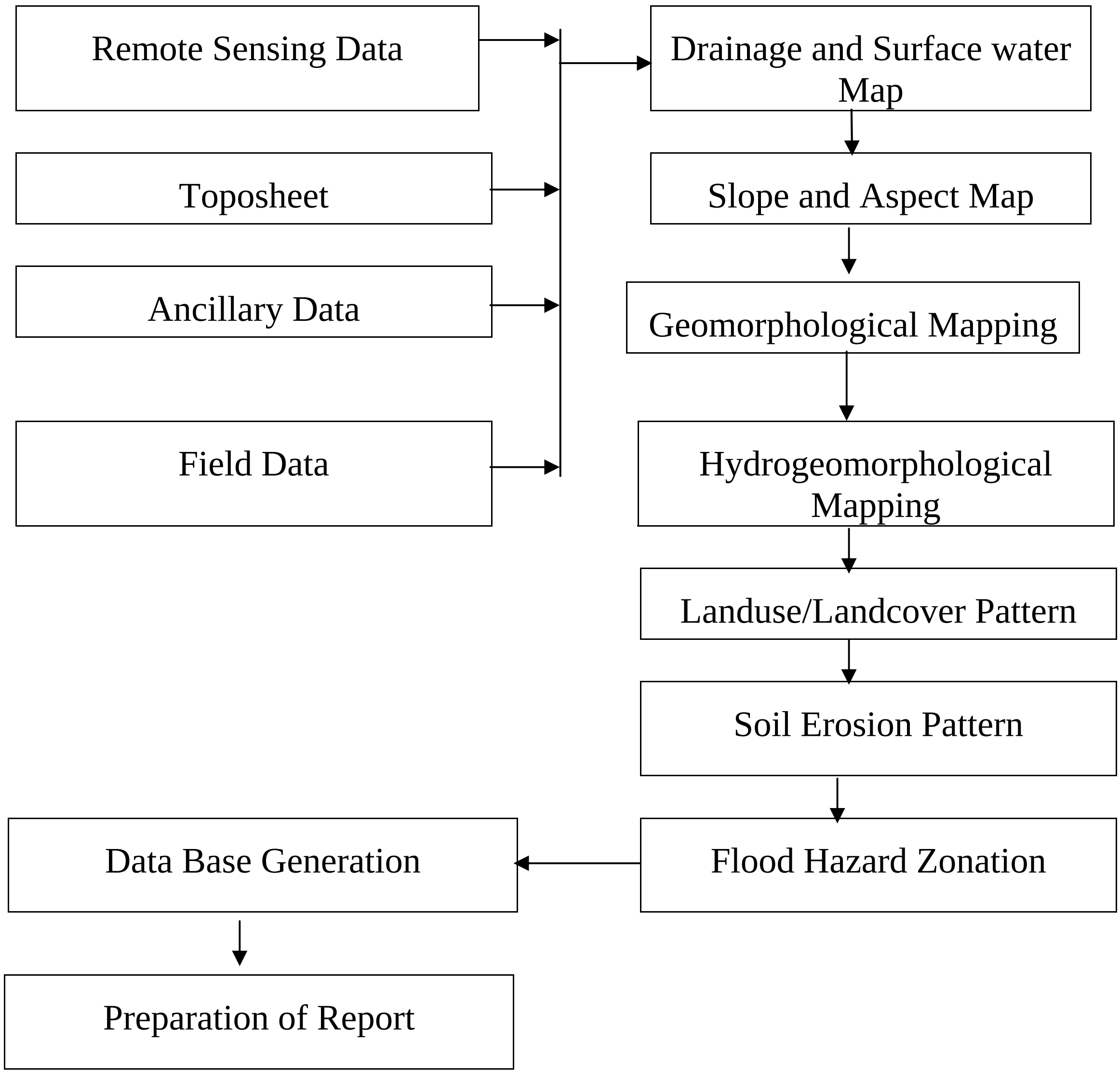
LOCATION(of localities)MAP OF MANIPUR VALLEY
(Catchment Area)



Objectives

1. Identification and mapping of flood prone area.
2. Remedial measures and recommendation thereof.
3. Generation of data base of flood hazard zones/ areas.

Methodology



Flood Records

Flood is a primary hazard in the valley during the monsoon season every year damaging crops and properties of the people. Floods occurred in the valley during the 20th century recorded so far are as follows: -

During September-October 1916 occurrence of flood in Manipur Valley was recorded. Flood occurred on Saturday 30th September and lasted up to Sunday 8th October. The flood affected major areas lying on the eastern side of the Imphal River in the Imphal East district. Some of the areas that were affected by the flood may mention as: Wangkhei, Khurai, Kongba, Porompat, Bamon Leikai, Soibam Leikai etc. Intensity of the flood was severe.

Flood in the Valley was recorded on June 1929 and lasted for three days. The flood was of low magnitude.

Another flood occurred during June 1941. Some of the areas lying on the western side of the Imphal river affected particularly Yaiskul area, due to breach of Imphal River embankment at Moirangkhom. The flood was of moderate magnitude.

Flood also occurred in Manipur Valley during September 1952. Intensity of the flood was moderate. During October 1953 flood of moderate magnitude occurred in the Valley. In 1965 also flood of moderate magnitude occurred in the Valley.

Once again flood occurred in the Valley during June-July 1966 and again on October 1966. In some of the areas such as Hiyanglam, Sugnu, Arong, Nongmaikhong, Wangoo, Tanjeng are inundated from June to October. Breach of embankment took placed at 60 places. The intensity of the flood was severe. The affected areas of the flood are mapped (Map enclosed).

During July-August 1989 flood occurred in Manipur Valley at its devastating worst. Altogether 361 localities were inundated. Breached of embankment took place at 40 places. 7 lakhs of people were affected and 97,500 hectares of paddy fields were damaged. Altogether 49,069 houses were damaged and 41,000 domestic animals were affected due to this flood. Flood affected areas are mapped. The magnitude of the flood was severe.

Again due to the incessant rainfall in the upper catchment area of the major rivers of Manipur Valley, water level of all the rivers rose rapidly from 14th October 1992. The daily precipitation in the form of rainfall on 14th, 15th and 16th October 1992 was very high and heavy discharge occurred in the rivers and caused breached, overtopping and piping at some of the places. Serious breaches took place at 4 different places. Some of the major affected areas were: Keirao, Arapti, Lilong, Mairenkhul, Oinam Laiphrakpam, Atoukhong, Turen Ahanbi, Lou Tara, Sambrukhong, Chandrakhong, Lilong Khunou, Ushoipokpi, Tharoipokpi, Kongba, Khongman, Bamon Leikai, Wangkhei, Phumlou etc. The flood was of moderate magnitude and flood affected areas are mapped.

Flood occurred again in Manipur Valley during September 1997. All the rivers flowing through Manipur Valley were rising rapidly from 25th September 1997. Breaches of embankments took place at four different places of Nambul River, two places of Wangjing River, one place of Merakhong River, two places of Imphal River, two places of Thongjaorok River, one place of Khujairok River and one place of Khabi River.

Major affected areas were: Pukhrambam, Thounaojam, Lourembam, Samurou, Wangoi, Wangjing, Tentha, Konthoujam, Lansonbi, Karam, Narankonjil, Oinam, Nungei, Irong, Karam Loukol, Kwasiphai, Irengbam, Yumnam Khunou, Phoijing, Bomdiar, Okram, Wangmataba, Phoudel, Haokha, Moijing, Ningombam, Khekman, Sagolband, Uripok, Khwairamband Bazar, Langthabal, Pukhrambam, Lourembam, Thounaojam, Sanjenbam etc.

Due to the flood, damage caused to houses rose up to 4965 numbers. The flood was of high magnitude and affected areas are mapped.

In 1998 flood occurred hardly in the Valley. However in August, breach of river embankment took place at one place of Wangjing River, as a result inundating the areas of Lamding Nashikhong, Lamding Laishram Leikai and some adjoining areas. Inundation also took place at some areas of Iroisemba during July 1998. Magnitude of the flood was low.

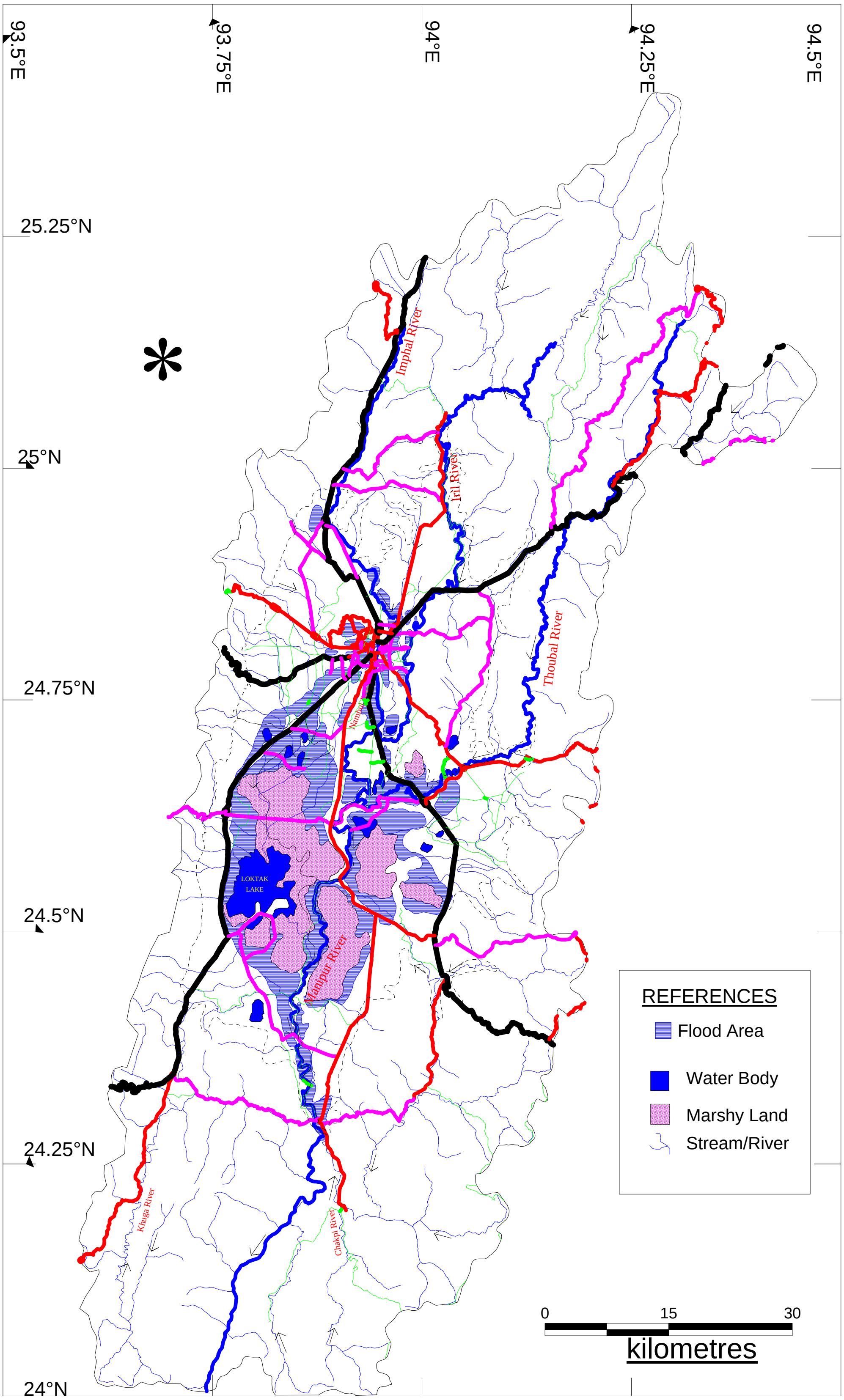
As usual, flood occurred in Manipur Valley during September 1999. There was incessant rainfall from 24th August to 3rd September 1999. The flood mainly affected the southern parts of the Valley. Not less than 7,300 houses and 15,300 hectares of paddy fields are affected. Major affected areas were : Thoubal Leisangthem, Khellakhong, Tentha, Heibong Makhong, Mayang Imphal, Uchiwa, Thoubal Athokpam, Andro, Hayeng, Hangoon, Santhel, Sekmaijing Khunou, Upokpi, Ithai, Laphupat Tera, Ngaikhong Khullen, Wangoo, Wabagai, Thounaojam, Moirang Konjengbam, Thanga part I & II and Karang. The flood was of moderate magnitude. Flood affected areas are mapped.

Flood occurred again in Manipur Valley during September 2000. Breaches of river embankment take place at 30 different places. Not less than 2,400 houses and 7,800 hectares of paddy field are affected. Breaches of river embankment take place at 11 places of Thoubal River, 6 places of Wangjing River, 2 places of Arong River, 2 places of Sekmai River and 3 places of Manipur River. Major affected areas were: Lamlai, Andro, Ngariyan Muslim & Kabui Loukol, Angtha Khunou Loukol, Wangkhem, Yairipok, Nepra, Khangbok, Thoubal; Okram, Ningombam, Haokha, Kiyam, Phoudel, Kshetri Leikai, Khekman, Moijing, Sabal Tongba, Leisangthem, Kiyam, Irong, Wangjing, Kakching, Wabagai, Hiyanglam, Sekmaijing, Arong-Nongmaikhong, Khordak, Wangoo, Thamnapokpi, Moirang, Maibam Uchiwa, Heibong Makhong, Khellakhong, Hayeng-Hangoon, Santhel and Kongba Laishram Leikai. The flood was of moderate magnitude. Flood affected areas are mapped.

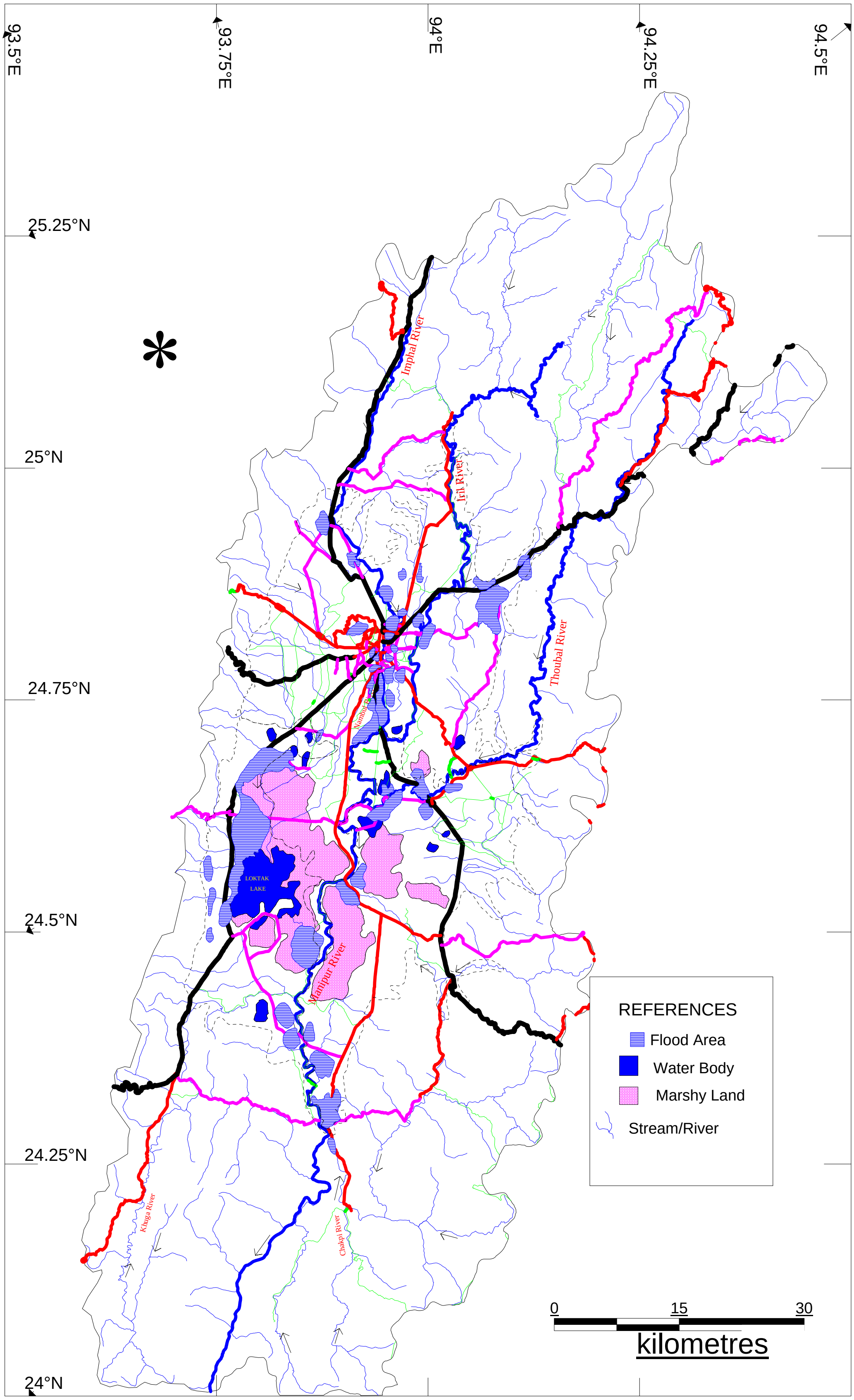
In the year 2001 flood of low magnitude occurred in some parts of Manipur Valley. On 7th June breach of embankment of Nambol River took place at Nambol, Kongkham: inundating Kongkham, Sabal Leikai, Maibam and Naorem. On 1st July Nambul River overflowed, inundating Uripok and Khwairamban Bazar. On 3rd July, Chandranadi River, a tributary of Nambul River overflows on the southern side, inundating cultivated lands of Chajing, Haoreibi and Karam.

During August 2002 a severe flood was occurred in Manipur valley. Breach of embankment took place at 59 places. Due to incessant rain in the catchments, all the rivers flowing in and around Imphal, Thoubal and Bishnupur districts were rising from August 11, 2002. On August 13, 2002, the water levels in all major rivers/streams in Manipur valley were rising alarmingly crossing the R.F.L on the same day. The water levels of the major rivers were so high on the above day that even the deckings of the bridges on the rivers were badly submerged under water. The flood mainly occurred in the south eastern parts of Manipur valley. About 10,000 houses and 20,000 hectares of paddy fields were affected. The flood affected areas are mapped.

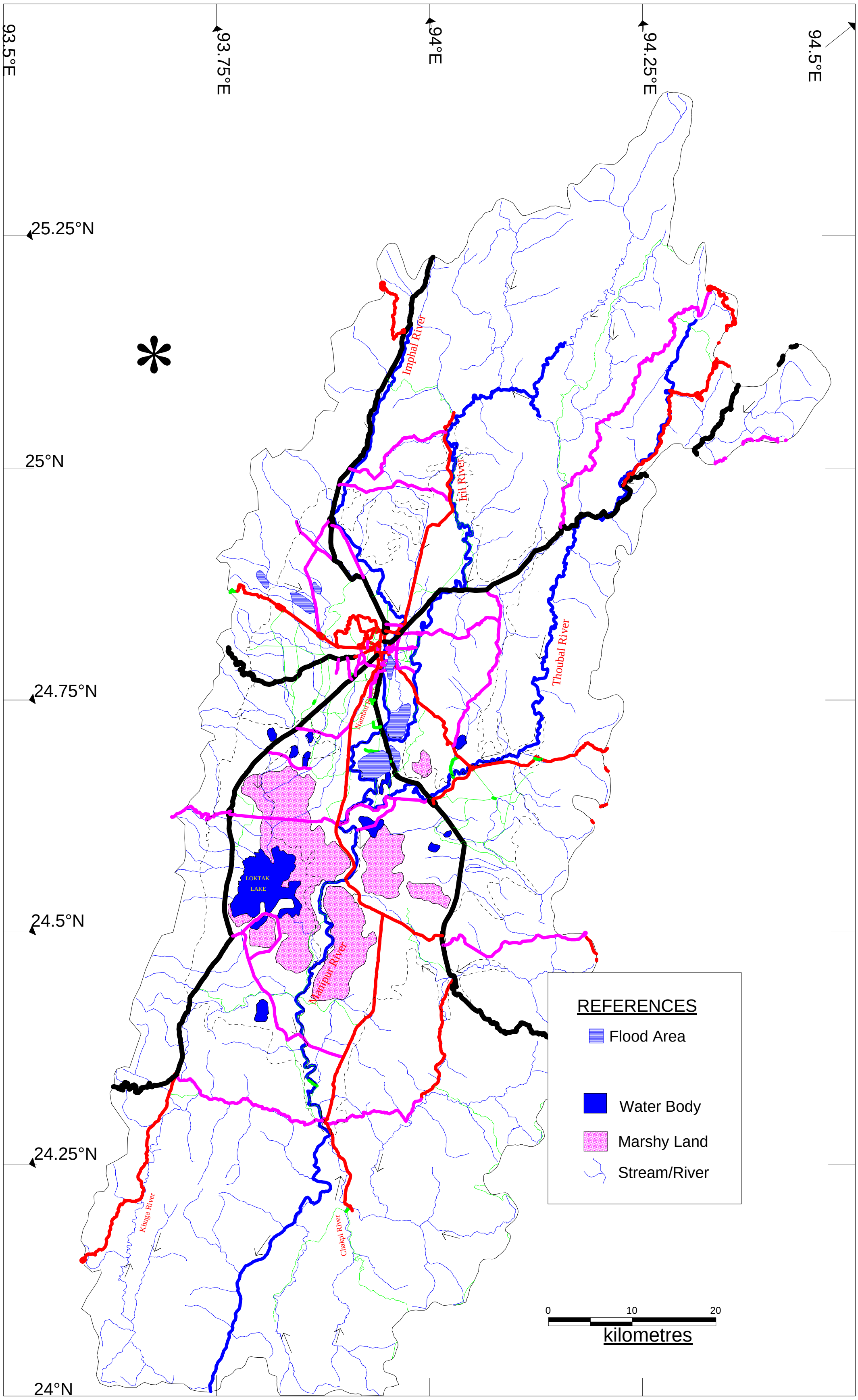
EXTENT OF FLOOD IN MANIPUR VALLEY DURING JUNE-JULY 1966



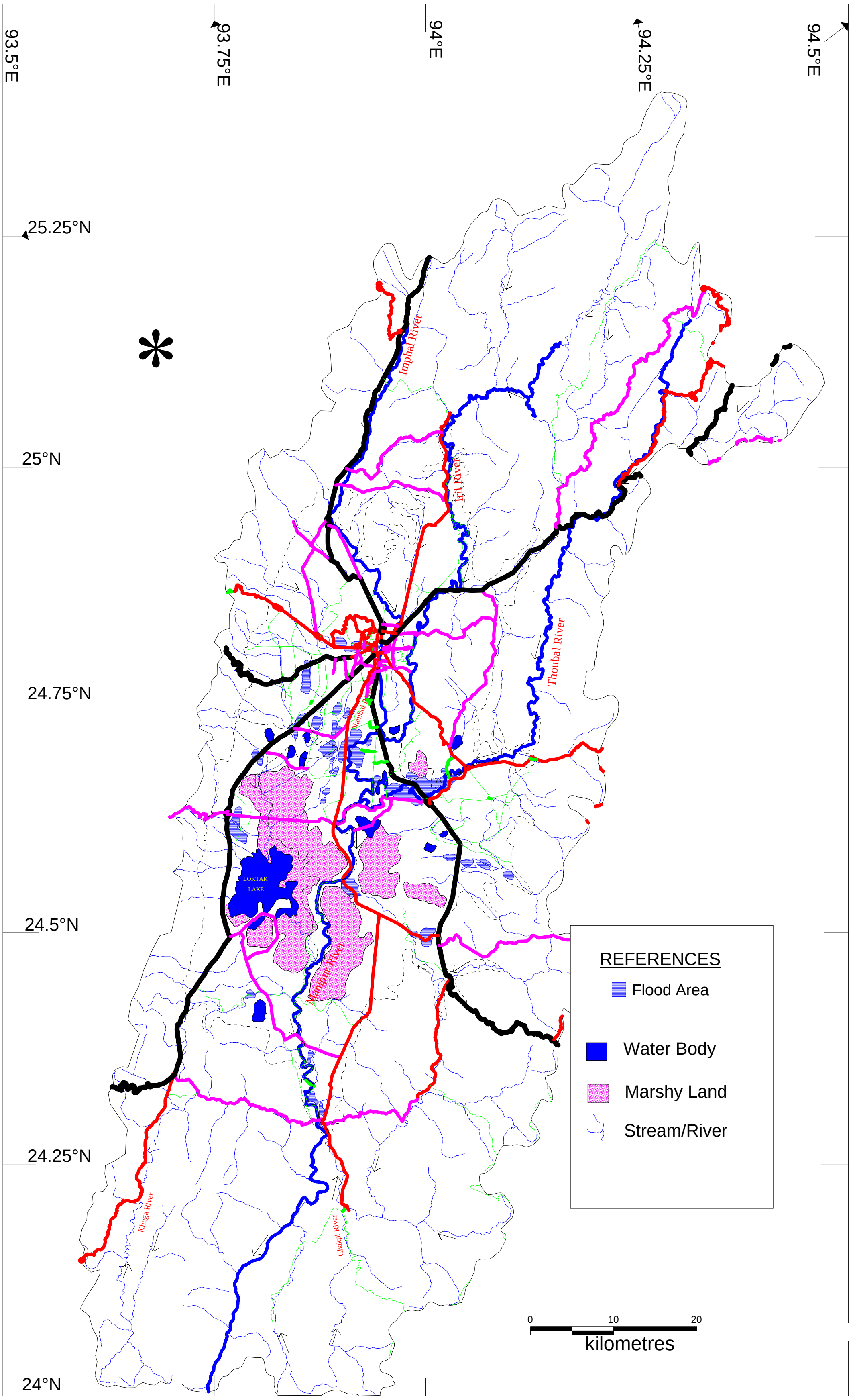
EXTENT OF FLOOD IN MANIPUR VALLEY DURING JULY-AUGUST 1989



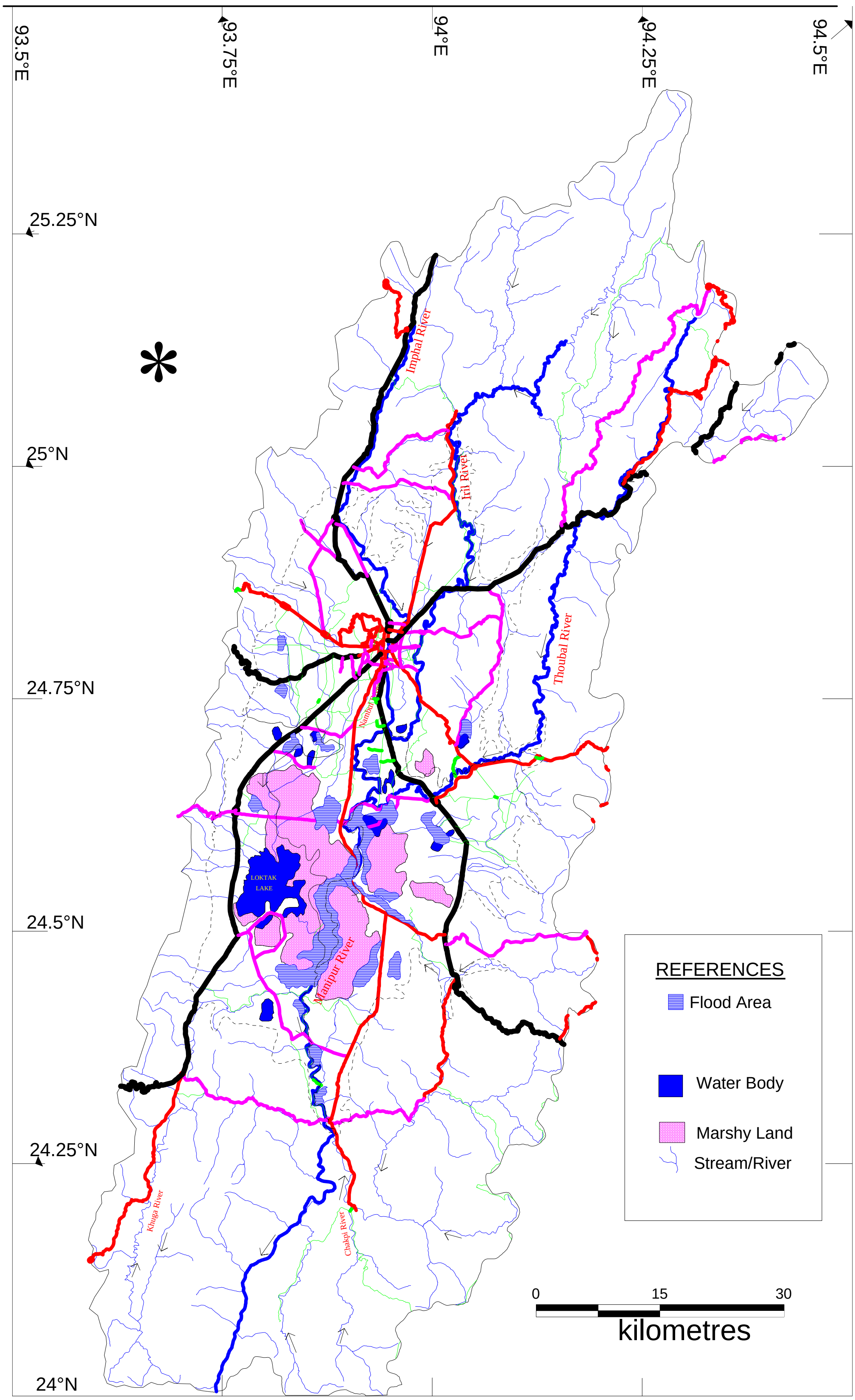
EXTENT OF FLOOD IN MANIPUR VALLEY DURING OCTOBER 1992



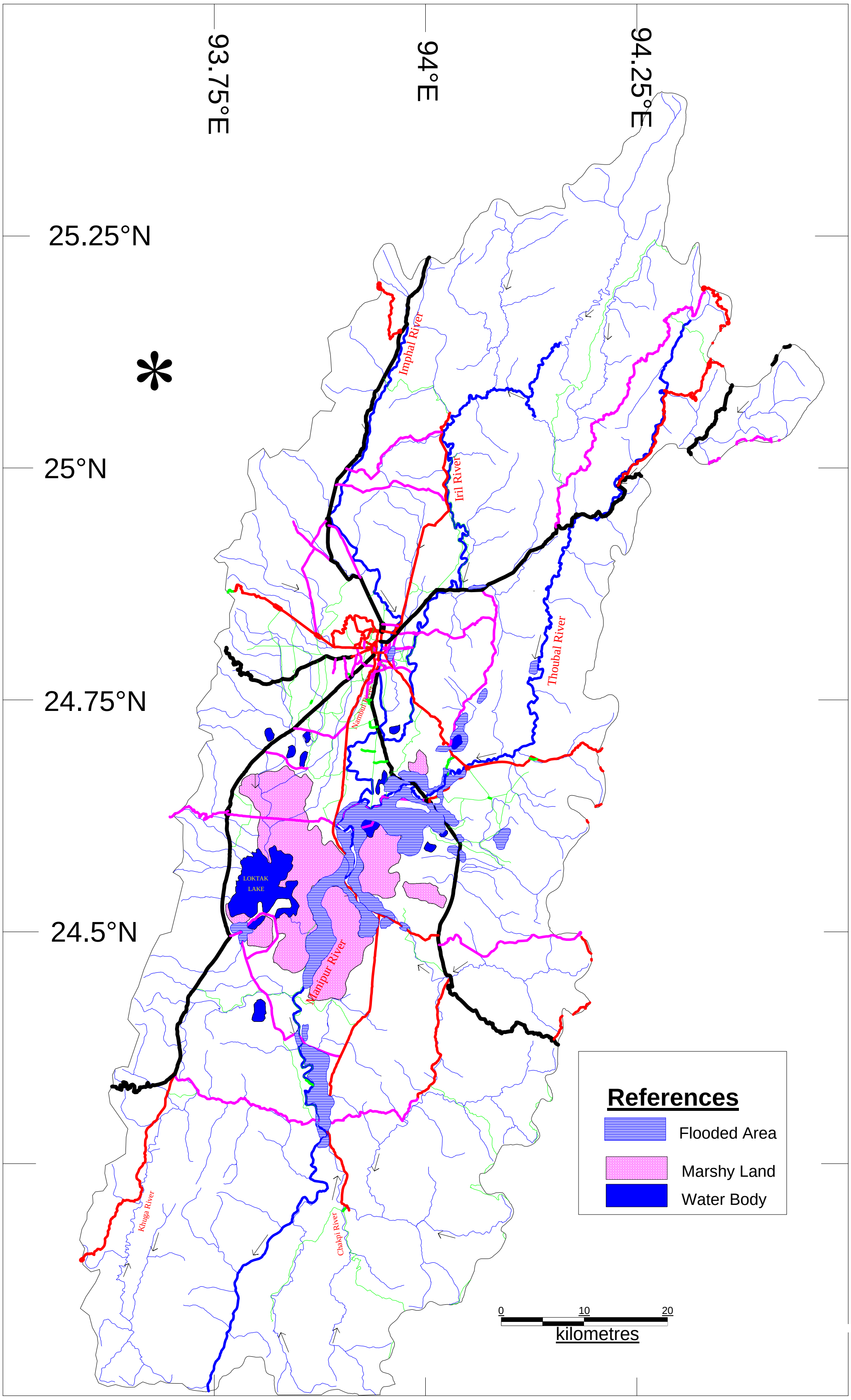
EXTENT OF FLOOD IN MANIPUR VALLEY DURING SEPTEMBER 1997



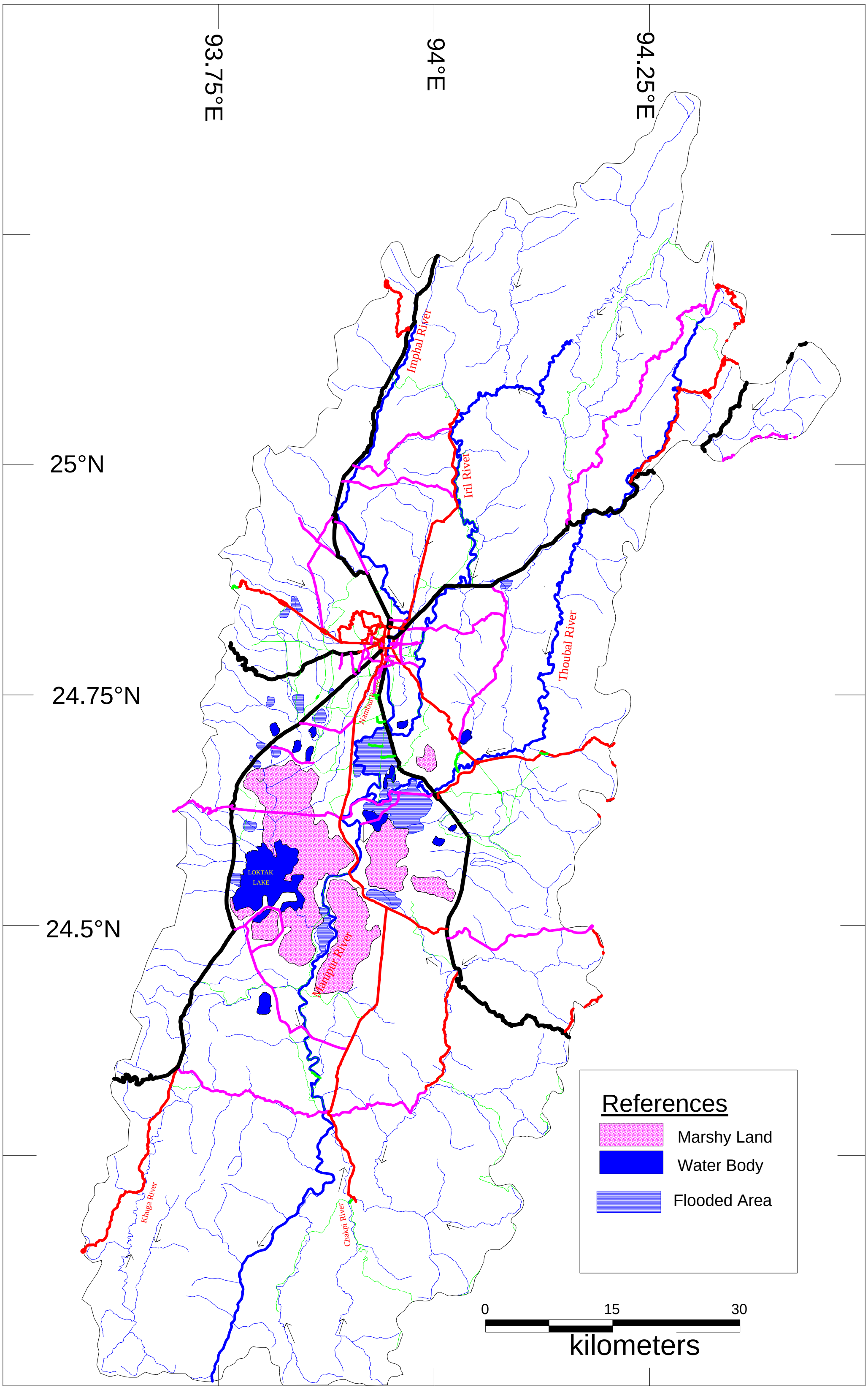
EXTENT OF FLOOD IN MANIPUR VALLEY DURING SEPTEMBER 1999



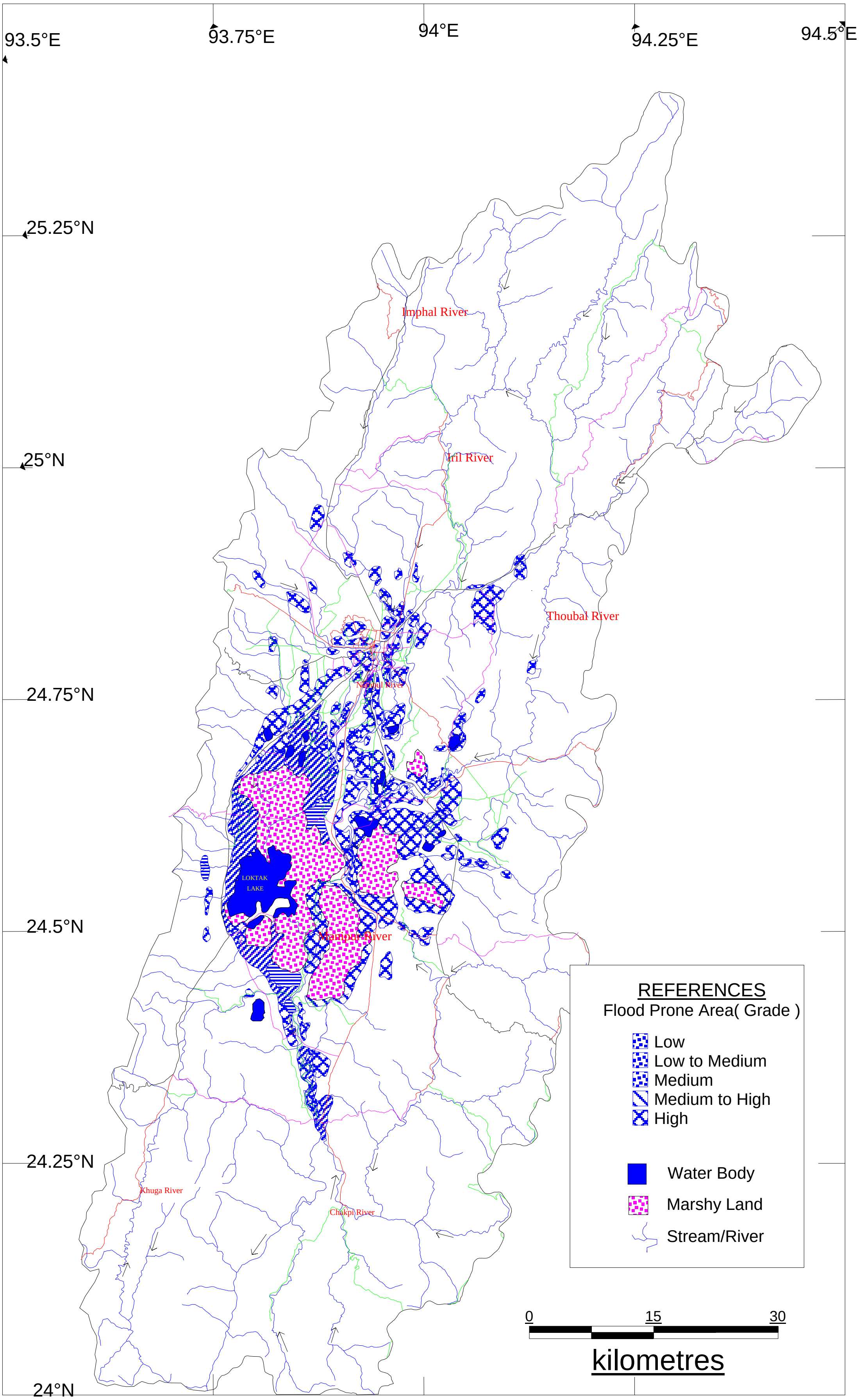
EXTENT OF FLOOD IN MANIPUR VALLEY DURING SEPTEMBER 2000



EXTENT OF FLOOD IN MANIPUR VALLEY DURING AUGUST 2002



FLOOD HAZARD ZONATION MAP OF MANIPUR VALLEY (CATCHMENT AREA)



Meteorological data analysis

Rainfall is the most important parameter for the analysis of flood. Rainy season in the study area, starts from May and extent up to October. Monthly rainfall data for Imphal Valley from 1975 to 2000 is given in table 1.

Highest monthly rainfall was recorded in July 1989 with an intensity of 461.9 mm. However, intensity of rainfall in June 1966 was 669.7 mm. Highest average monthly rainfall (during 1975-2000) occurred during the month of July with an intensity of 241.28 mm of rainfall, June in the 2nd rank with an intensity of 236.06 mm of rainfall. August with 190.02 mm and September with 149.27 mm of rainfall occupy the 3rd or 4th ranks.

1991 got highest annual rainfall with an intensity of 2134.5 mm of rainfall Total average of yearly rainfall is 1416.9 mm.

Flood occurred in the year of 1966, 1989, 1992, 1997, 1999 and 2000. Year 1989 and 2000 got above average yearly rainfall.

In 1989 highest daily rainfall of Imphal occurred on 30th July with 158.6 mm of rainfall. There was continuous daily rainfall from 28th July to 1st August. Total rainfall during July 1989 was 461.9 mm. Flood occurred from 30th July 1989.

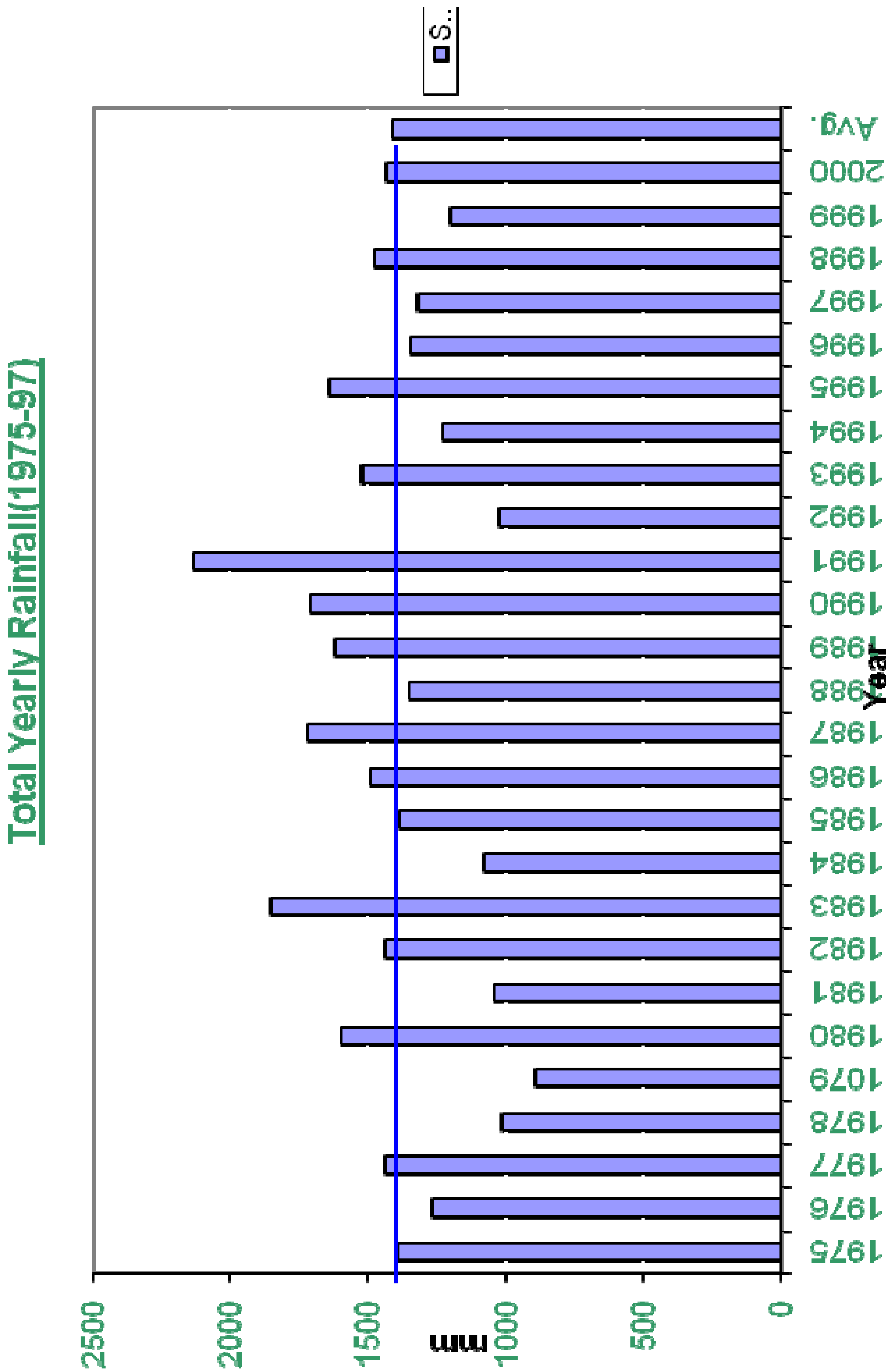
Highest daily rainfall in 1992 occurred on 16th July with 58.4 mm of rainfall. Continuous daily rainfall occurred from 13th October to 17th October. Total monthly rainfall during October 1992 was 143.3 mm. Flood occurred from 15th October.

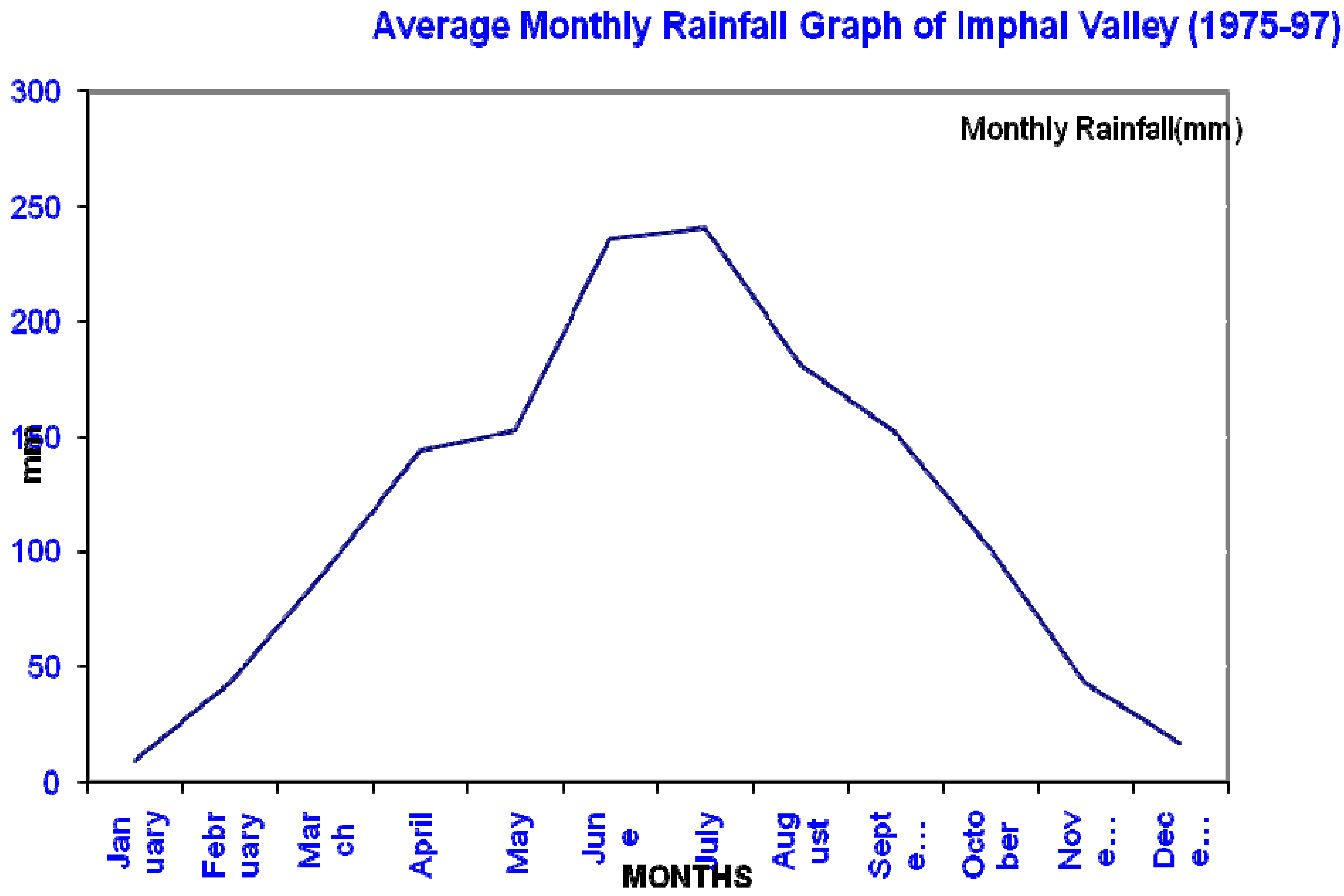
Highest daily rainfall in 1997 occurred on 27th September with 79.6 mm of rainfall. Total monthly rainfall during September was 317.8 mm. There was continuous daily rainfall from 22nd September to 28th September. Flood occurred from 28th September.

Total monthly rainfall during August 1999 was 267.8 mm. There was continuous daily rainfall from 24th August to 3rd September. Flood occurred during September 2nd to 10th.

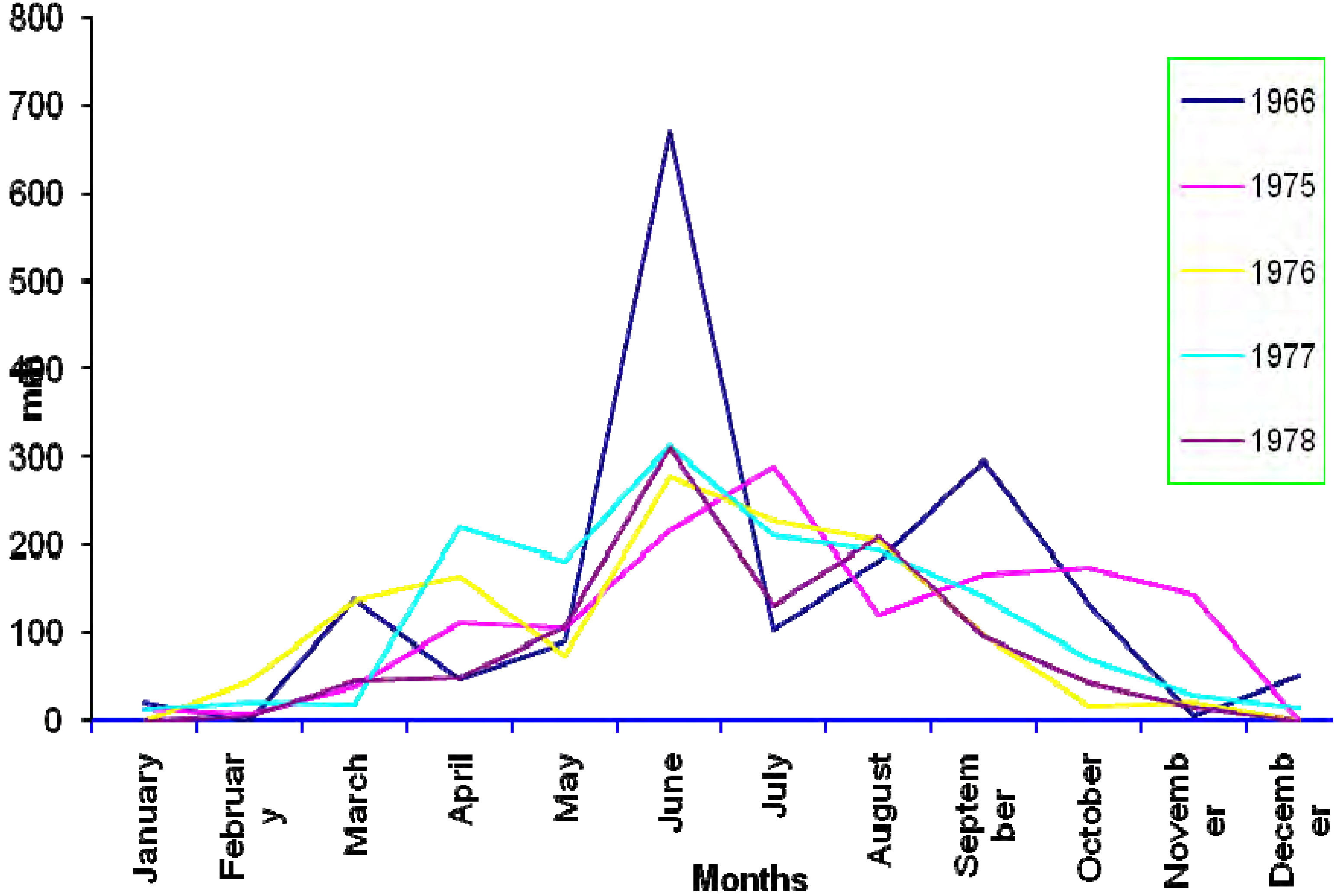
In 2000 total monthly rainfall of August was 168.5 mm and for the month of September it was 177 mm. Continuous average rainfall observed from 26th August to 6th September. Flood occurred from 2nd to 9th September.

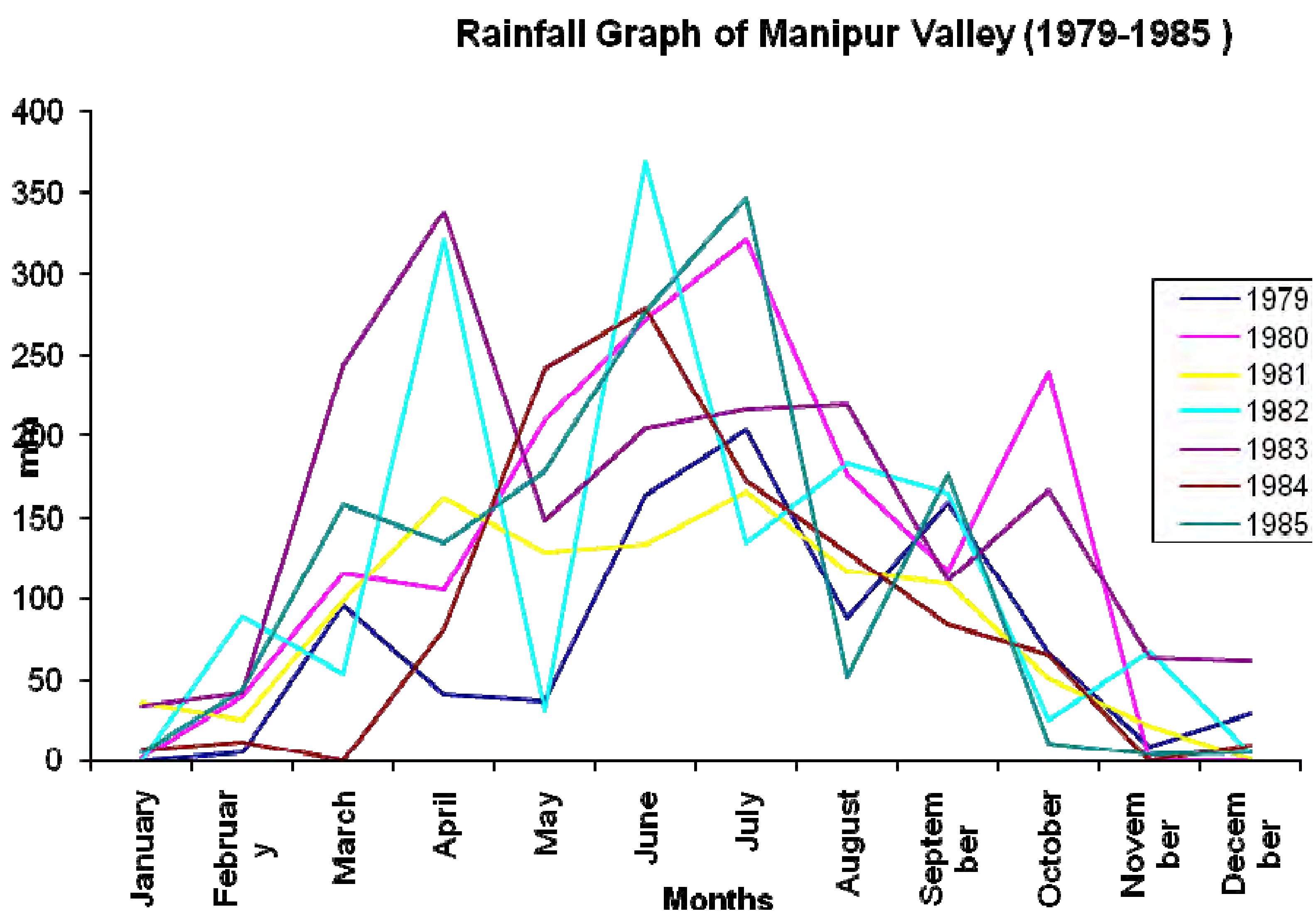
Total monthly rainfall for the month of June 2001 was 363.5mm. There was continuous daily rainfall from 31st May to 23rd June and from 27th June to 30th June. On 6th June 48.1 mm of rainfall and on 2nd July 7.5 mm of rainfall occurred.

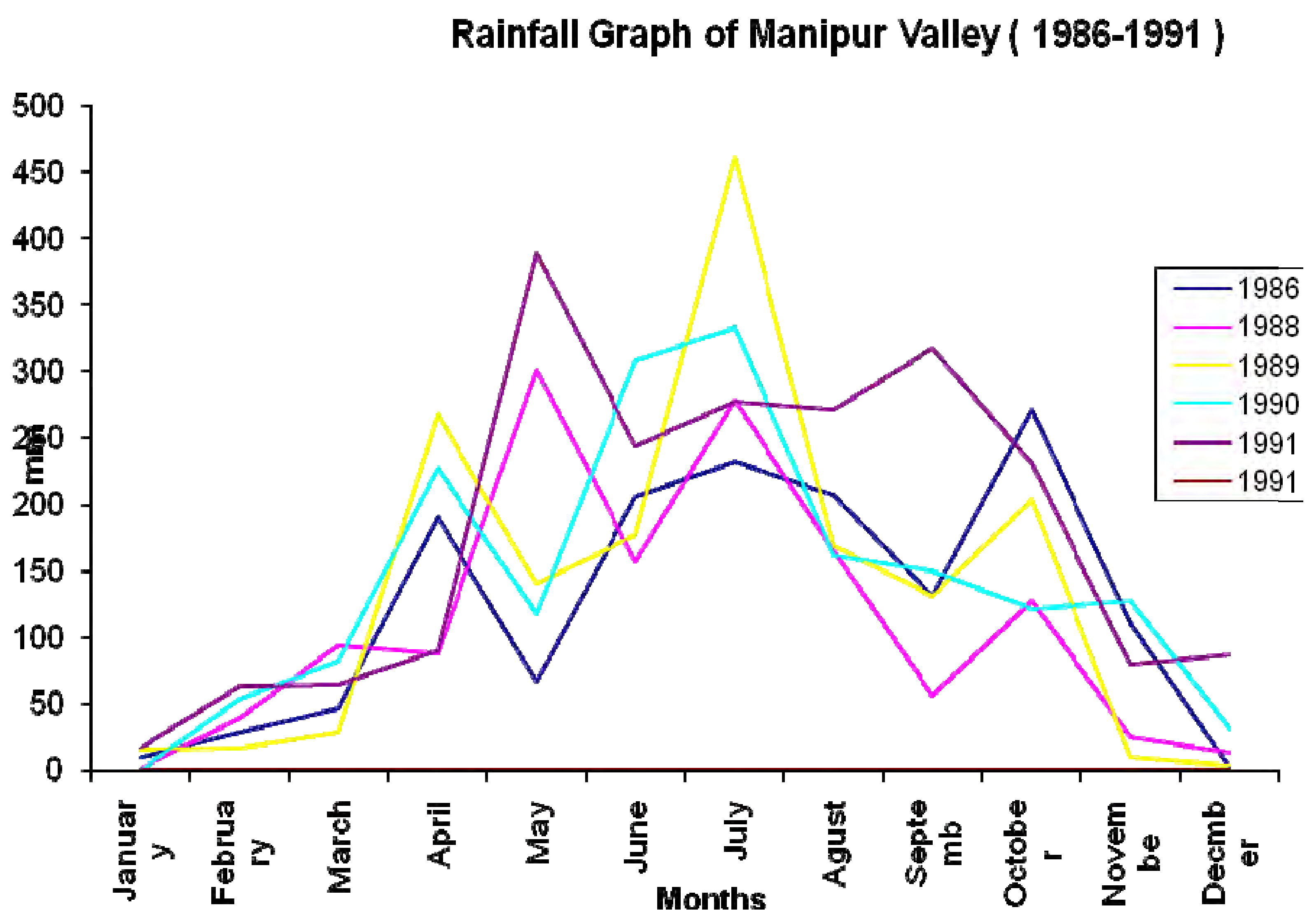

Total Yearly Rainfall(1975-97)
mm
2500
2000
1500
1000
500
0
Year
Avg.
S..

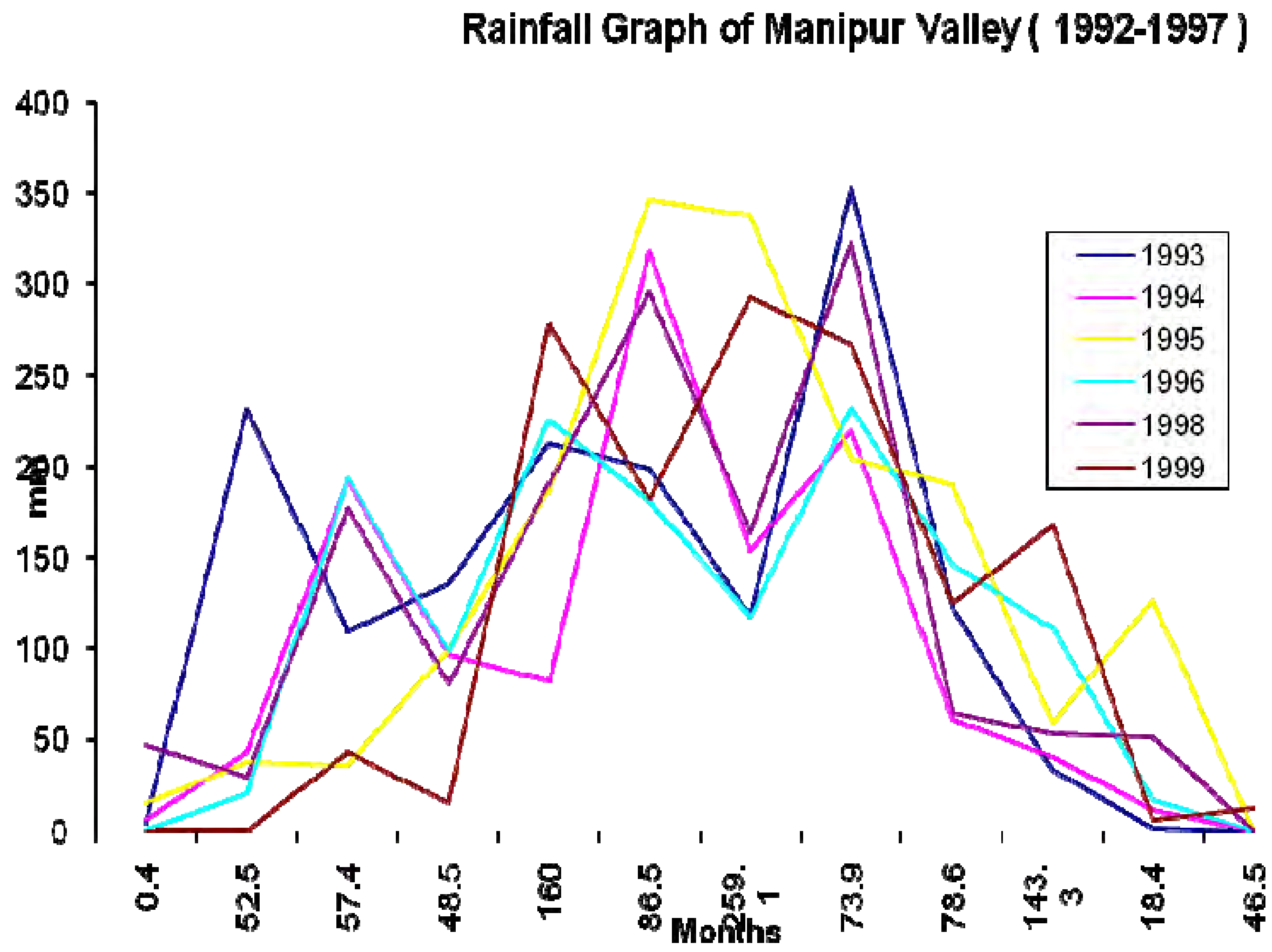

Average Monthly Rainfall Graph of Imphal Valley (1975-97)
Monthly Rainfall(mm)
mm
300
250
200
150
100
50
0
Jan uary
Febr uary
Mar ch
April
May
Jun e
July
Aug ust
Sept e...
Octo ber
Nov e...
Dec e...
MONTHS

Rainfall Graph of Manipur Valley (1966,1975-1978)

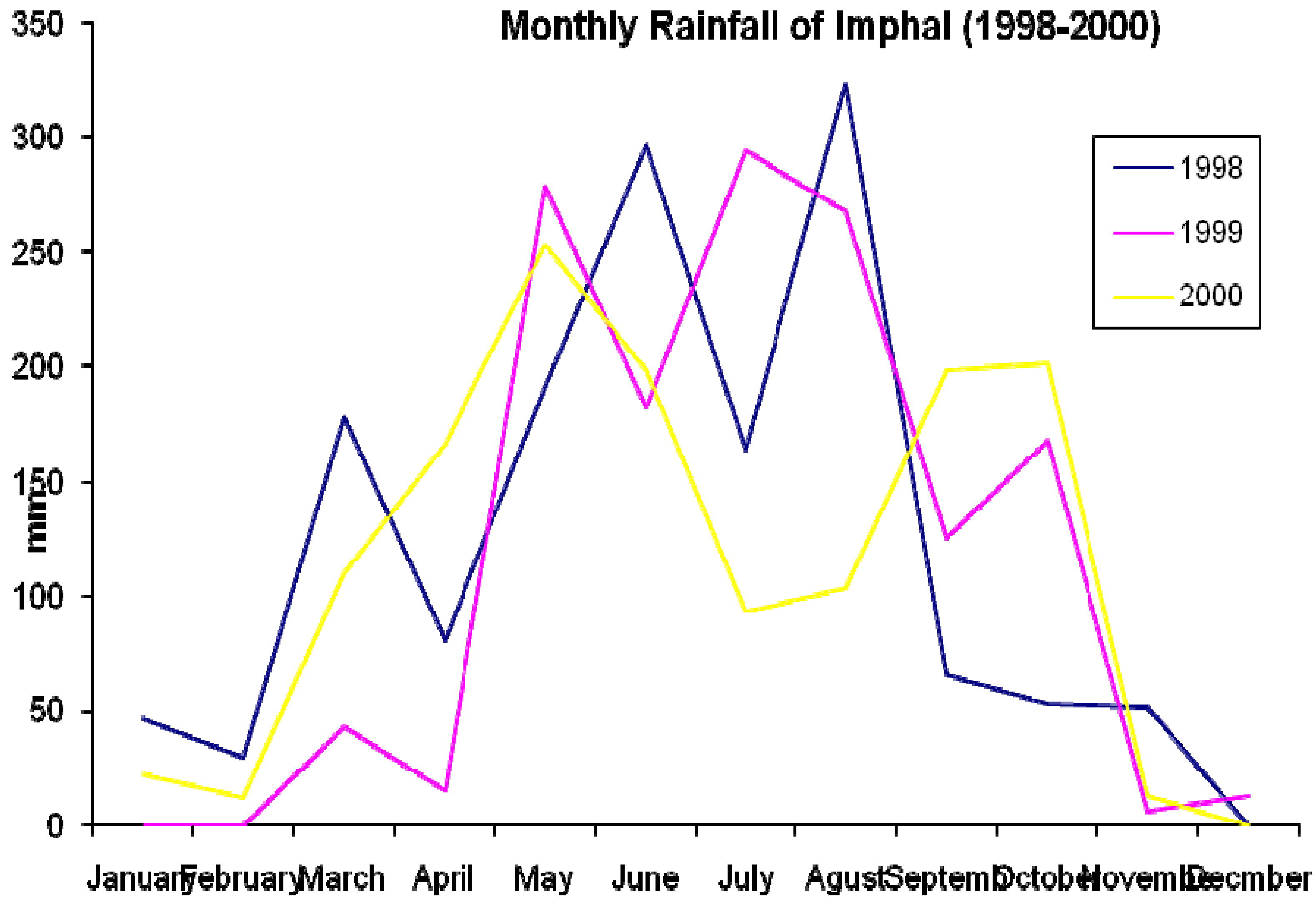



Rainfall Graph of Manipur Valley (1979-1985)
400
350
300
250
200
150
100
50
0
mm
January
Februar y
March
April
May
June
July
August
Septem ber
October
Novem ber
Decem ber
Months
1979
1980
1981
1982
1983
1984
1985

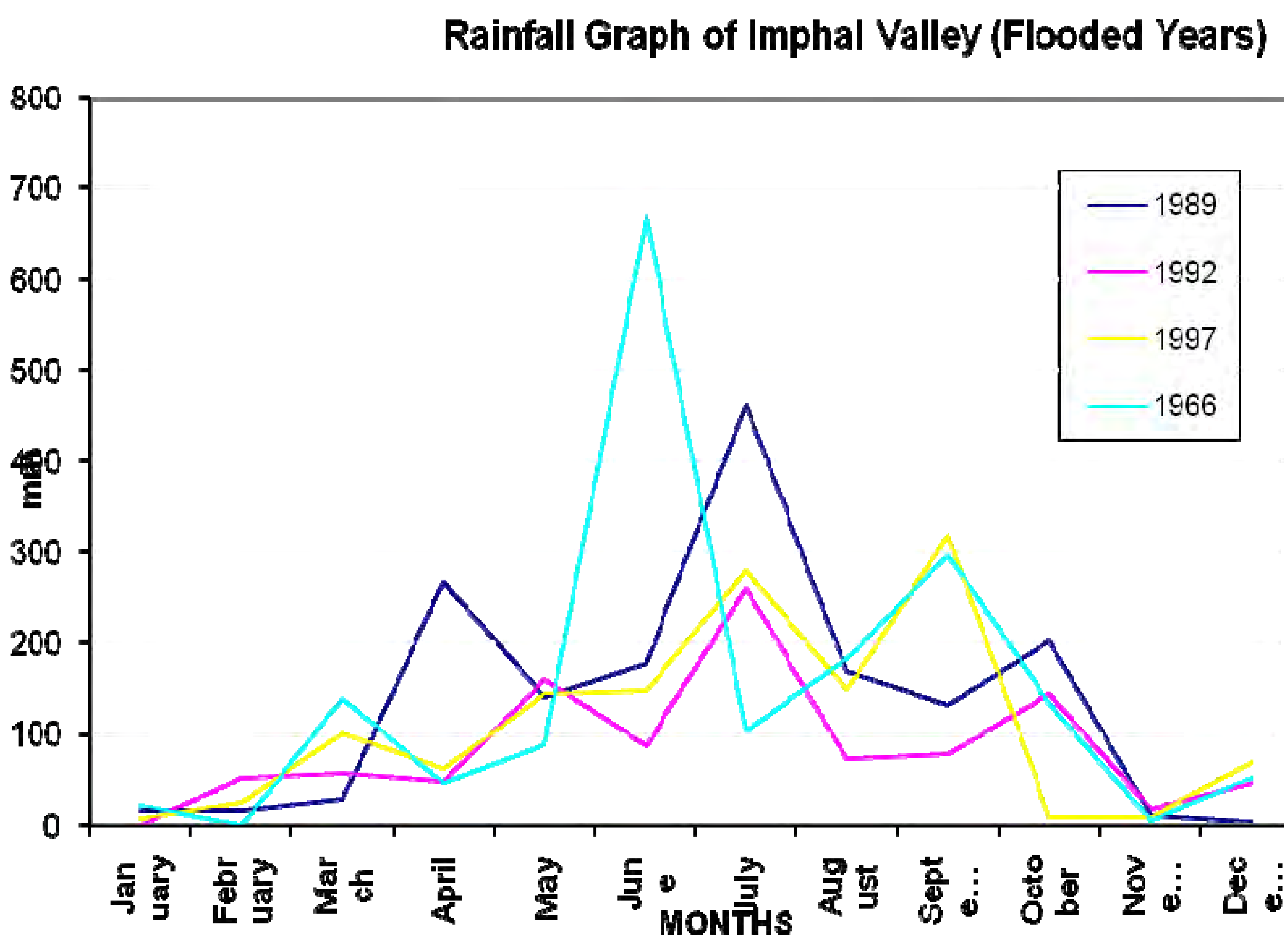

Rainfall Graph of Manipur Valley (1986-1991)
mm
500
450
400
350
300
250
200
150
100
50
0
Januar y
Februa ry
March
April
May
June
July
Agust
Septe mb
Octobe r
Novem be
Decmb er
Months
1986
1988
1989
1990
1991
1991

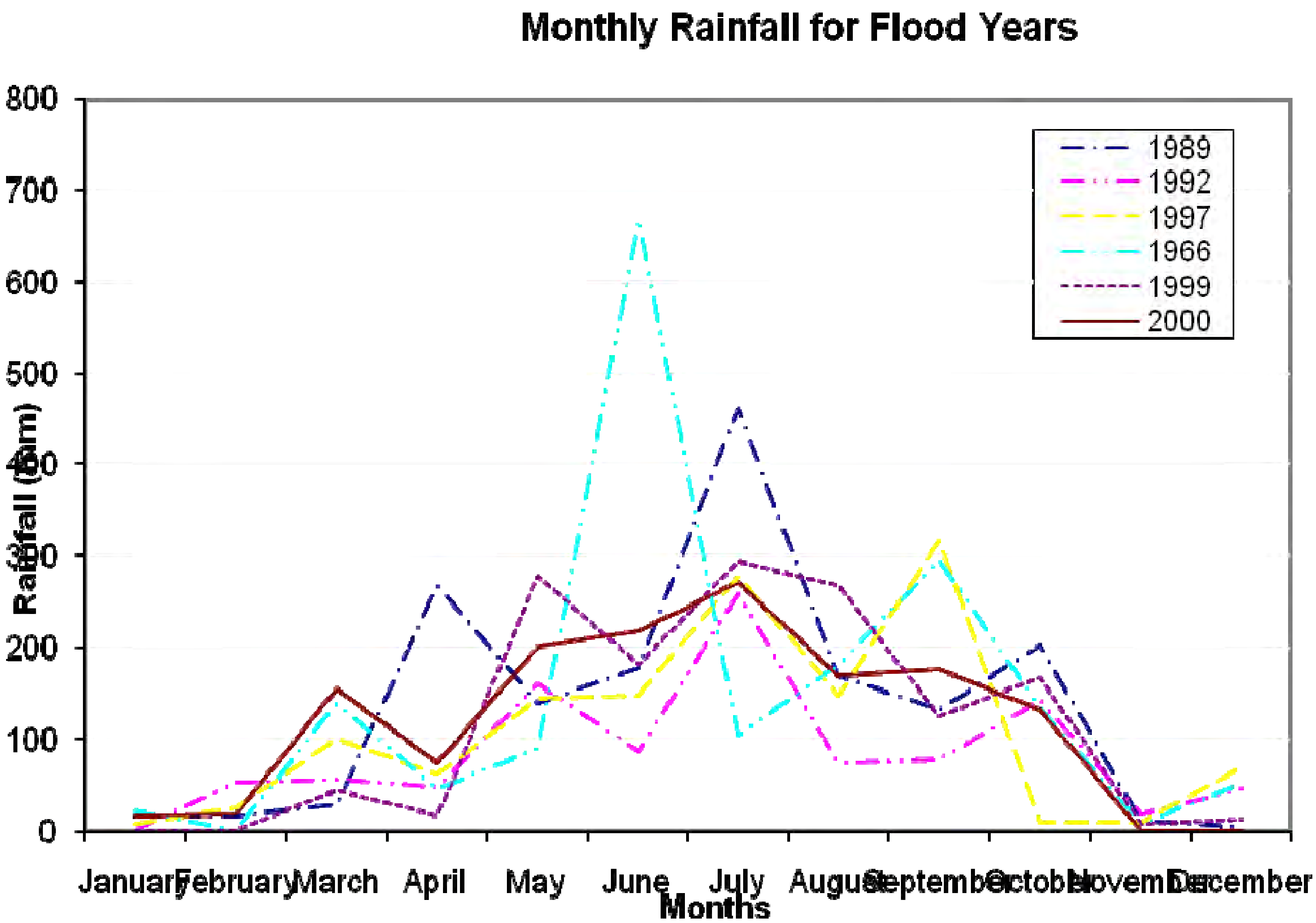


Rainfall Graph of Manipur Valley (1992-1997)
400
350
300
250
200
150
100
50
0
mb
0.4
52.5
57.4
48.5
160
86.5
259.
1
73.9
78.6
143.
3
18.4
46.5
Months
1993
1994
1995
1996
1998
1999



Monthly Rainfall of Imphal (1998-2000)
350
300
250
200
150
100
50
0
mm
January
February
March
April
May
June
July
Agust
Septem
October
November
Decmber
1998
1999
2000


Rainfall Graph of Imphal Valley (Flooded Years)
800
700
600
500
400
300
200
100
0
mm
1989
1992
1997
1966
Jan uary
Febr uary
Mar ch
April
May
Jun e
July
Aug ust
Sept e...
Octo ber
Nov e...
Dec e...
MONTHS



Monthly Rainfall for Flood Years
Rainfall (mm)
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December
Months
1989
1992
1997
1966
1999
2000

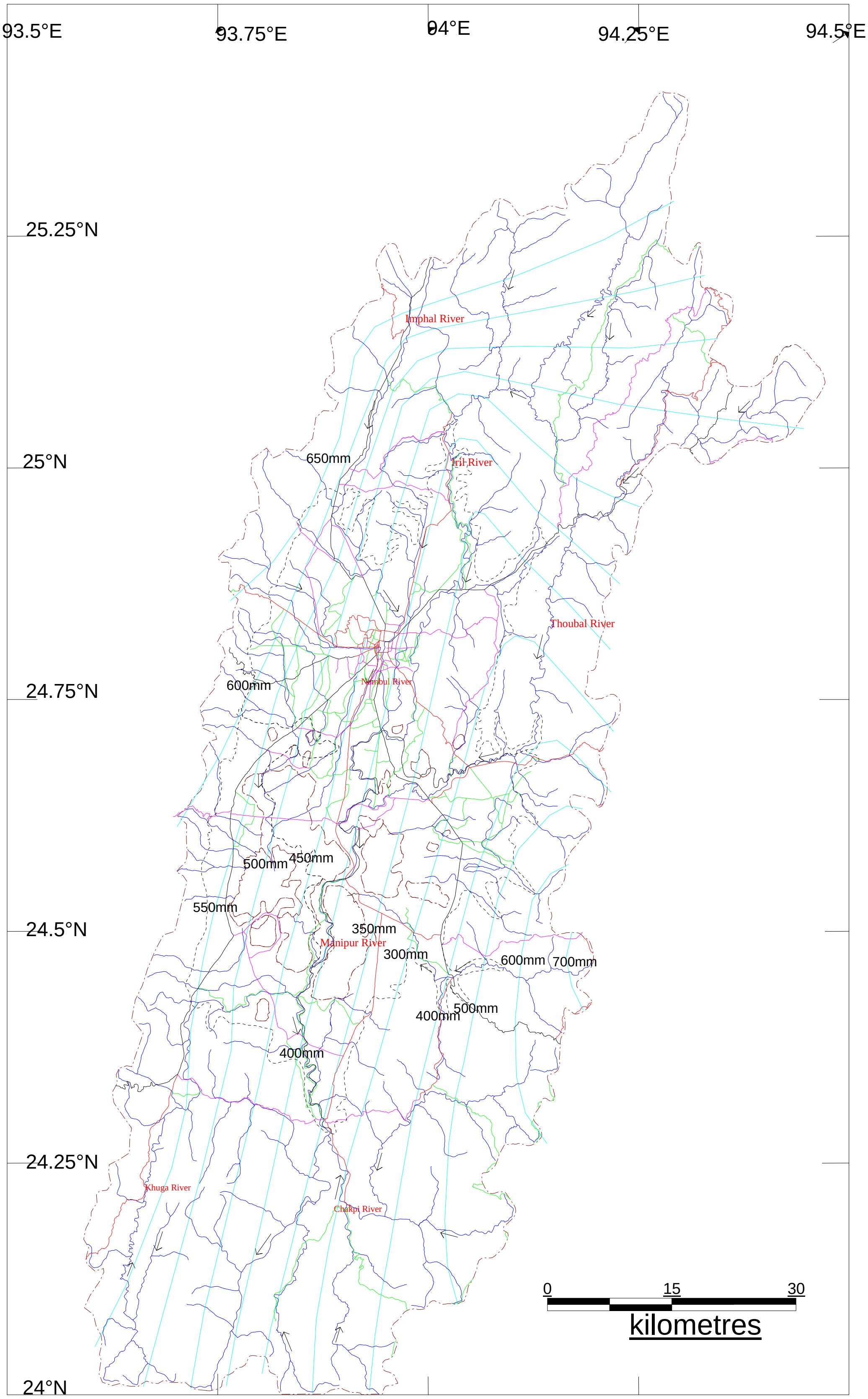
Isohyetal Maps

From the isohyetal maps of study area, for the month of July 1989 (map enclosed), the northern areas i.e. the upper catchment of Imphal, Iril and Thoubal Rivers; the main major rivers of the Manipur Valley, got more rainfall. Intensity of rainfall in Kangpokpi, Saikul and Litan were 617.6mm, 425mm, and 447.9mm respectively. In the southeastern side of the study area i.e. the upper catchment area of Sekmai and Chakpi rivers rainfall reached up to 700 mm.

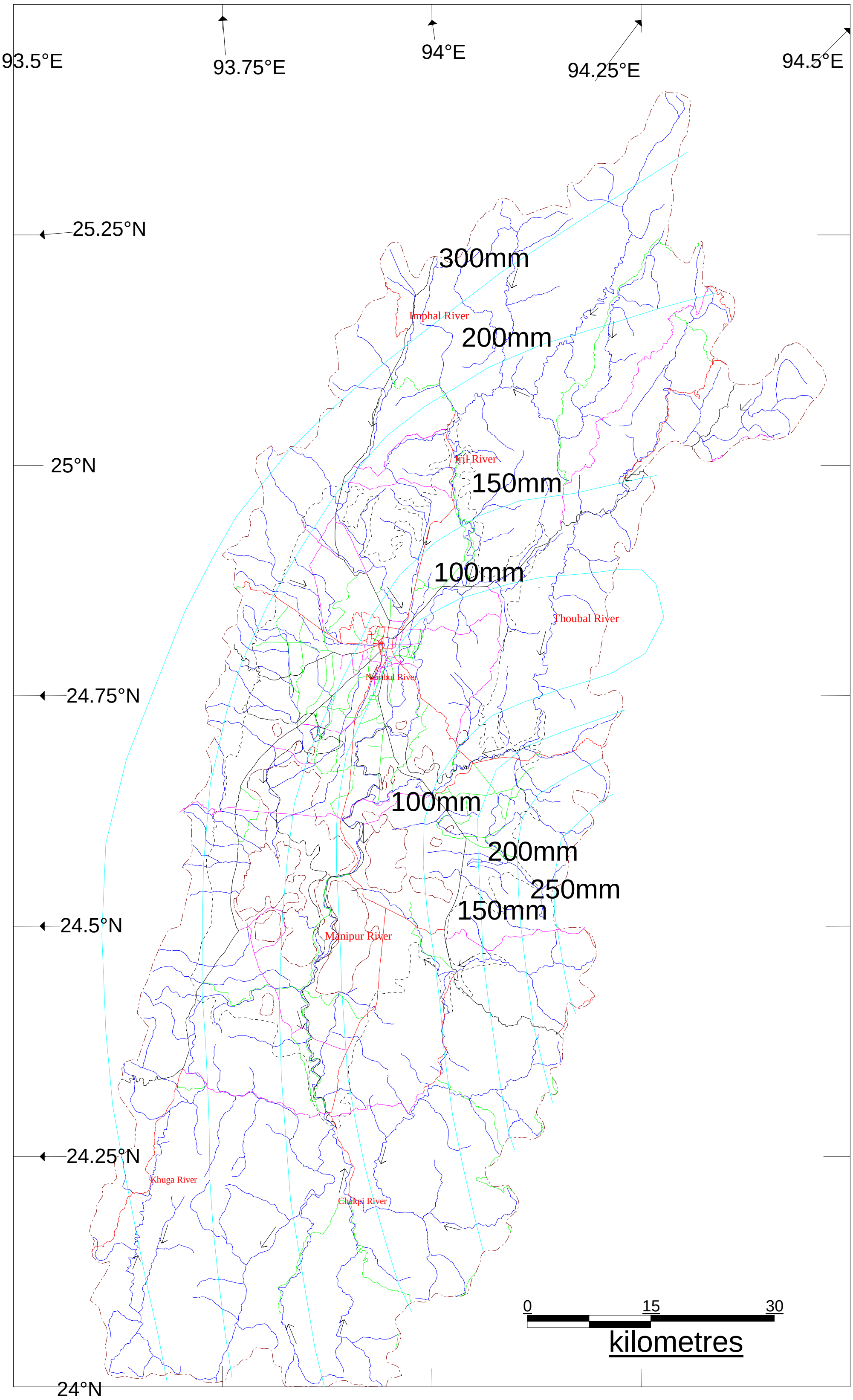
Again from the isohyetal map of study area for October 1992 (map enclosed), high rainfalls were recorded in the northern parts i.e. the upper catchments area of Imphal, Iril and Thoubal rivers. In the south-western and south-eastern parts high rainfall are observed, which are the upper catchment areas of Khuga, Sekmai and Ckhakpi Rivers.

Thus high intensity of rainfall is observed in the hilly areas i. e. the upper catchnent of various rivers drain through Manipur Valley. Hence the rivers have high discharge during the rainy season. This is the main factor, which causes flood in the Manipur Valley.

ISOHYETAL MAP OF MANIPUR VALLEY(Catchment Area) For The Month of July 1989



ISOHYETAL MAP OF MANIPUR VALLEY(Catchment Area)
For The Month of October 1992



Rainfall frequency for Imphal

The purpose of the frequency analysis of an annual series is to obtain a relation between the magnitude of the event and its probability of exceedence.

A simple empirical technique is to arrange the given annual extreme series in descending order of magnitude and to assign an order number m. The total number of years is taken as N. The probability P of an event equal to or exceeding is given by the Weibull formula

$$P = (m/N+1)$$

The recurrence interval $T = 1/P = (N + 1)/m$

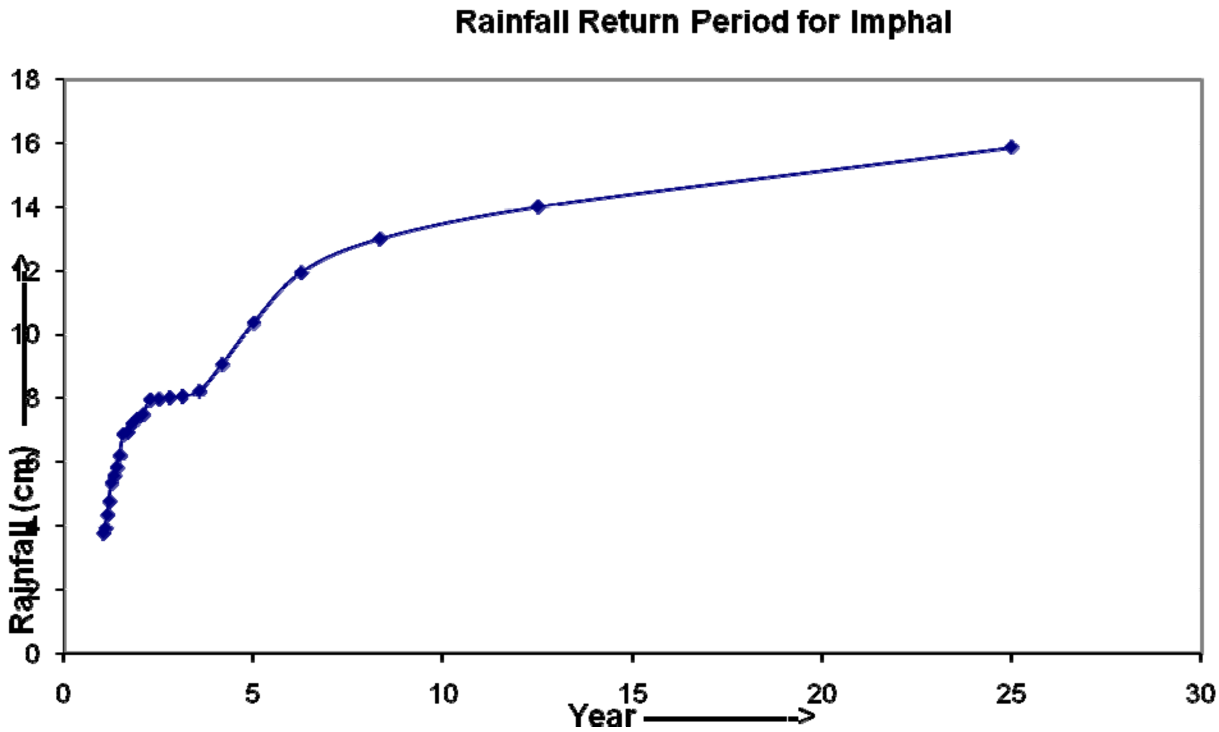
Having calculated P (and hence for T) for all the events, the variation of the rainfall magnitude is plotted against the corresponding T. By suitable extrapolation of this plot, the rainfall magnitude of any specific duration for any recurrence interval can be estimated.

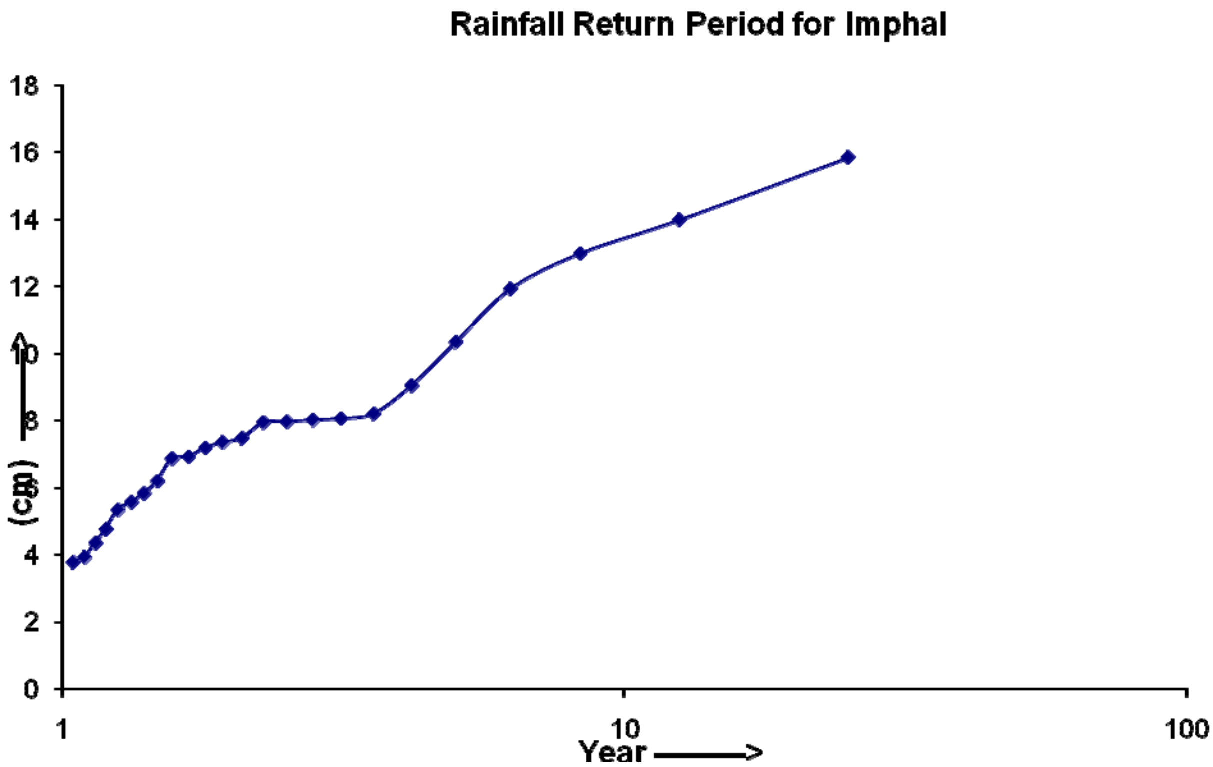
The data are arranged in descending order (Table 2).

A graph is plotted between the rainfall magnitude and return period, T on a semi logarithmic paper. A curve is drawn through the plotted points. From this curve we found that an intensity of 140 mm have the chance to occur every 14 year and 160 mm every 29 year.

Table 2

Sl. No.	Date	Rainfall mm.	Rainfall cm.	P=m/N+1	T=1/P year	Rainfall Cm. Vs Year
1	30th July 1989	158.6	15.86	0.035	28.57	15.86
2	5th June 1984	140	14	0.071	14.08	14
3	11th July 1983	130	13	0.107	9.34	13
4	5th Oct. 1980	119.4	11.94	0.142	7.04	11.94
5	5th July 1985	103.6	10.36	0.178	5.62	10.36
6	12th July 2000	95.5	9.55	0.214	4.67	9.55
7	18th may 1995	90.6	9.06	0.25	4	9.06
8	22nd June 1977	82.2	8.22	0.285	3.51	8.22
9	10th Oct.1986	80.7	8.07	0.321	3.11	8.07
10	1st Nov. 1991	80.3	8.03	0.357	2.8	8.03
11	18th Feb. 1993	79.8	7.98	0.392	2.55	7.98
12	27th Sept. 1997	79.6	7.96	0.428	2.34	7.96
13	9th June 1978	74.9	7.49	0.464	2.15	7.49
14	20th Aug. 1987	73.6	7.36	0.5	2	7.36
15	21st May 1998	73.3	7.33	0.53	1.88	7.33
16	26th June 1988	72	7.2	0.571	1.75	7.2
17	27th May 1994	69.4	6.94	0.607	1.65	6.94
18	29th June 1996	68.8	6.88	0.643	1.55	6.88
19	4th Nov. 1975	62.1	6.21	0.678	1.47	6.21
20	21st Oct. 1999	61.7	6.17	0.714	1.4	6.17
21	16th July 1992	58.4	5.84	0.75	1.33	5.84
22	15th May 1990	55.8	5.58	0.786	1.27	5.58
23	3rd June 1976	53.5	5.35	0.821	1.22	5.35
24	18th June 1982	47.8	4.78	0.857	1.16	4.78
25	29th Nov. 1974	43.6	4.36	0.893	1.12	4.36
26	5th Aug. 1979	39.4	3.94	0.928	1.08	3.94
27	15th Oct. 1981	37.9	3.79	0.964	1.04	3.79


Rainfall Return Period for Imphal
18
16
14
12
10
8
6
4
2
0
Rainfall (cm)
0
5
10
15
20
25
30
Year ------>


Rainfall Return Period for Imphal
18
16
14
12
10
8
6
4
2
0
(cm)
1
10
100
Year ----->

Slope aspect

For the study of land utilization and geo-environment assessment, slope aspect serve as an important terrain parameter. The main factors that control the evolution of slope are structure, lithology, geologic processes and time.

So far five classes of slope have been identified in the study area.

1. Nearly level (0-1%)

The slope class is observed in the south-central part of the valley area. These areas are basically plain areas, which are adjacent to the wetlands. Agricultural lands and settlements are the prominent land use types. Area covers by this category of slope is 1437.5 sq. km. i.e. 22.7% of the study area.

2. Very gently sloping (1-3%)

This class of slope is mainly on the eastern and western foothills of the study area. Important land use categories found in this area are agricultural land (terrain for cultivation and horticulture), scrub land and settlements. This category of slope covers an area of 350 sq. km. i.e. 6.53 % of the study area.

3. Gently sloping (3-5%)

This class of slope is not observed in the study area.

4. Moderately sloping (5-10%)

This class of slope is also not observed.

5. Strong sloping (10-15%)

This class of slope is observed in the northern and southern part of the Valley area. Agricultural land, scrubland and settlements are the main land use pattern. Area covered by this category is 75 sq. km. i.e. 1.18% of the study area.

6. Strong to Steep slope (> 33%)

This class of slope is mainly observed on all sides surrounding the Valley area. This area is dominated with forest, scrubland, settlements and agricultural lands. This category covers an area of 306.25 sq. km. i.e. 4.84% of the area.

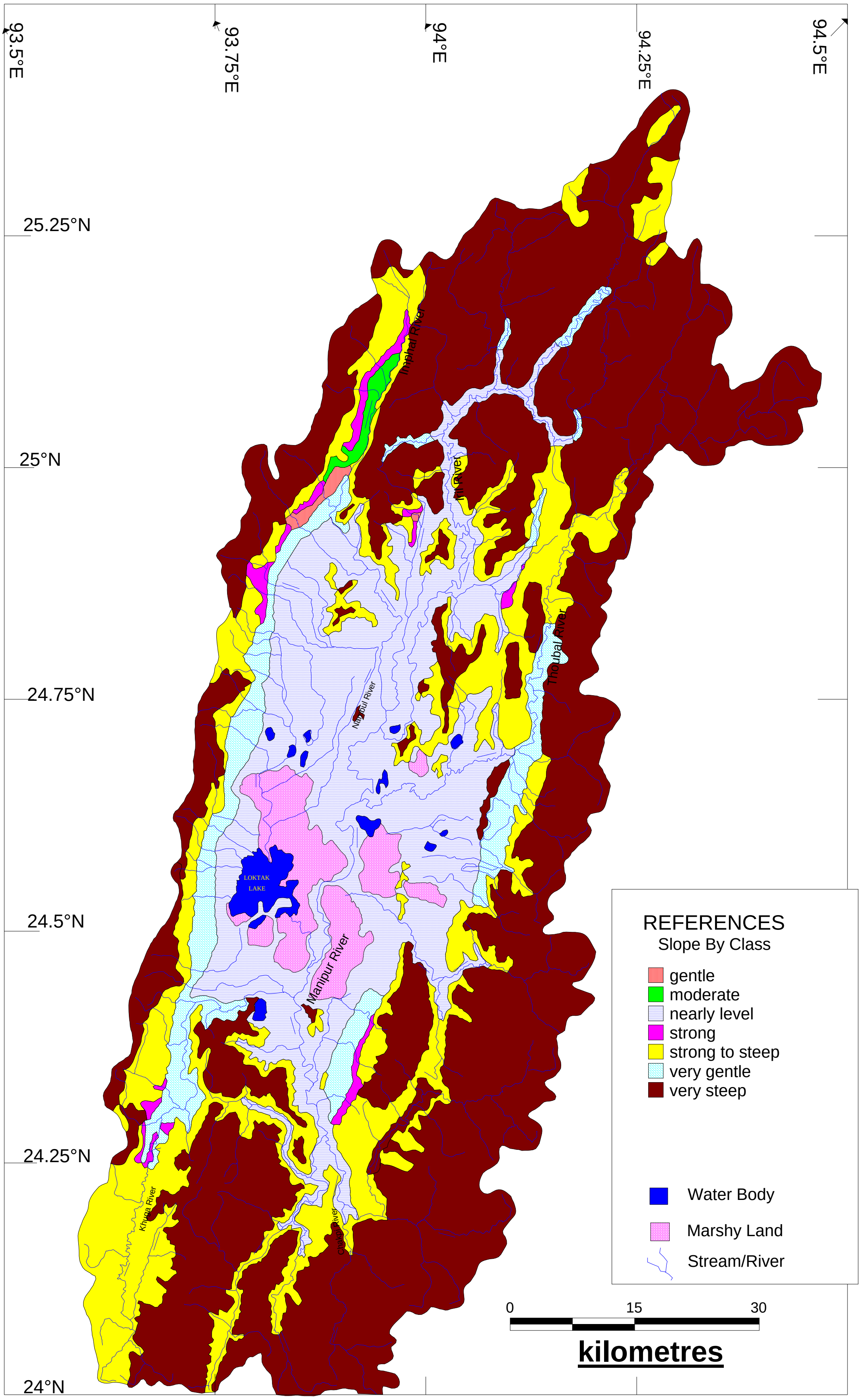
7. Very steep slope

Very steep slope class occupies the major portion of the study area in the upper catchments area. This area is dominated with forest cover, scrub land and shifting cultivation.

This category occupies 4163.25 sq. km. i.e. 65.75% of the study area.

As this category occupied 65.75% of the study area, it definitely accelerates the speed of the various streams and rivers and hence steams and rivers become more voluminous during rainy season and erosional capacity becomes more and as a results more sediment loads. Besides this factor, land with or without scrub and shifting cultivation area which is one of the prominent land use type, is also an important factor which enhances speed and sediment loads of the various run off which falls on streams and rivers.

SLOPE MAP OF MANIPUR VALLEY(Catchment Area)



Geomorphology and Hydrogeomorphology

Information on landforms is an important input for land management and identification of potential zones of groundwater occurrence.

Manipur Valley is virtually a flat alluvium filled valley. The valley is nearly 780 m high above the mean sea level with a very low southerly gradient. The Valley is surrounded in all sides by hill ranges of denudostructural nature trending NNE-SSW direction. A number of isolated hillocks of denudational remnants are found within the valley. Imphal River and its major tributaries: Iril, Imphal, Thoubal and Khuga Rivers are main drainage of the valley. These rivers have a nearly NNE-SSW trend concurring with the regional structural trend. Loktak Lake, the largest fresh water lake in the entire northeast India, lies in the south-western portion of the valley. Possibly it represents the lowest elevation of the valley. The lake also has a distinct and separate drainage system. The lake itself serves as an inland basin.

Geology

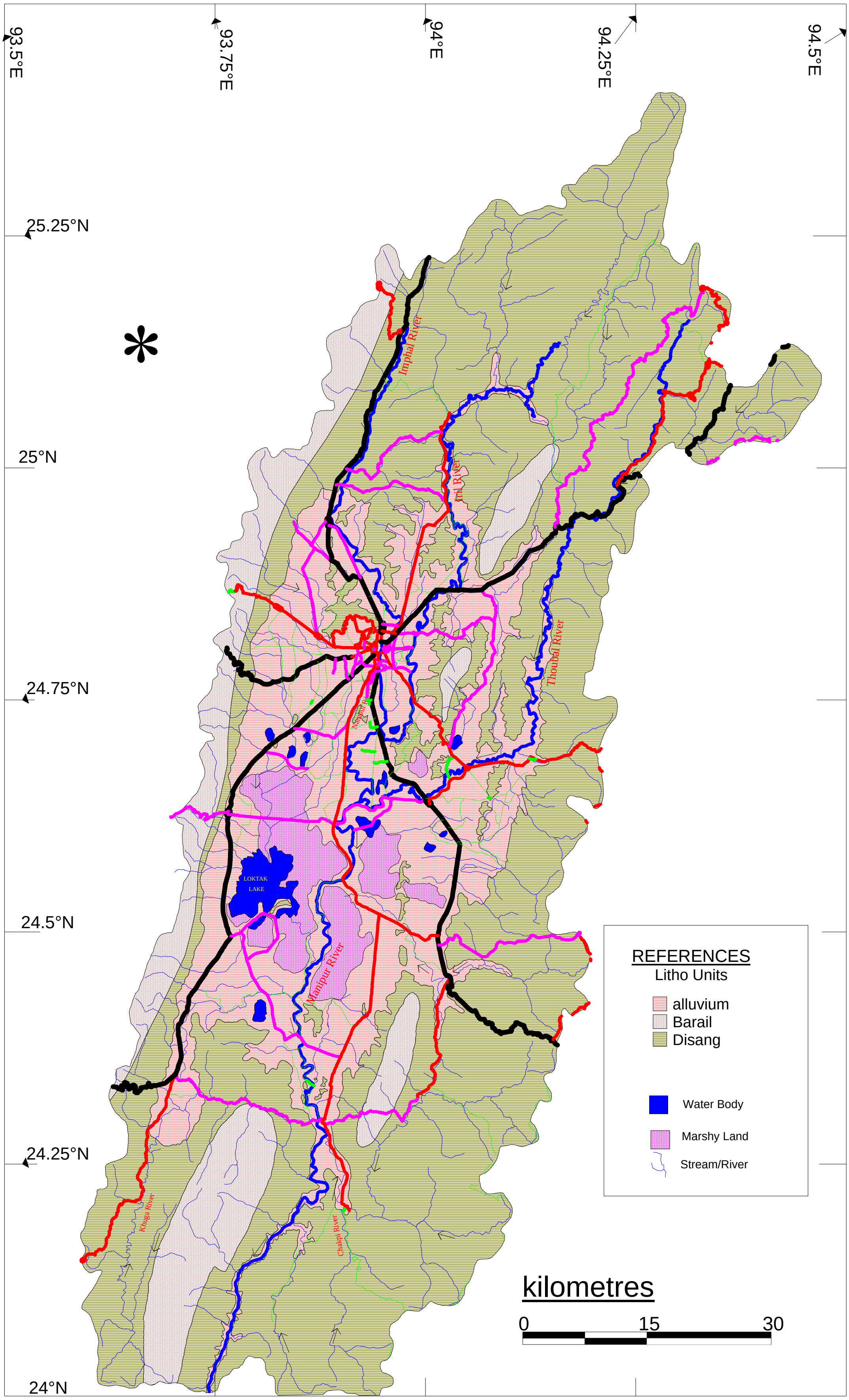
Basically Manipur Valley is made up of alluvium of fluvio lacustrine origin. They are usually dark grey to black in colour. The principal constituents are clay, silt and sand whereas sand, gravel, pebbles and boulders are found in the foothill regions. The hillocks inside the valley are basically composed of Disang shales but some have sandstone capping on the eastern side of the valley. These capping are mainly Barails and occur in the form of outliers. A Geological map of the study area is prepared and enclosed.

Disangs

The Disangs are dark grey to black splintery shales. The term Disang was first introduced by Mallet (1876). They are usually thinly laminated, intercalation of siltstone and fine grained sandstone in the form of lensoids and bands. Based on the nature and lithocharacter, the Disangs are found to be flysch sediments displaying turbidite character at places.

Usually almost all the hillocks within the valley are made up of Disang shales. They are often brown to reddish brown in colour due to weathering. Denudo-structural hills of Disangs surrounded the valley area in all sides.

GEOLOGY MAP OF MANIPUR VALLEY



Barails

The Barails are grey to brownish colour sandstone of fine to medium grain size. The term Barails was first coined by Evans (1932). They are greywake in composition. They are usually alternations of shale and sandstone giving rise to typical turbidite character.

The contact between the two lithounits Barails and Disangs is observed on the western side a few Km. away from the valley periphery. The contact is found to be a gradational one i.e. as one approaches towards the contact there is a gradual increase in the frequency of silt/sand bands that ultimately become predominate in sandstone (Barails).

Alluvium

Alluvium covers the widest arial extent in the valley. They are mainly dark grey to black carbonaceous clay, silt and sand of which clay forms the main sediments while silt and sand are subordinate. Average thickness of the alluvium is about 100-150m. Along the foothills sand, gravel and bouldary deposits as well as fan deposits are common.

Geomorphology and Hydrogeomorphological units

A Geomorhological map and a Hydrogeomorphological map of the study area are prepared.

Hydrogeomorphological units observed in Manipur Valley (catchment area) are identified as:

(i) Denudo-structural hills

(ii) Residual hills

(iii) Piedmont zone

(iv) Alluvial fan

(v) Alluvial plain and

(vi) Valley fills

Denudo-structural hills

A group of hill ranges surrounding the valley are formed due to different erosional and weathering processes and most prominently due to the plate kinematics of the Indian and Burmese plates.

This zone is characterized by very close space linear strike parallel ridges and intervening narrow valleys, in association with lineaments, fracture, fold patterns, cuestas etc. They trend in NNE-SSW direction. They occupy the major portion of the study area. Some of the hillocks inside the valley area are also have structural elements, moreover they are oriented in NNE-SSW direction, and hence they are also included in this category.

Residual hills

Residual hills of low relief comprising of shale, fine grained sandstone and siltstone, form as isolated hills, exposed at places in alluvial plain area. Most of these hills are covered by grasses and scrubs.

Piedmont zone

Piedmont zone is a gently sloping area situated in between hills and plains which are found on the western sides of the valley, they are however rare in the eastern side. This zone consists of sand, gravel, pebbles and boulders.

Valley Fills

Valley fills are observed in the upper reaches of the major rivers. They are filled with pebble, cobble, gravel, sand and silt.

Alluvial fan

They are more gently sloping areas situated in between hills and plains, consisting of sands, gravels and pebbles.

Alluvial plain

Alluvial plain covers the widest arial extent in the valley, consisting of carbonaceous clay, silt and sand, of which clay forms the main sediments.

Wetlands

Loktak Lake the largest fresh water lake in the North –East India, lies in the south-western part of the valley. Possibly it represents the lowest elevation of the valley. Loktak Lake and associated swamps occupy an area of 246.72 sq. km. However water mass in the lake shows considerable variation during monsoon and post monsoon periods. The lake also has a distinct drainage system of a catchment area of 980 sq. km. The lake serves as an inland basin.There are also many smaller lakes found mostly on the southern part of the valley. They are:

Waithou Lake:

Located at a distance of 17 km. due south of Imphal town on NH 39 with a surface area of 0.99 sq. km.

Utrapat :

This lake is situated in Nambol, about 20 km. due southwest of Imphal town with a surface area of 0.36 sq.km.

Sanapat :

This lake is located at Nambol at a distance of 32 km. due southwest of Imphal town. Surface area of the lake is 1.97 sq. km.

Ikop pat :

This lake located in Thoubal District at a distance of about 40 km. due southeast of Imphal measures a maximum area of 6.2 sq. km.

Discussion

The denudostructural hills act as surface run-off zones. The yield of ground water in this area is very poor. Degraded forest and shifting cultivation on the steep slopes of these hills permit more soil erosion and surface run-off.

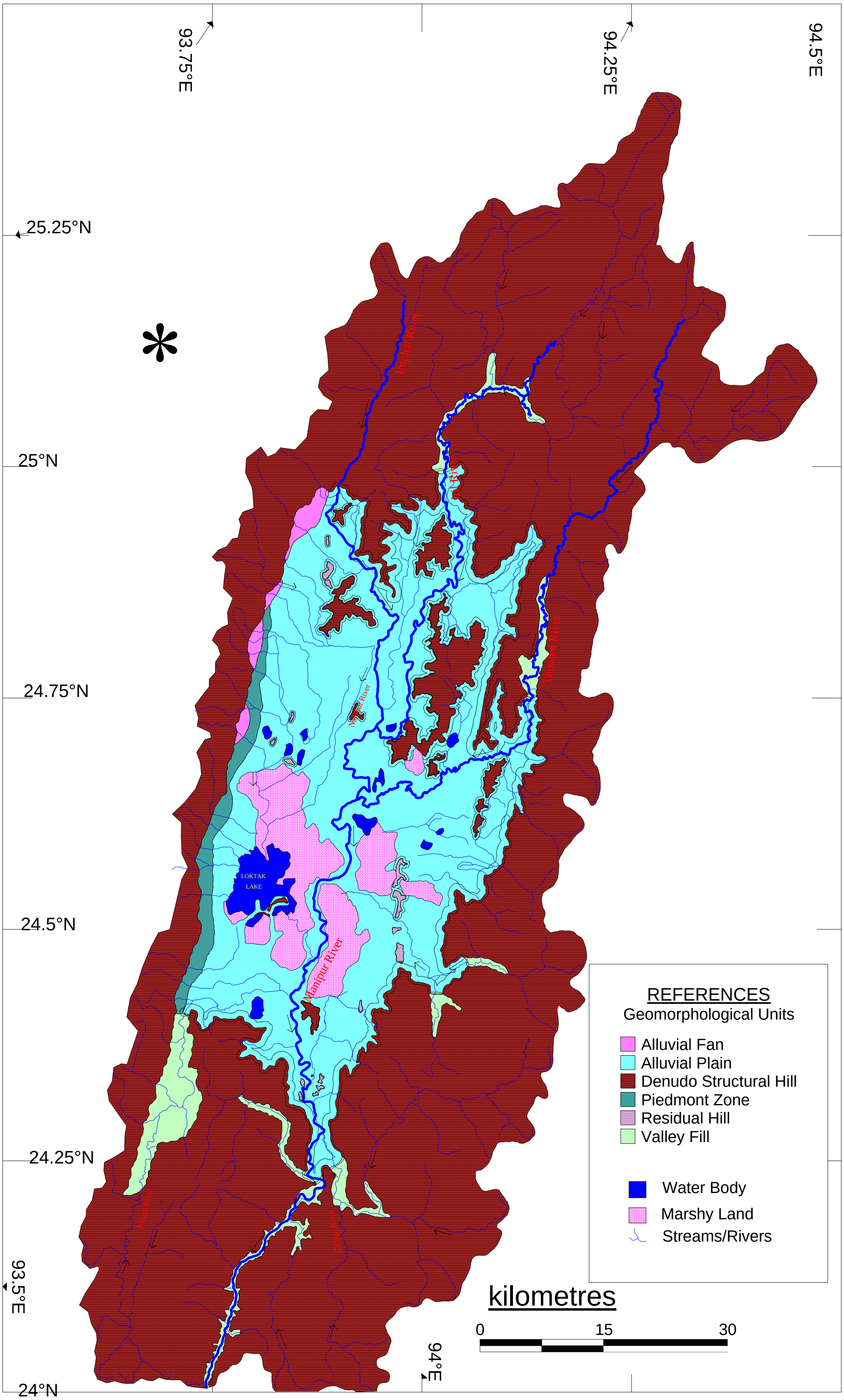
The nature and character of the alluviums in the valley indirectly indicate the rare chances of getting good potential ground water. However in this alluvial plain area, traces of in filled channels in the form of linear to curvilinear narrow patches are observed. They show sequential horizon of gravel, coarse to fine grain sand and finally capped by clay at the top. These in filled channels trace form perspective zone for ground water exploitation in alluvial plain area.

On close examination the hillocks within the valley shows presence of sand/silt lensoids of considerable thickness. These bands may serve as good horizons of ground water.

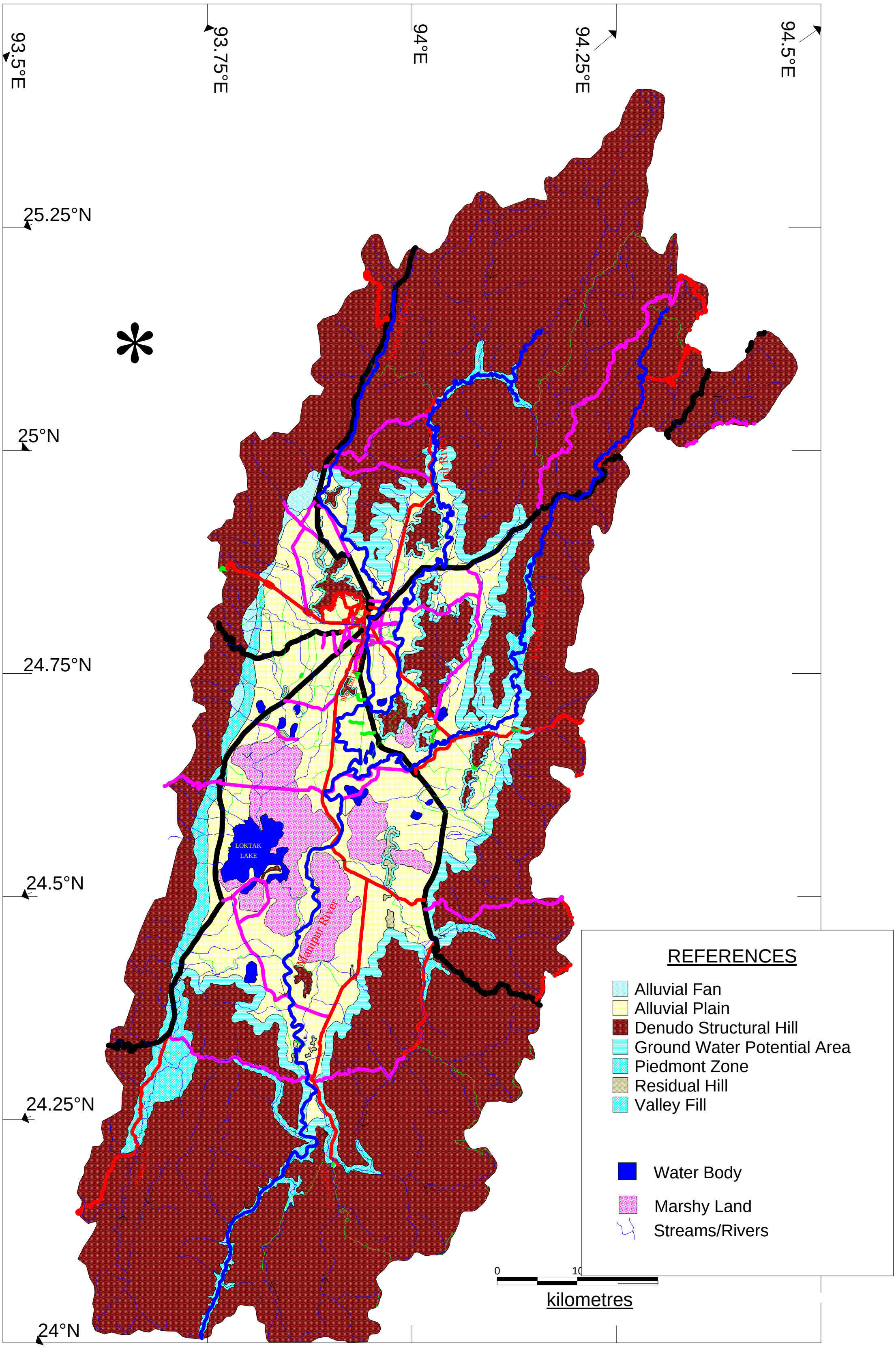
The piedmont zone and alluvial fan consist of sand, gravel, pebble and boulders. This zone will serve as good perspective area of ground water.

The potential of ground water and ground water table in the Manipur Valley is very high and utilisation of ground water is very less. Ground water acts major role in increasing the longer stagnation of surface water in low-lying areas of the project area.

GEOMORPHOLOGICAL MAP OF MANIPUR VALLEY



HYDROGEOMORPHOLOGICAL MAP OF MANIPUR VALLEY
(CATCHMENT AREA)



Land Use / Land Cover

Land is non-renewable resource and hence assessment of land use /land cover is essential for planning and development of land and water resources. Hence it is useful in flood management study.

The study area falls within the meridians N24° 0′ to N25° 25′ and parallels E93° 35′ to E94° 29′. Physiographically, the terrain is an elevated plain surrounded from all sides by structural hills of Disang formation.

The climate of the area is sub-tropical monsoon type. Annual rainfall varies from 895 mm to 2134 mm in the valley and up to 2134 mm in the hilly area. Temperature varies from 1° to 30° in the winter and 10° to 36° in summer.

Data use and methodology

False colour composites of Landsat TM acquired in May 1995 and IRS-IB acquired in Feb.1995 on 1:50,000 scale are visually interpreted to map the changes in land use/land cover pattern. Survey of India toposheets on 1:50,000 scales are also used for reference data. The image characteristics viz. size, shape, shadow, tone, texture patterns and associated features are considered for the interpretation. The land use/land cover studies are carried out for smaller units after dividing the study area into nine river basin areas. Maps depicting various land use/land cover have been generated using ground truth data and the details of the area have been presented in tabular form(Table 3) and in the form of map.

Forest area

Forest area is seen as red to light red tone with fine to medium texture with irregular shape and varying size on the satellite imagery, distributed mostly in the hilly areas. Crown density is about 40%.

The major species found in the area are Ageratum conyzoides, Cedrela toona, Castanopsis sp., Machilus sp., Diptercaropus, Eugenia pracox, Quercus sp., Cinnamon sp.,Mallotus sp., Lilaca sp., etc. Forest cover in the area is 2475 sq.km. which is 39% of the study area.

Largest forest cover is found in Iril river basin which is 628 sq. km. (i.e. 50%) and least is found in Wangjing river basin which is 20 sq.km. (i.e. 6.5%).

Land with or without scrub

Land with or without scrub is also one of the dominant land use/land cover categories observed in the study area. This area exhibits light grey to greenish white tone, fine to medium texture, irregular in shape and varying in size mostly associated with forest cover area, showing degradational characteristics. Its location at higher altitude renders it prone to degradational characteristics. The topsoil is easily washed out leaving the area more or less barren, with scanty scrub cover; this land use category is identified in almost all basins at different altitudes.

Table 3

Watershed	Forest (sq. km.)	Land with or without scrub (sq. km.)	Settlement (sq. km.)	Agricultural Land (sq. km.)	Waterlogged / Swampy/ Marshy land (sq. km.)	Water Body (sq. km.)	Total Area (sq. km.)
Iril River	628	332	165	131	1	3	1260
Thoubal River	298	384	70	155	8	5	920
Imphal River	125	78	118	144	82	13	560
Khuga River	226	145	58	29	-	-	458
Loktak Catchment	72	138	171	355	169	77	980
Wangjing River	20	88	32	121	39	5	305
Sekmai River	87	188	34	87	27	3	426
Chakpi River	555	78	13	14	-	-	660
Other Rivers	464	116	49	78	50	6	763
Total	2475	1545	710	1114	376	112	6332
P. C. (%)	39.09	24.40	11.21	17.59	5.94	1.77	100

Settlement / Built up land

This land use category is identified by reddish brown uniform patches with mottled tones on the satellite imagery. The settlement area is found in varying shape and size. Total area in this category is found to be 710 sq. km.

Agricultural land

Agricultural land is mainly distributed in the valley plains, piedmonts and pediments; covers the largest land use category in the valley area.

This land feature is identified with light to medium red tone, fine to medium texture exhibiting scattered/contiguous pattern, varying in size, often rectangular in shape and mostly in association with build up land. The fallow land is identified as a feature with light to medium bluish/ greenish tone, fine/ medium texture. This category is also found in the valleys at the upper reaches of the rivers and streams as scattered in hilly area. The major species grown in these areas are paddy, sugar cane, maize, mustard, cabbage, potato, pea etc. Cropland including fallow land is estimated to be 1114 sq. km. in area.

Waterlogged / Swampy / Marshy land

This category of land is seen as brown, purple black tone with medium texture on the satellite imagery and mostly found at the periphery of the Loktak and other lakes of Manipur Valley. This land use category is found almost in southern shallow part of the valley area.

These lands are heavily infested with aquatic plants like Cymbopogon sp.,Cynodon sp., Aeschybinemene indica, Jussea sp., Rumex sp., Sagihara sp., Lemna minor etc. and many other aquatic weeds. This land use category covers an area of 376 sq.km.

Lake / Reservoir / Tanks

Lakes are the major shares in this category. They are mostly found to confine in the southern part of the valley.

A number of tanks are also observed in the study area, they are found adjacent to the built up lands. The water in the tanks is stored mostly in the rainy seasons and they are found to be dry sometimes during winter.

Discussion

Regulation of water mass of the various streams and rivers are done in two ways. On one hand the Loktak Lake serves as an inland basin / reservoir for many streams and rivers.

On the other hand the Manipur River is the only river in which all the rivers of Manipur Valley drain off in and the Khordak stream connects the Loktak itself with the Manipur River. Hence, the monitoring and study of these two factors are very much essential for the study of flood problems in Manipur Valley.

The lakes of Manipur are now known to have their own life and hydrologic characteristics related to the evolving geo-physical character of the land itself. In the beginning of this century, there were nearly 500 lakes in Manipur Valley, covering a large portion of the Valley. Apart from the Loktak, by far the most important and largest, other well known lakes of Manipur are Ikoppat, Waithoupat, Ngakrapat, Loushipat, Sanapat, and Utrapat etc. Degraded and disappearing lakes include Ikop pat, Waithoupat, Kharungpat, Loukoipat, Loushipat, Khonghampat, Lamphelpat, Porompat, Takyelpat, Akampat, Kombireipat, Keishampat, Hicham Yaichampat, Sangaipat and many others.

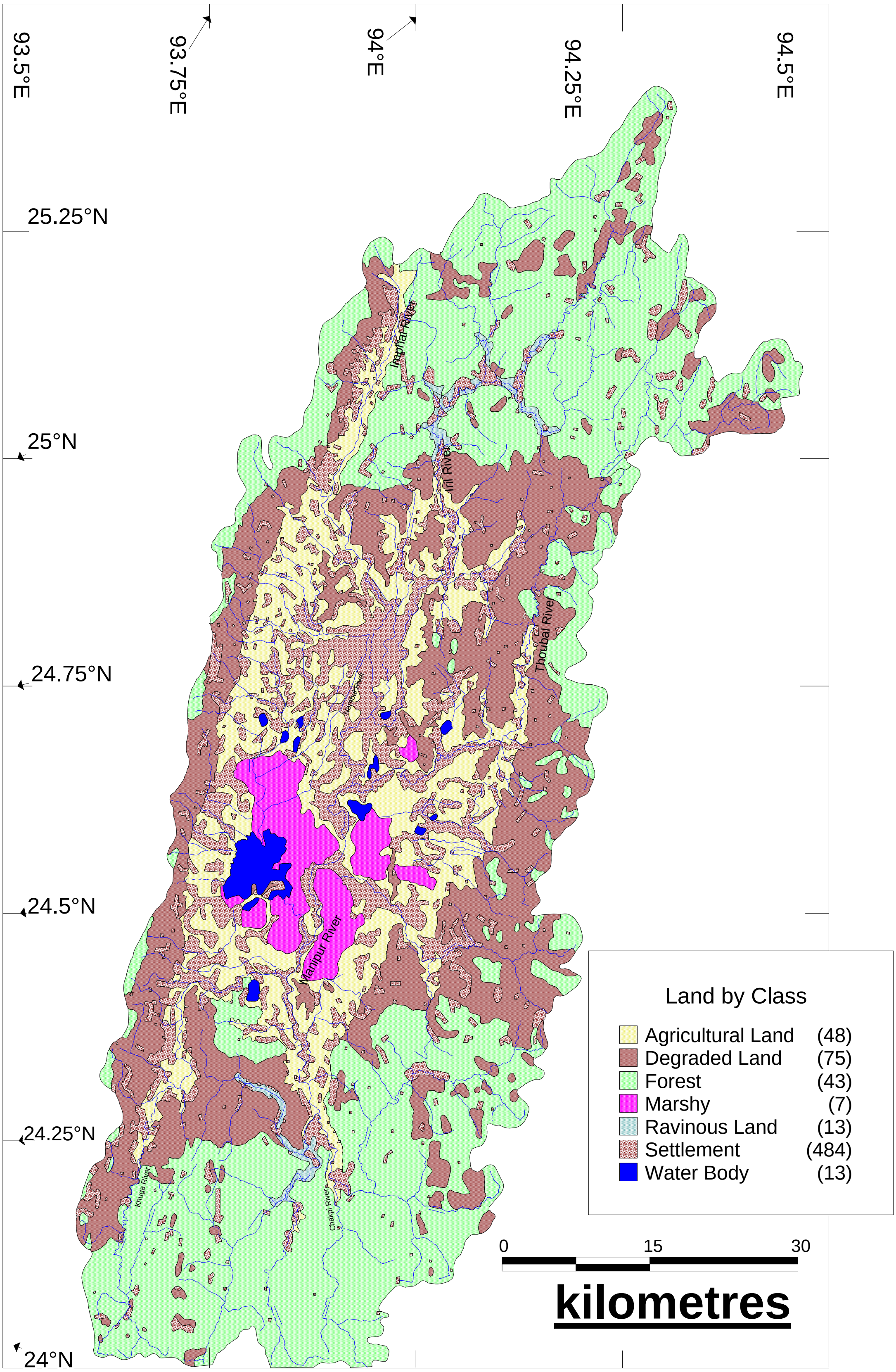
Most part of the lakes are infested by thick growth of macrophytes and phoomdis, which reduce the lake volume carrying capacity.

Rivers, which feed Loktak Lake, flow down with steep slope for a short distance before meeting the Loktak Lake. Hence speed of the streams is generally high and subsequently load carrying capacity is high which causes siltation of the lake. Thus the water holding capacity of the Lake decreases, causing inundation to the surrounding areas of the lakes.

At Ithai, flow of the Manipur river during monsoon is of the order of 400 cumecs and river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream, this is also one of the mentionable factors. Moreover a geological rocky formation rises gradually at the southern end of the valley just below the confluence of the Khuga River with the main Manipur river near Ithai village and extend upto Sugnu which is known as "Sugnu hump". The rocky outcrop of the Sugnu hump serves as a natural barrier to the flow of the Manipur river, which is the only out let river of the whole Manipur Valley.

The bed level of the Manipur River at Ithai is 762.2 m. and the river course downstream of the Ithai barrage passes through a narrow gorge of about 50 metres wide and thereafter traverses through relatively hilly terrain with small patches of plain valley on either bank of the Manipur River. The riverbed continues to slope up to a point about 1.6 km. downstream of Sugnu village to deepest bed level of 756.7 metres. Therefore, in a short stretch of about 800 metres, the bed level rises steeply upto 763.7 m. and remains at the general elevation of 762.5 m.. Because of this hump, the outflow of the sediment is restricted, resulting in the raising up of the riverbed due to deposition of sediment.

LANDUSE MAP OF MANIPUR VALLEY (Cachment area)



Soil Erosional Patterns

Soil is one of the most important resources on earth and is formed under varying topographic and climatic conditions by physical, chemical, and biological processes. Soil consists of products of weathering of rocks, intermixed with living organism and product of their decay, moisture and air in the interstitial space. It is the upper part of the weathering material resting on bedrock, and containing organic and inorganic nutrients in geologic sense.

Soils of the study area are developed on shale and sandstone rocks of Tertiary age. The temperate climate with high rainfall is responsible for very deep weathering of the rocks. The soils are formed in situ on the hill areas and as alluvium on the valley areas.

Soil loss of an area is related to various factors such as: (a) slope angle of the area, (b) land use practice of the area, (c) relative relieve of the area and (d) drainage density of the area. Here we try to produce soil erosional pattern (map) of the study area by a combined study of all the above facts as separate thematic layers.

Table-4: Weightage and classes of soil erosional patterns

Terrain factor	Class	Weightage/Grade
Land Use/ Land Cover	Dense cover	1
	Moderate cover	2
	Sparse cover	3
	Open cover	4
Slope angle	0-3%	1
	3-5%	2
	5-10%	3
	10-15%	4
	15-35%	5
	>35%	6
Relative relieve	Up to 800 m	1
	800-1,000 m	2
	1,000-1,500 m	3
	1,500-2,000 m	4
	>2,000 m	5
Drainage density (per sq. km.)	<5	1
	5-7	2
	7-8	3
	8-9	4
	>9	5

Data use and methodology

The soil erosional pattern analysis of the study area is carried out in a bi-phase manner. Initially various thematic maps viz. geology, geomorphology, drainage network, slope aspect, relative relieve and land use have been prepared on the basis of field information, interpretation of SOI toposheets and remote sensing data from IRS-IB March 1995.

Finally, superimposition and integration of various thematic maps using appropriate weightages was executed for the generation of the derived map of soil erosional pattern map.

The map shows five classes of soil erosional grade.

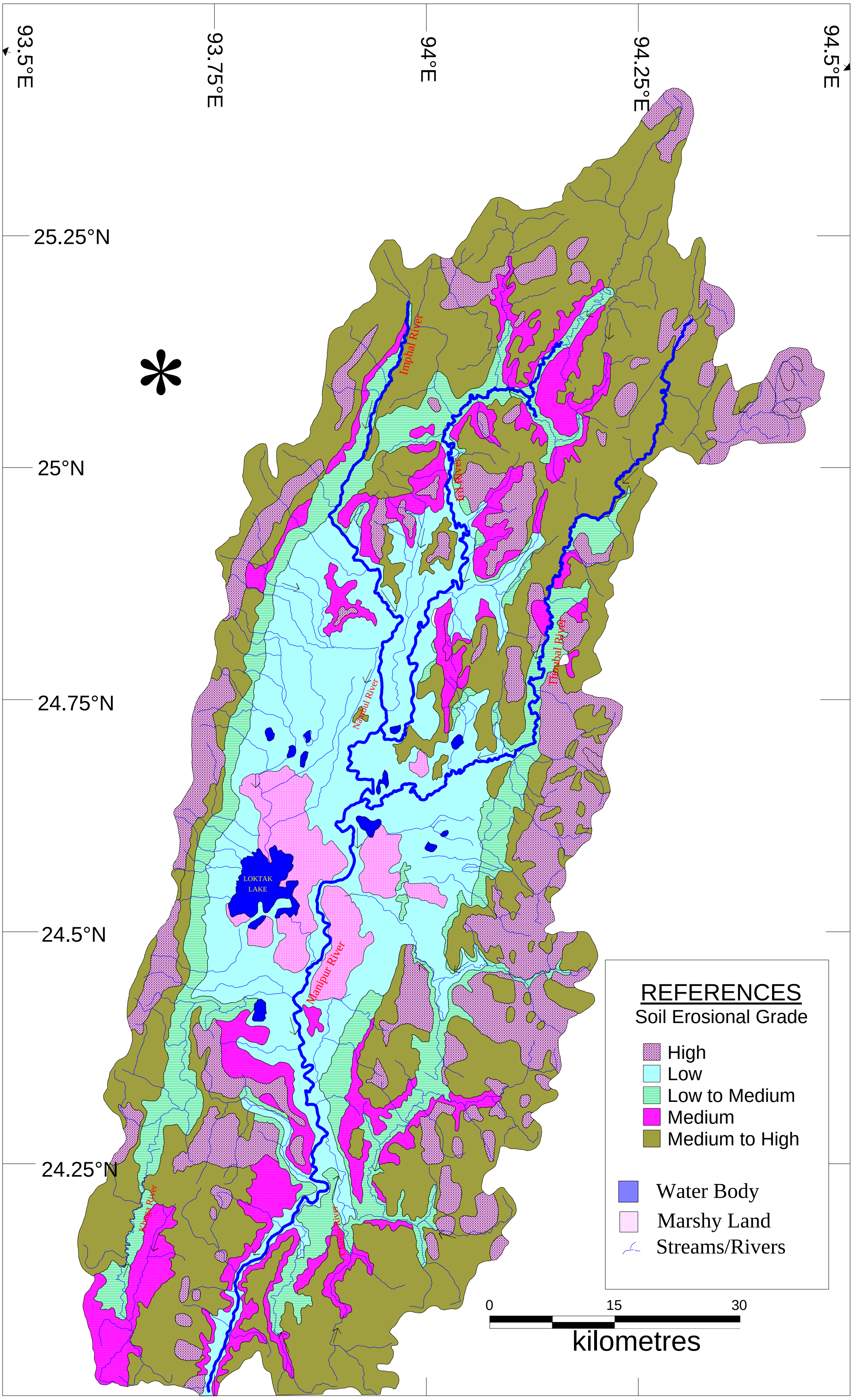
Grade	Area in sq. km.	P.C. to total area
i) High	1088	17
ii) Moderate to High	2144	34
iii) Moderate	637	10
iv) Low to Moderate	781	12
v) Low	1682	27

The two classes, high and moderate to high together occupy 3232 sq.km. which is 51% of the study area, and occur in the upper catchment areas. High soil erosional rate enhances quick run-off and consequently more discharge. High soil erosion also encourages swallowing of river courses and lakes by enhancing deposition of sediments, thus reducing carrying capacity of river flow as well as water holding capacity of lakes.

These points are needed to study carefully in assessing flood problem in Manipur Valley.

We should take careful actions viz. contour bunding, check dams, debris basin and plantation of fast growing species to reduce soil loss and also contour canals, subsurface dykes, gully plugging, terracing whenever suitable. In order to recommend the design and size of a particular type of intervention scheme, site specific and detailed field studies of the site are required so as to get maximum benefit and minimum environmental damage.

SOIL EROSIONAL PATTERN OF MANIPUR VALLEY
(CATCHMENT AREA)



Drainage Analysis of Manipur Valley

Manipur Valley is drained by three major rivers viz. (i) Imphal river, (ii) Iril river, (iii) Thoubal river and many minor rivers such as : (i) Sekmai river, (ii) Chakpi river, (iii) Khuga river, (iv) Nambul river, (v) Nambol river, (vi) Wangjing river, (vii) kongba river etc.

The various river either fall directly into or indirectly connected (through lakes) with Imphal river which is later on known as Manipur river . Thus Manipur Valley is oriented with the Manipur river system.

The catchment area of Manipur Valley can be divided into 9 Basins

	Name of the river basin	Catchment area
(i)	Imphal River Basin	560 sq. km.
(ii)	Thoubal River Basin	920 sq. km.
(iii)	Iril River Basin	1260 sq. km.
(iv)	Sekmai River Basin	426 sq. km.
(v)	Khuga River Basin	458 sq. km.
(vi)	Wangjing River Basin	305 sq. km.
(vii)	Chakpi River Basin	660 sq. km.
(viii)	River systems which fall on Loktak Lake	980 sq. km.
(ix)	Other Rivers fall on Manipur River	763 sq. km.
	Total	6332 sq. km.

A quantitative analysis of the various river system were carried out using morphometric techniques with reference to the problem of flood in the valley.

Methodology

The morphometric analysis of the 9 drainage system was carried out, for the most part on the SOI topographical maps on the scale 1:50,000. Checking of the drainages has done on the valley area.

Analysis

A broad characteristic of the various drainage system of Manipur Valley is given in table.

Sekmai River

Expected stream numbers are observed, VI order segment come above the standard line of stream number vs. stream order graph. However, depletion in mean stream length is observed in the III, IV and VI order segments. Hence, the area adjoining to stream segments of the order III and VI are more prone to erosion and more sediment loads since these areas are in hilly area. And the areas adjoining to V and VI order are prone to flood.

Khuga River

Depletion of stream number is observed in the stream order no. V, and depletion of mean stream length is observed in stream segments of the order III, IV & VI. Hence, the area adjacent to stream segments of the order IV, V & VI are more likely to be affected by flood.

Methodology

The smallest unbranched stream segment is designated the first order segments, the one formed by the merging of two such first order segments, the second order stream and so on. The numbers of stream segments present in each order are counted and tabulated. These data are graphically represented on semi-logarithmic paper.

The length of the various stream segments were measured order wise and the total length as well as the mean stream length of the streams of a given order to the mean stream length of the next lower order, is then calculated. Logarithmic plots of the total length against the stream order were also made.

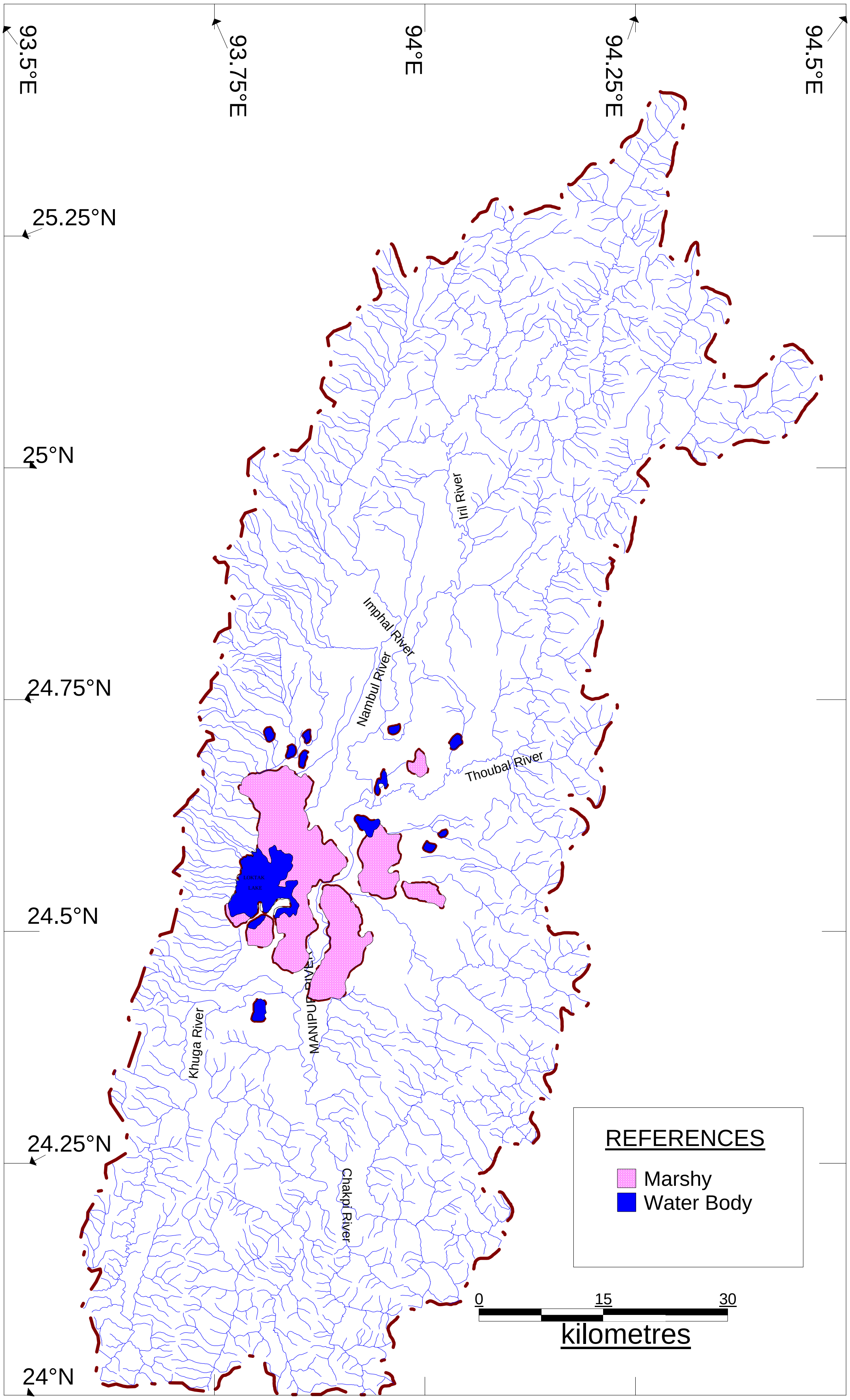
Horton's first law of stream number states that the numbers of streams of different orders, in a given drainage basin tend closely to approximate an inverse geometric series.

Imphal River System

The Imphal river which drain through the heart of the Valley is originated from Kangpokpi area and is found to be a six order stream; running north to south direction.

From the stream number vs. stream order graph of Imphal River, we observed depletion of stream number of order II, III & IV. Bifurcation ratio between order I&II, II & III and III &IV come above 4. Hence, during the rainy season river flow will create pressure in stream segments of order no. II, III & IV and up to order no. V to some extent. Again from the mean stream length vs. stream order graph, we observed depletion of mean stream length at order no. II segments, as a result there will be more stream pressure on the order no. III segment. From the above findings, stream order no. III & IV segments are prone to stream bank erosion, over topping and breaches.

DRAINAGE MAP OF MANIPUR VALLEY(Cachment area)



Thoubal River

The Thoubal River originates from Ukhrul and flows in eastern part of the valley. It covers a catchment area of 920 sq. km.

In the stream number vs. stream order graph of the Thoubal River we observe the graph as almost as a straight line, which is the ideal condition of a mature dissected river. However in the mean stream length vs. stream order graph, we observe depletion in the IV order segment. Hence there will be stream pressure in the IV order stream segments and V order to some extent. In addition to this the high bifurcation ratio between stream segment III & IV, IV & V and V & VI are other factors which arises for stream pressure on corresponding higher order segments.

Iril River

The Iril River which originates from the north-eastern part of the state traverses in the north-eastern part and eastern part of the valley. It comprises total catchment area of 1260 sq. km. For the Iril River we observe slight depletion in the III order stream, in stream number vs stream order graph. Again from the mean stream length vs. stream order graph depletion is observed in order II segment, as a result pressure will be more in III segments.

Imphal/ Iril/ Thoubal River

Since Imphal, Iril and Thoubal River confluence together and drain as Manipur River, we also try to analyse the three major rivers as a whole. From this analysis, we find that stream segments of order IV, VI and VII are lacking from the standard number, and in the mean stream length vs. stream order graph it is observed that stream segments of order IV, V and VII are lacking from standard mean length. Hence, definitely there will be problems regarding breach and overtopping in these segments.

Wangjing River

In the stream number vs. stream order graph, high stream segment number is observed in the IV order segment, and we also observed depletion in mean stream length in II & III order and mean stream length of V order segment is fairly high. Hence stream pressure will be high at the area of confluence between stream segment of IV and V order. As stream segment of order II & III lies in the hilly area, there is likely to be more erosion in these areas.

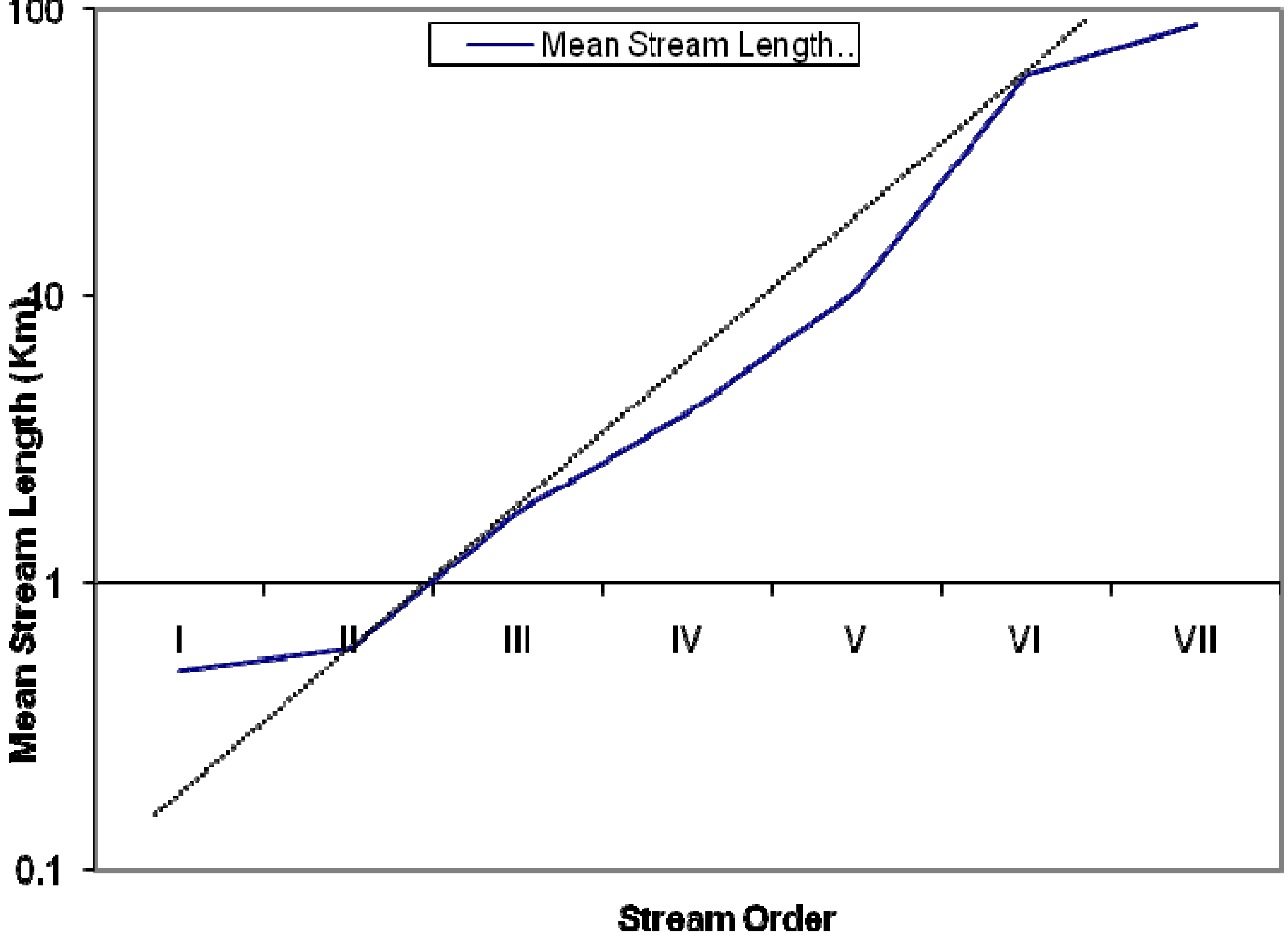
Chakpi River

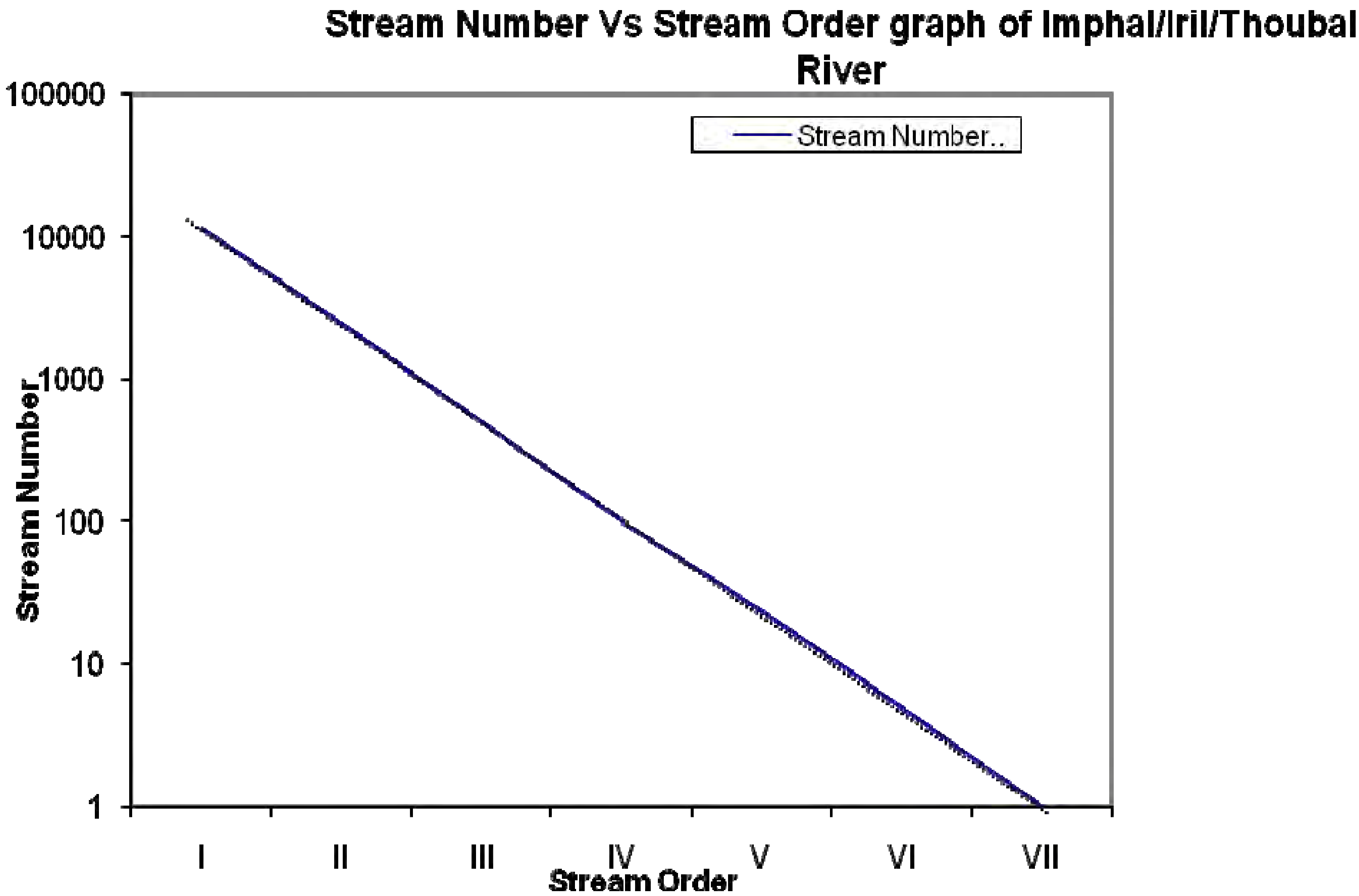
The Chakpi River system originates from the south-eastern part covering a catchment area of 660 sq. km. The Chakpi and its tributaries after flowing down steep slope for a short distance confluence with the Manipur river in an up current direction causing the current turbulent, hence making Sugnu and its surrounding areas prone to flood.

River systems which fall on Loktak lake

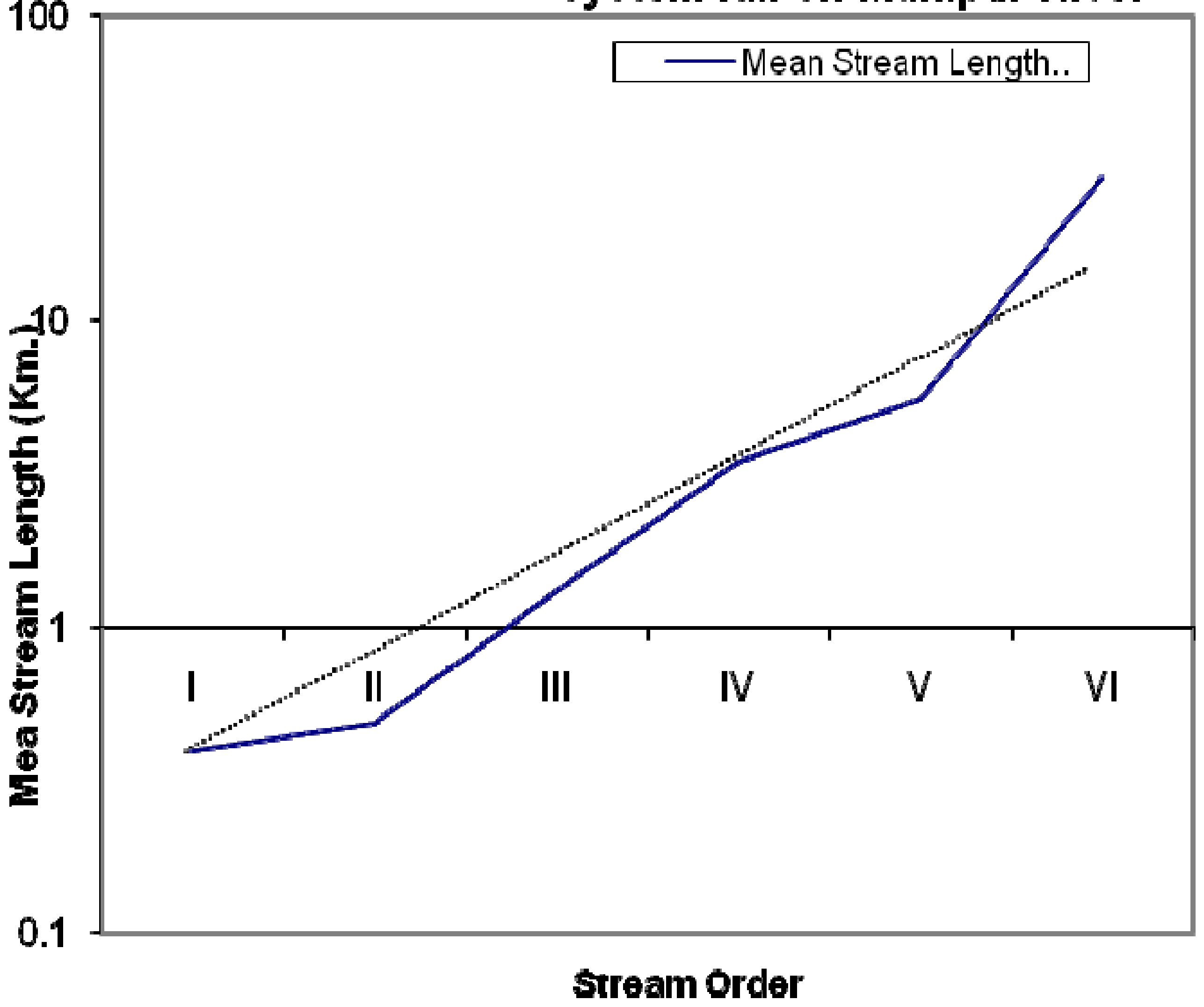
The Loktak and its various feeding rivers and streams cover a catchment area of 980 sq. km. extending from the western side to the southern part of the valley and connected to the Manipur river. From the mean stream length vs stream order graph, we observe depletion in length in the stream segments of the order V. Consequently areas adjoining to stream segments of order no. V are prone to flood during the rainy season.

Mean Stream Length Vs Stream Order graph of Imphal/Thoubal and Iril River

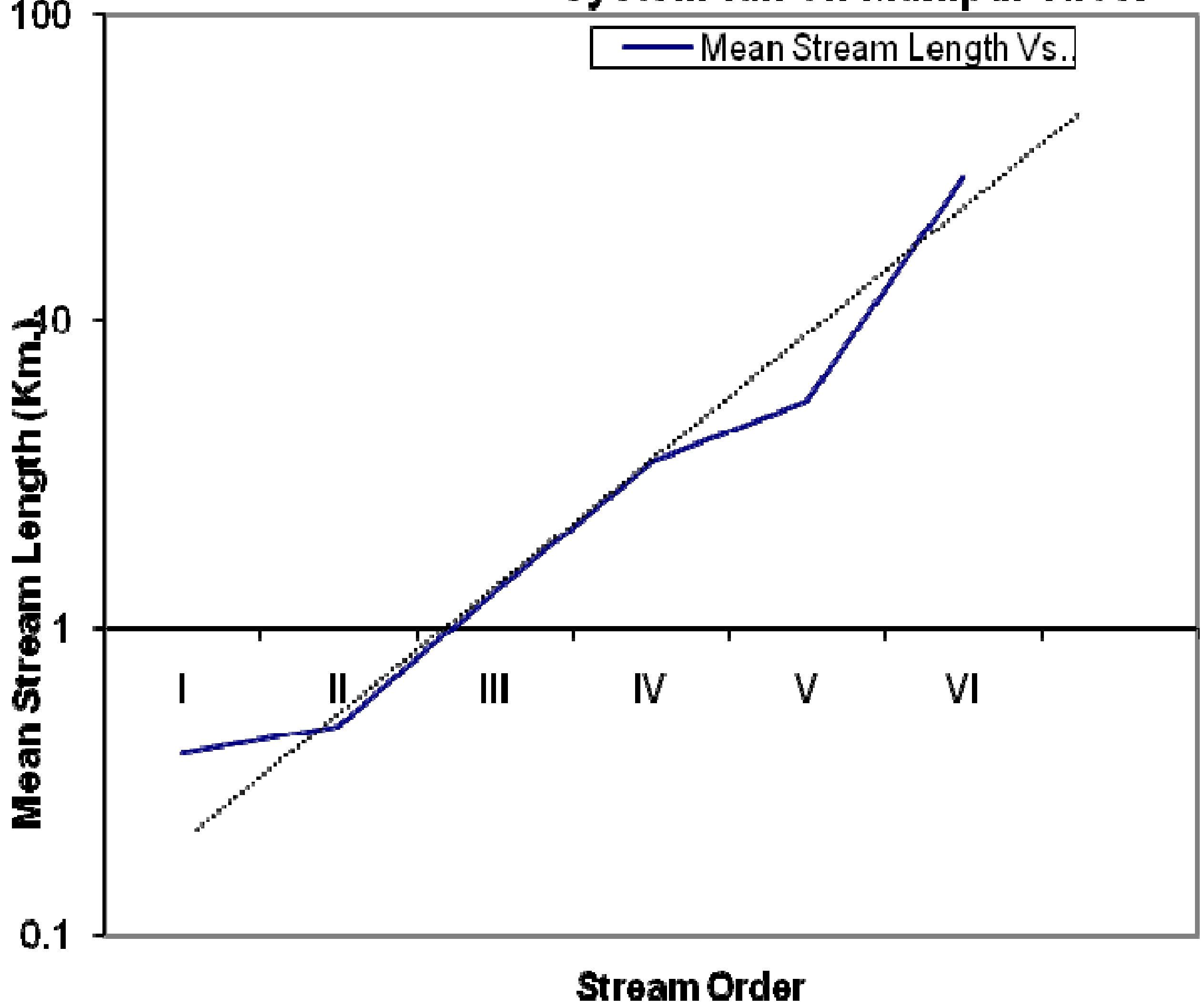


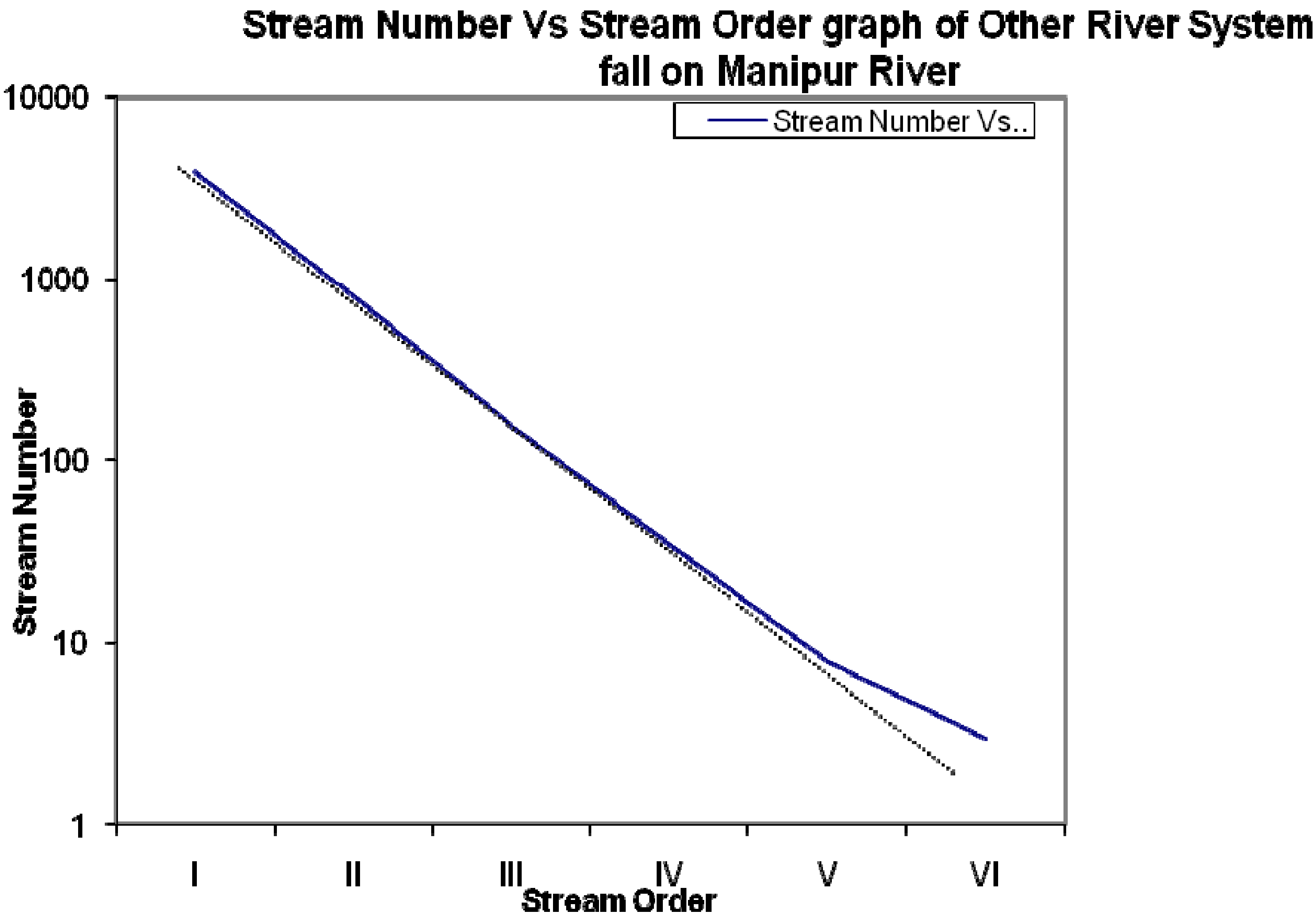

Stream Number Vs Stream Order graph of Imphal/Iril/Thoubal River
Stream Number..
100000
10000
1000
100
10
1
Stream Number
I
II
III
IV
V
VI
VII
Stream Order

Mean Stream Length Vs Stream Order graph of Other River system fall on Manipur River

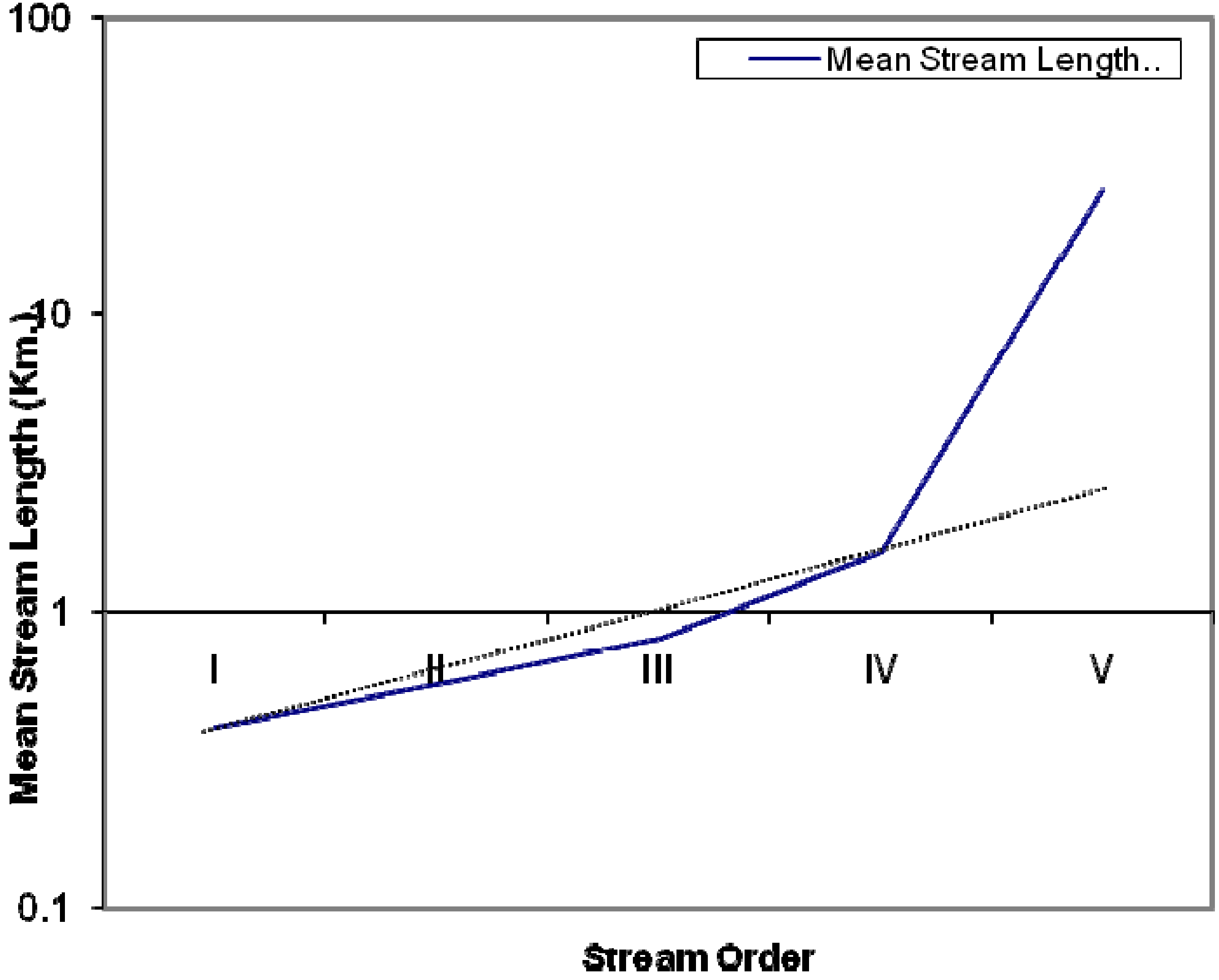


Mean Stream Length Vs Stream Order graph of Other River System fall on Manipur River

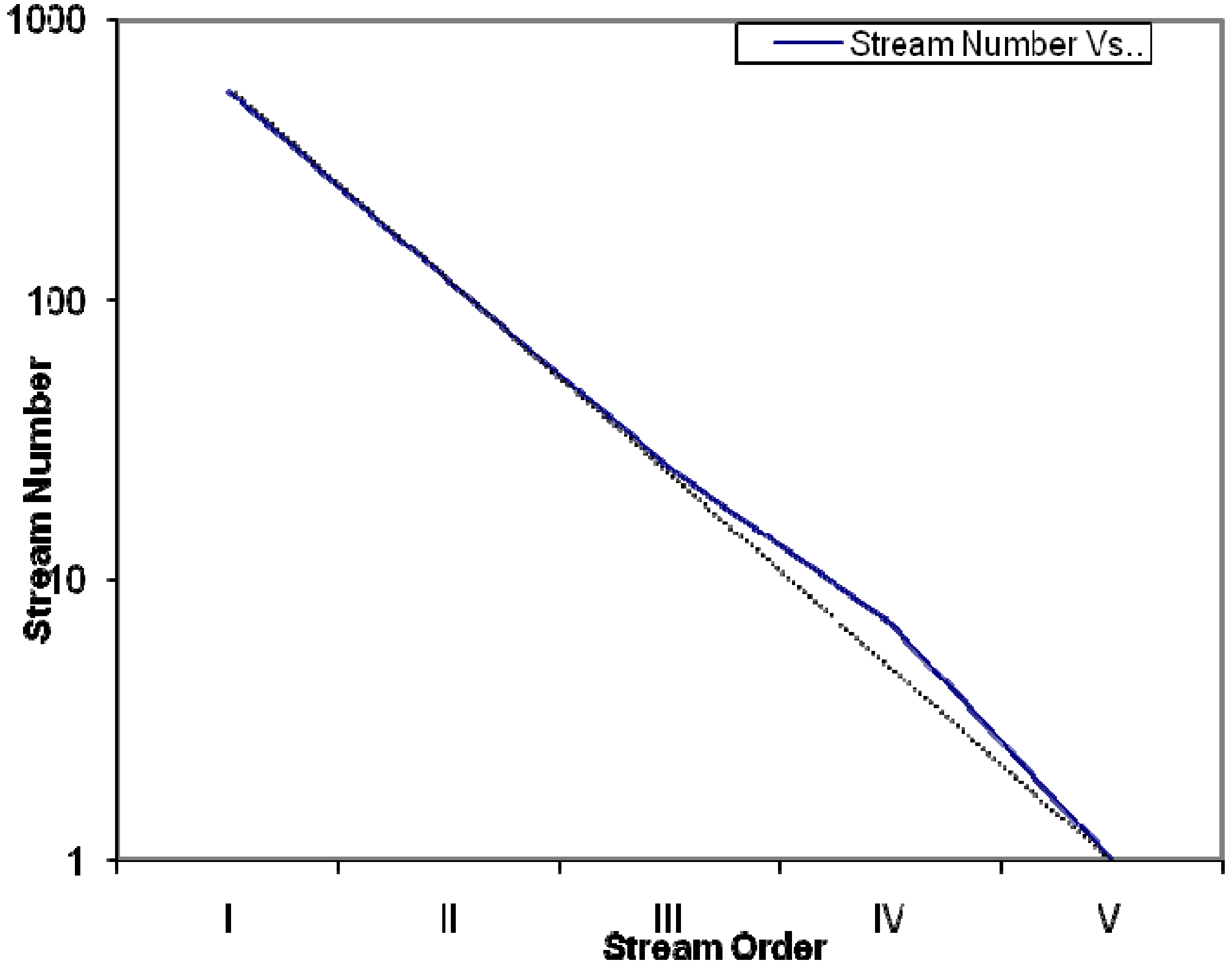


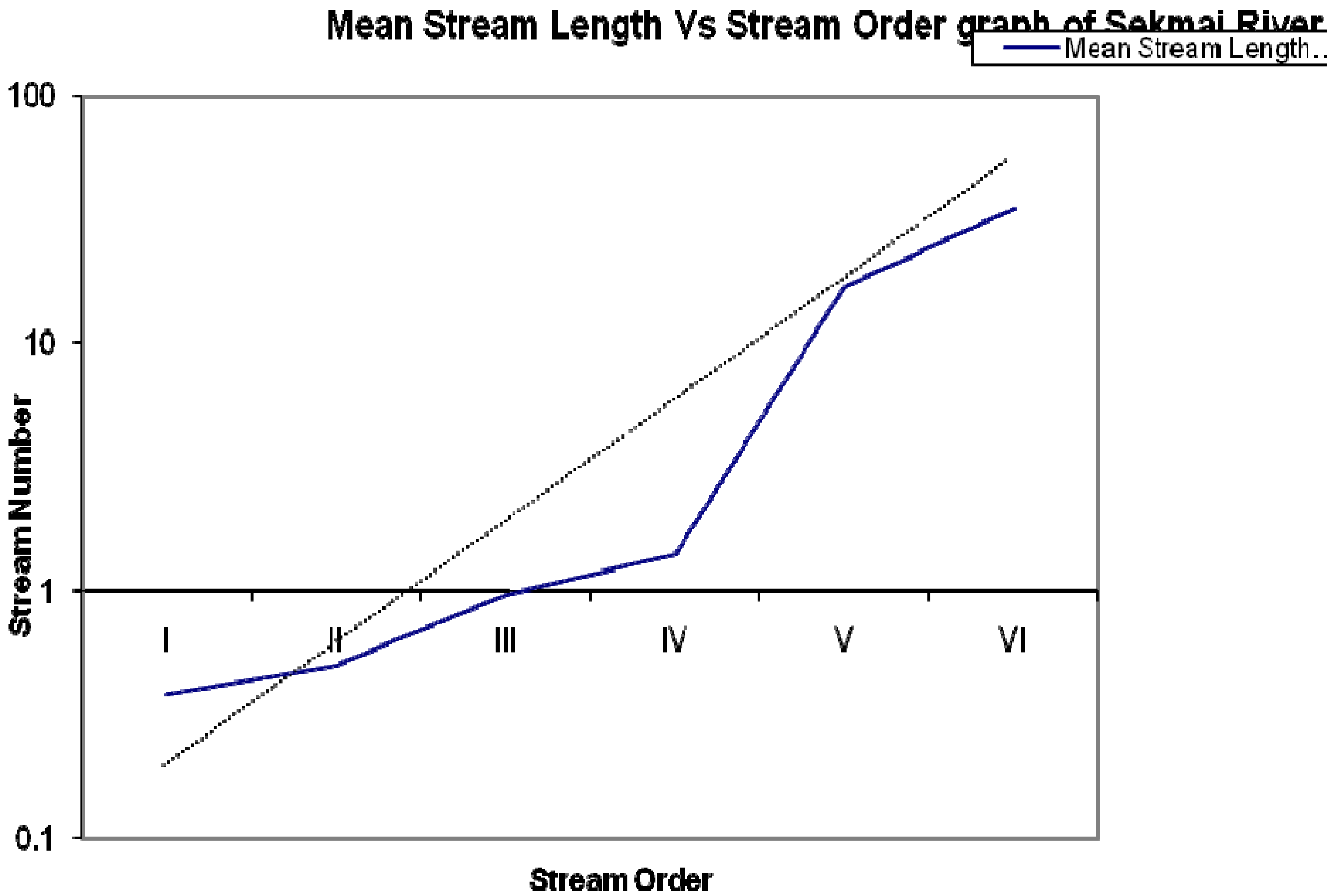

Stream Number Vs Stream Order graph of Other River System
fall on Manipur River
Stream Number Vs..
10000
1000
100
10
1
Stream Number
I
II
III
IV
V
VI
Stream Order

Mean Stream Length Vs Stream Order graph of Wangjing River

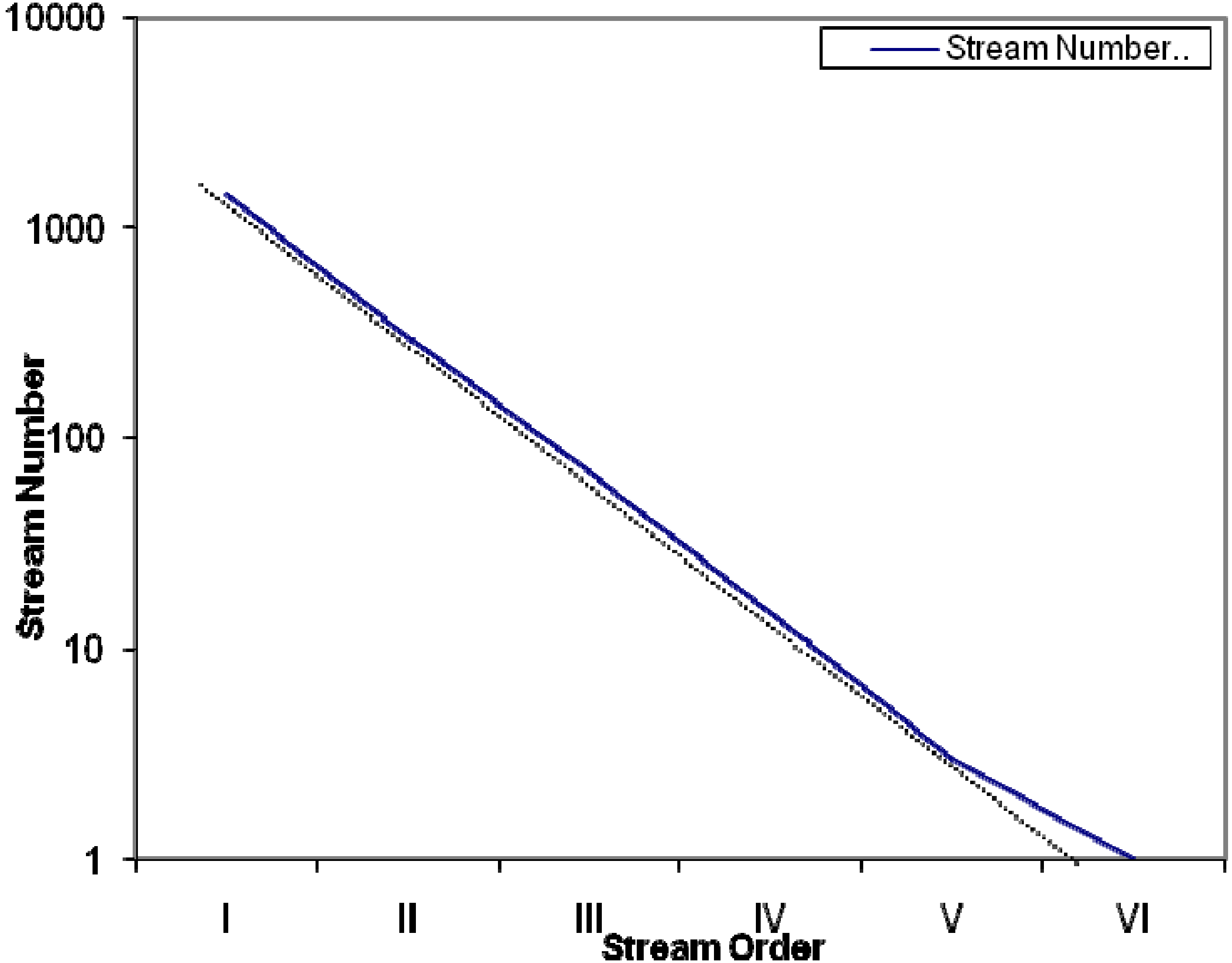


Stream Number Vs Stream Order graph of Wangjing River

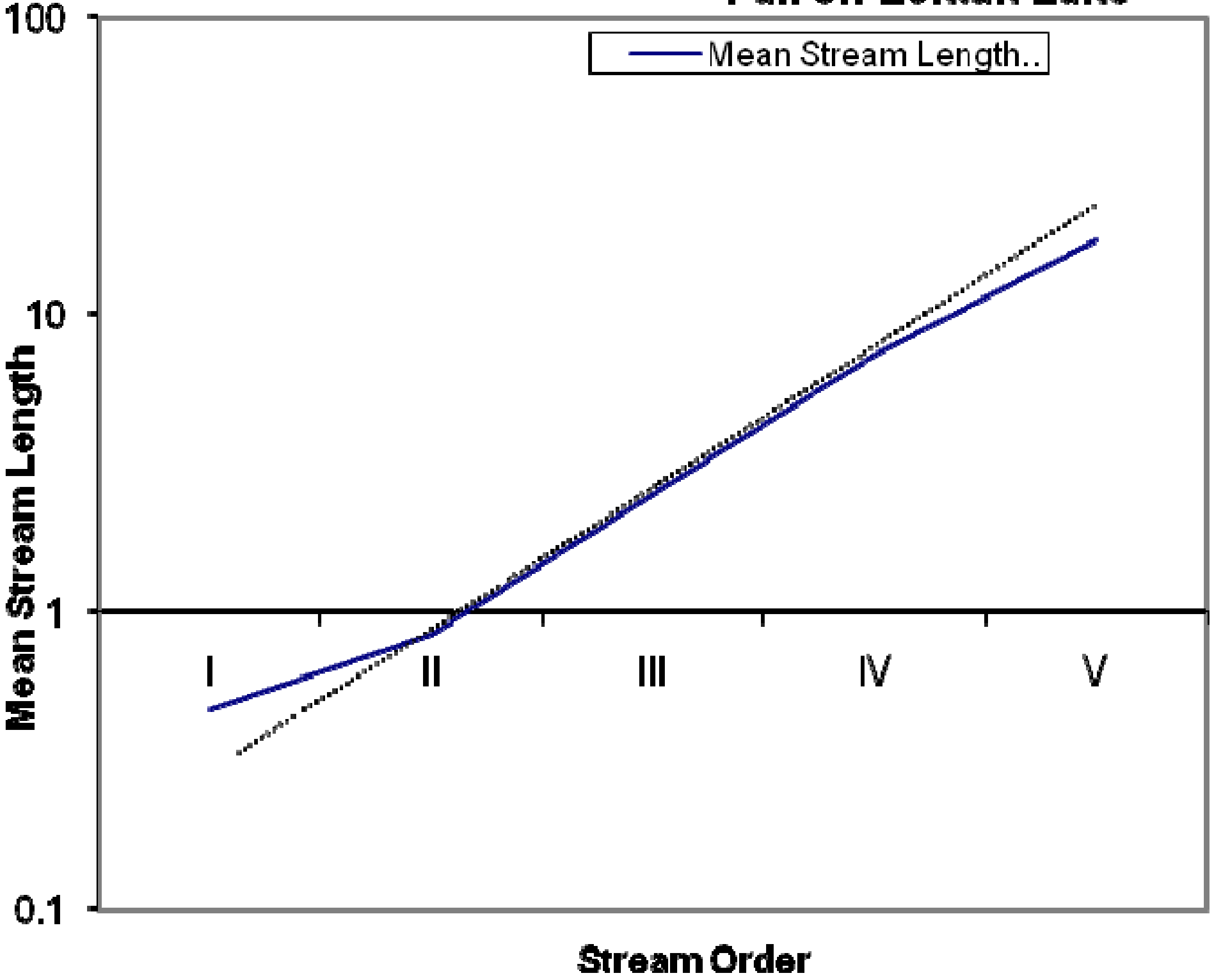



Mean Stream Length Vs Stream Order graph of Sekmai River
Mean Stream Length..
100
10
1
0.1
Stream Number
I
II
III
IV
V
VI
Stream Order

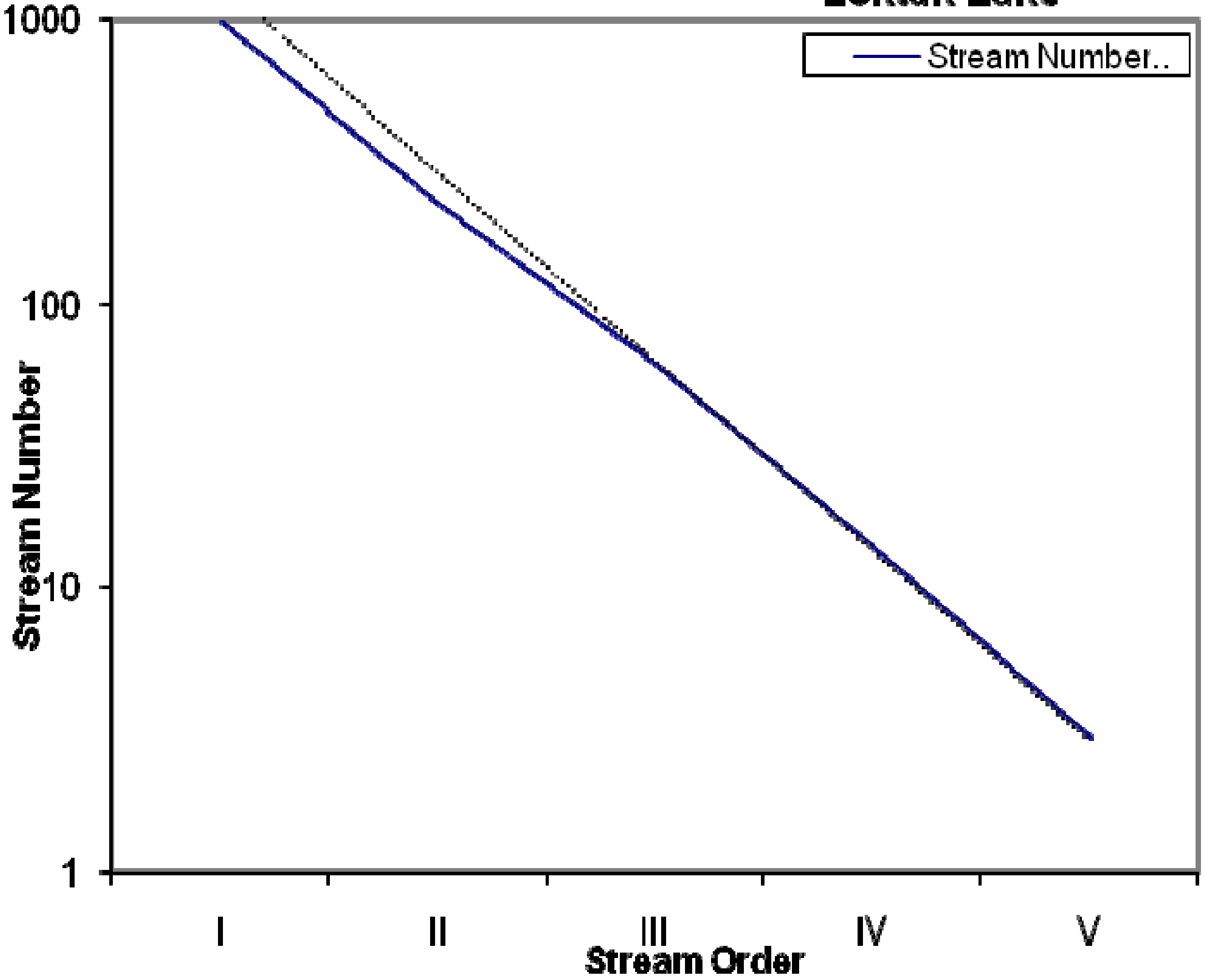
Stream Number Vs Stream Order graph of Sekmai River



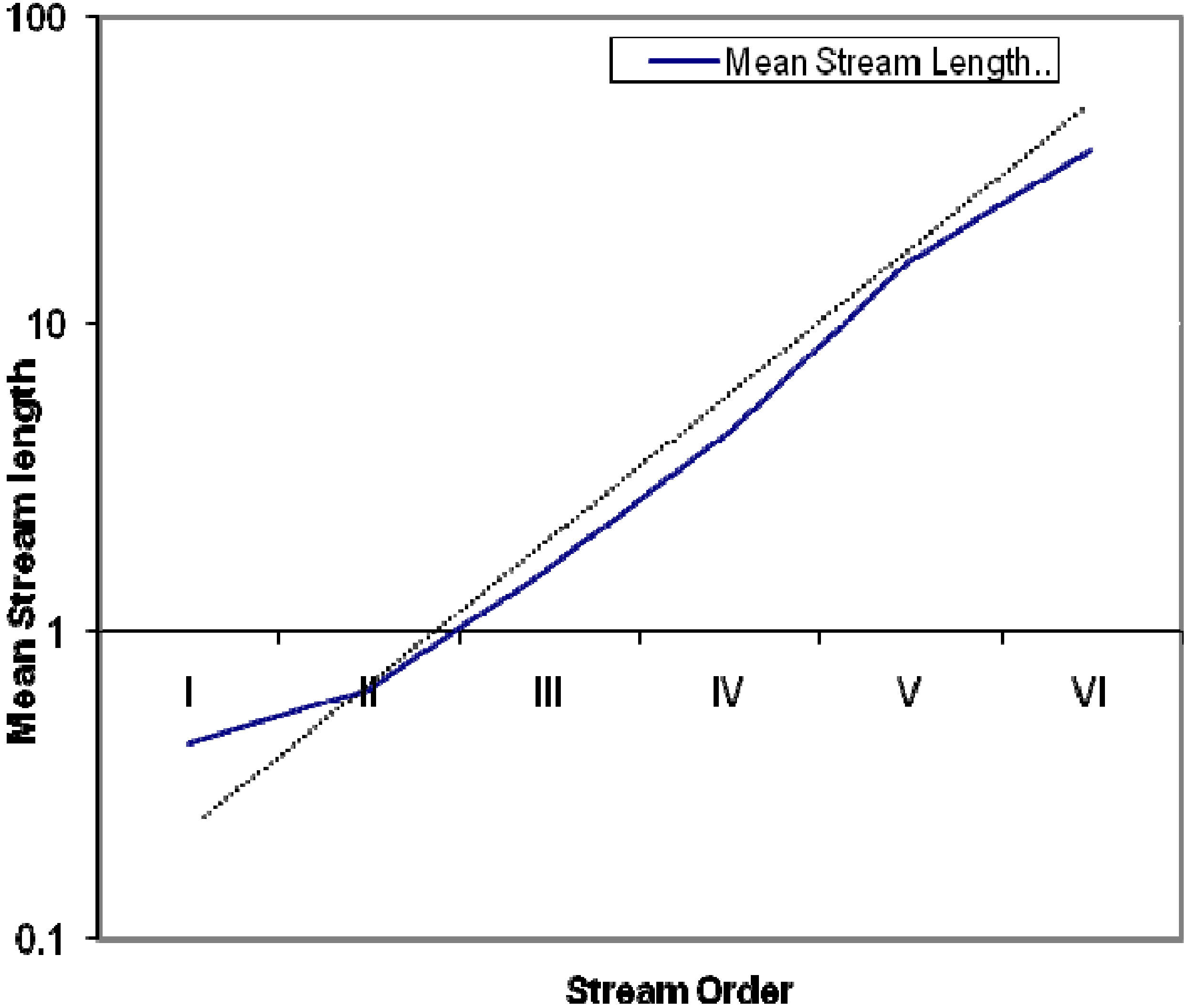
Mean Stream Length Vs Stream Order Graph of River System Fall on Loktak Lake

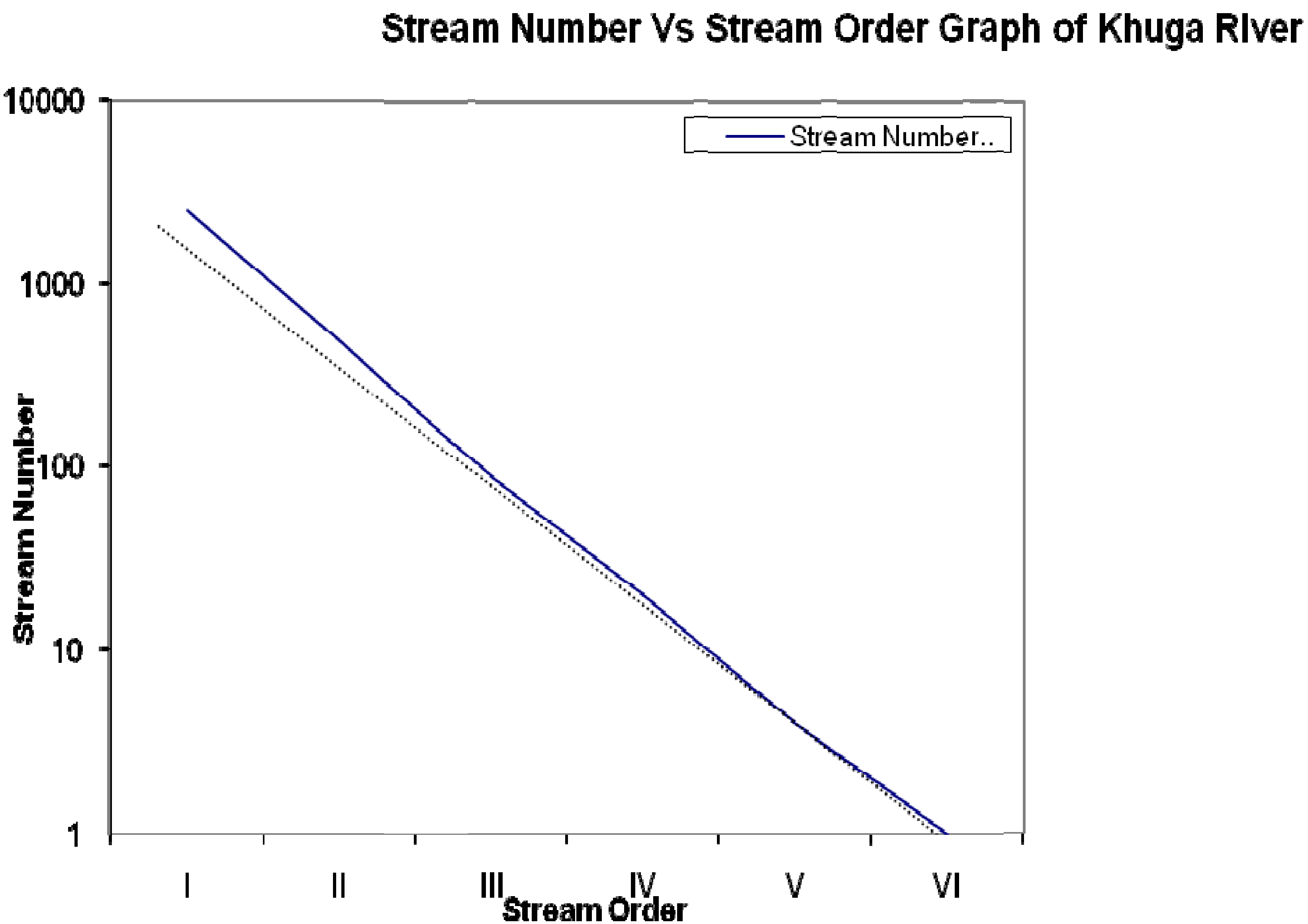


Stream Number Vs Stream Order Graph of River System Fall on Loktak Lake



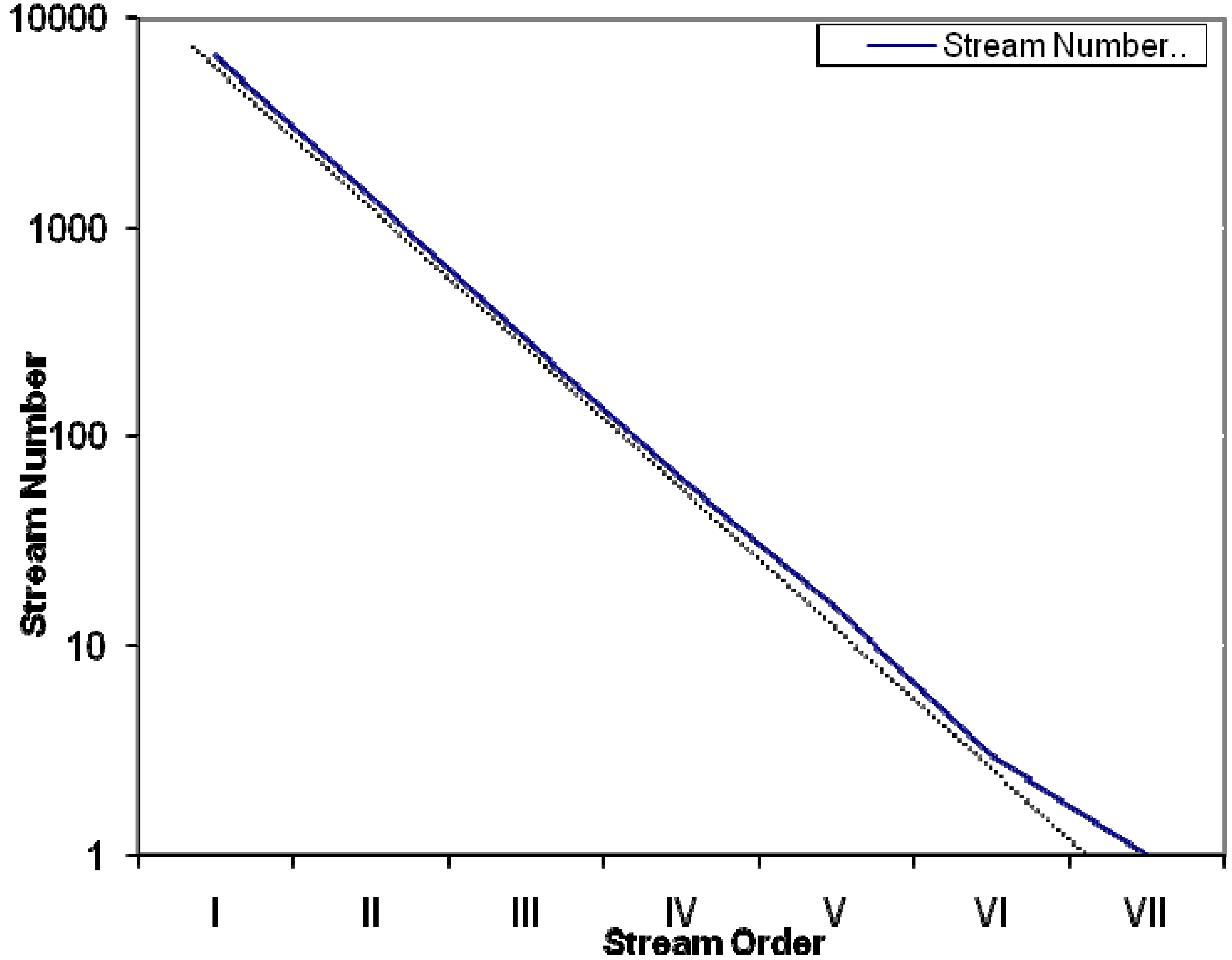
Mean Stream Length Vs Stream Order Graph of Khuga River

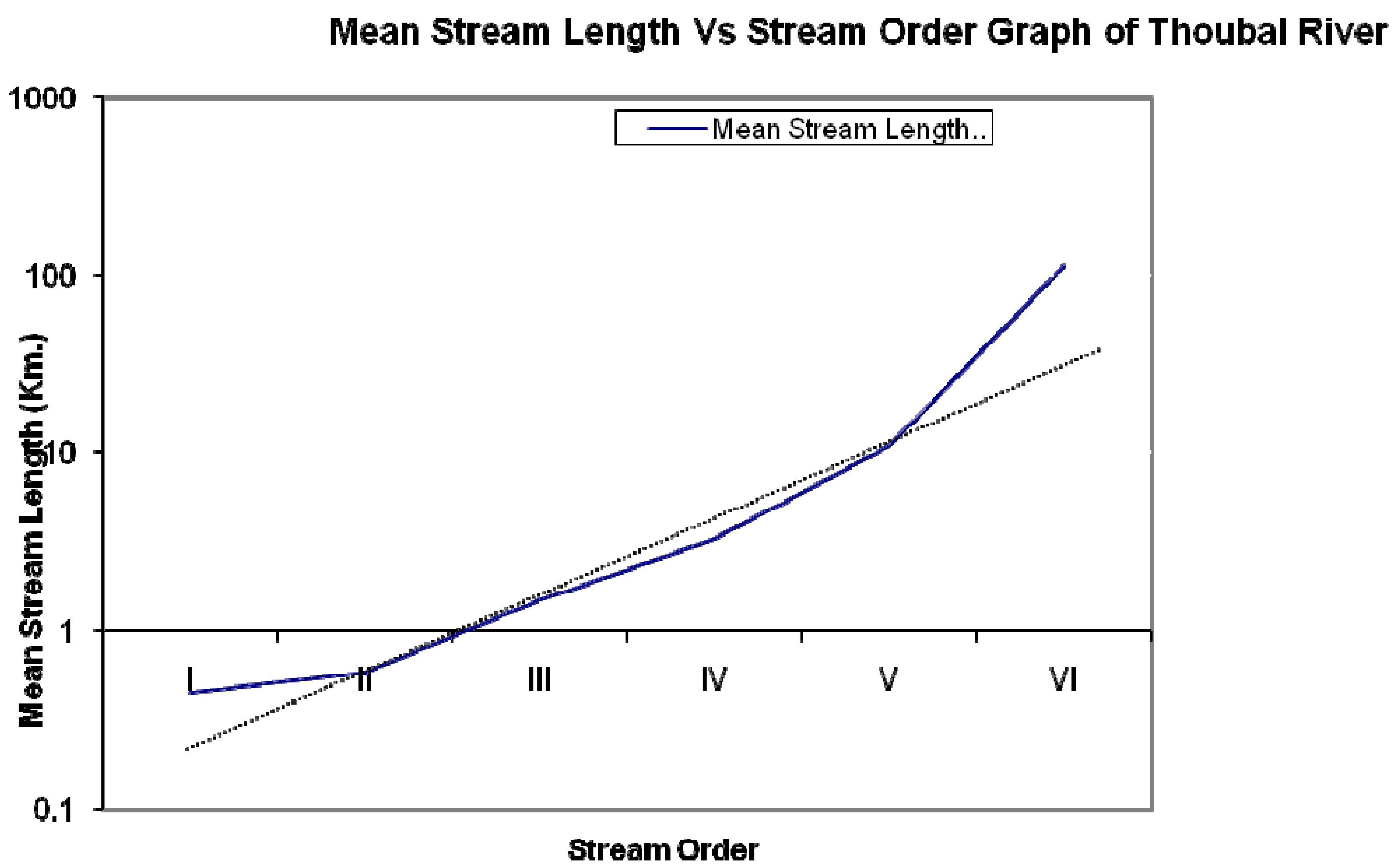



Stream Number Vs Stream Order Graph of Khuga RIver
Stream Number..
10000
1000
100
10
1
Stream Number
I
II
III
IV
V
VI
Stream Order

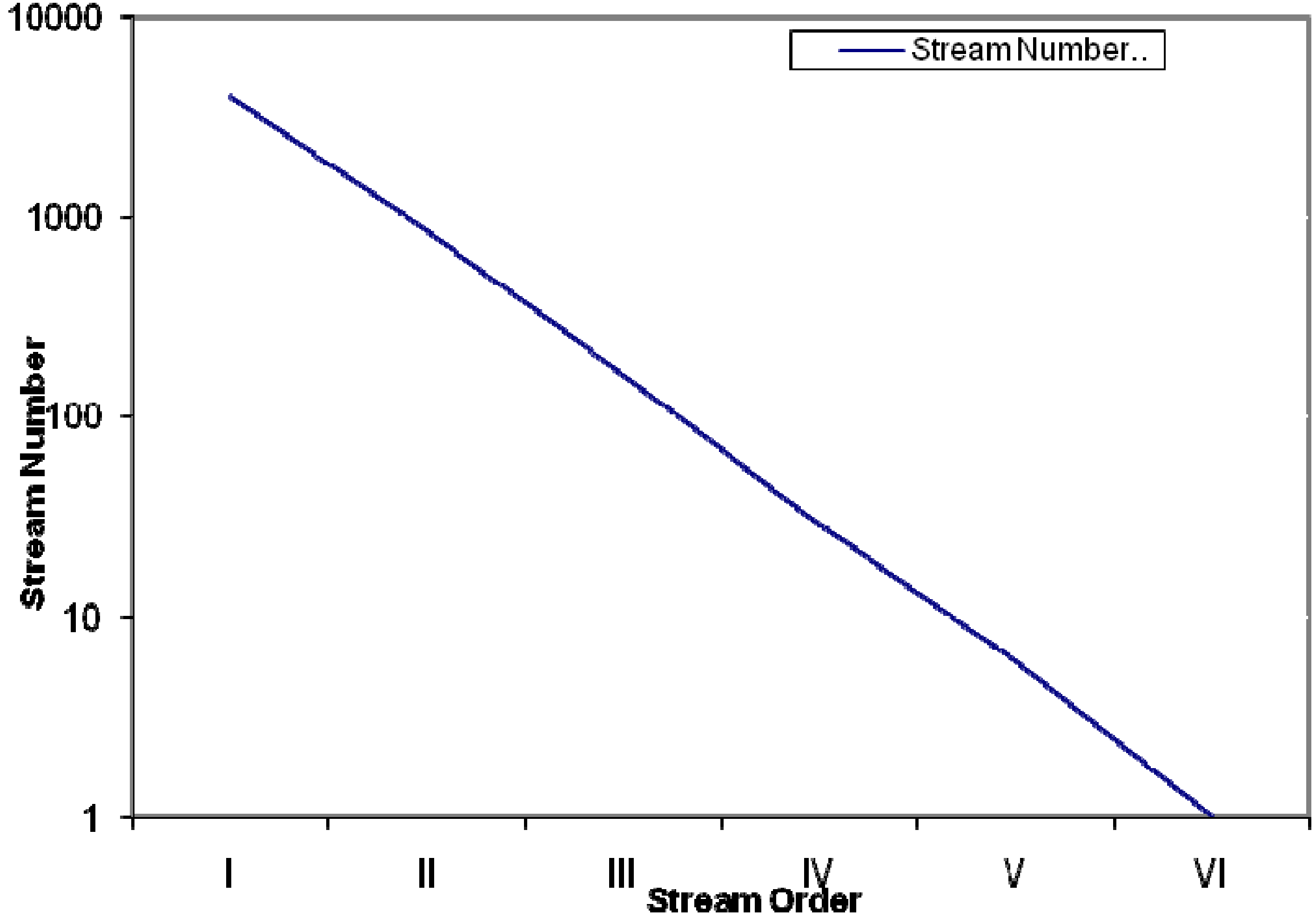
Mean Stream Length Vs Stream Order Graph of Iril River

Stream Number Vs Stream Order Graph of Iril River

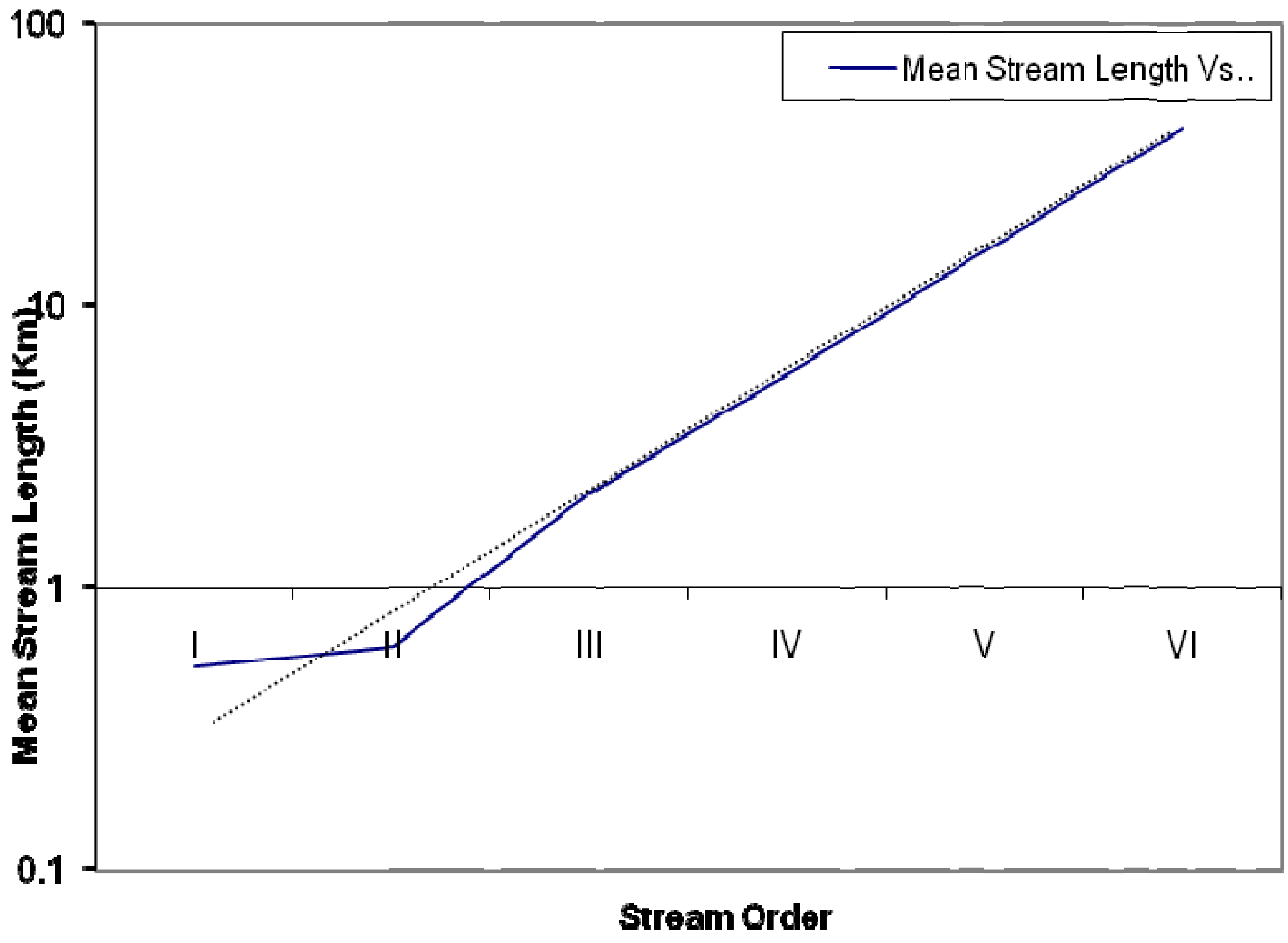



Mean Stream Length Vs Stream Order Graph of Thoubal River
Mean Stream Length..
1000
100
10
1
0.1
Mean Stream Length (Km.)
I
II
III
IV
V
VI
Stream Order

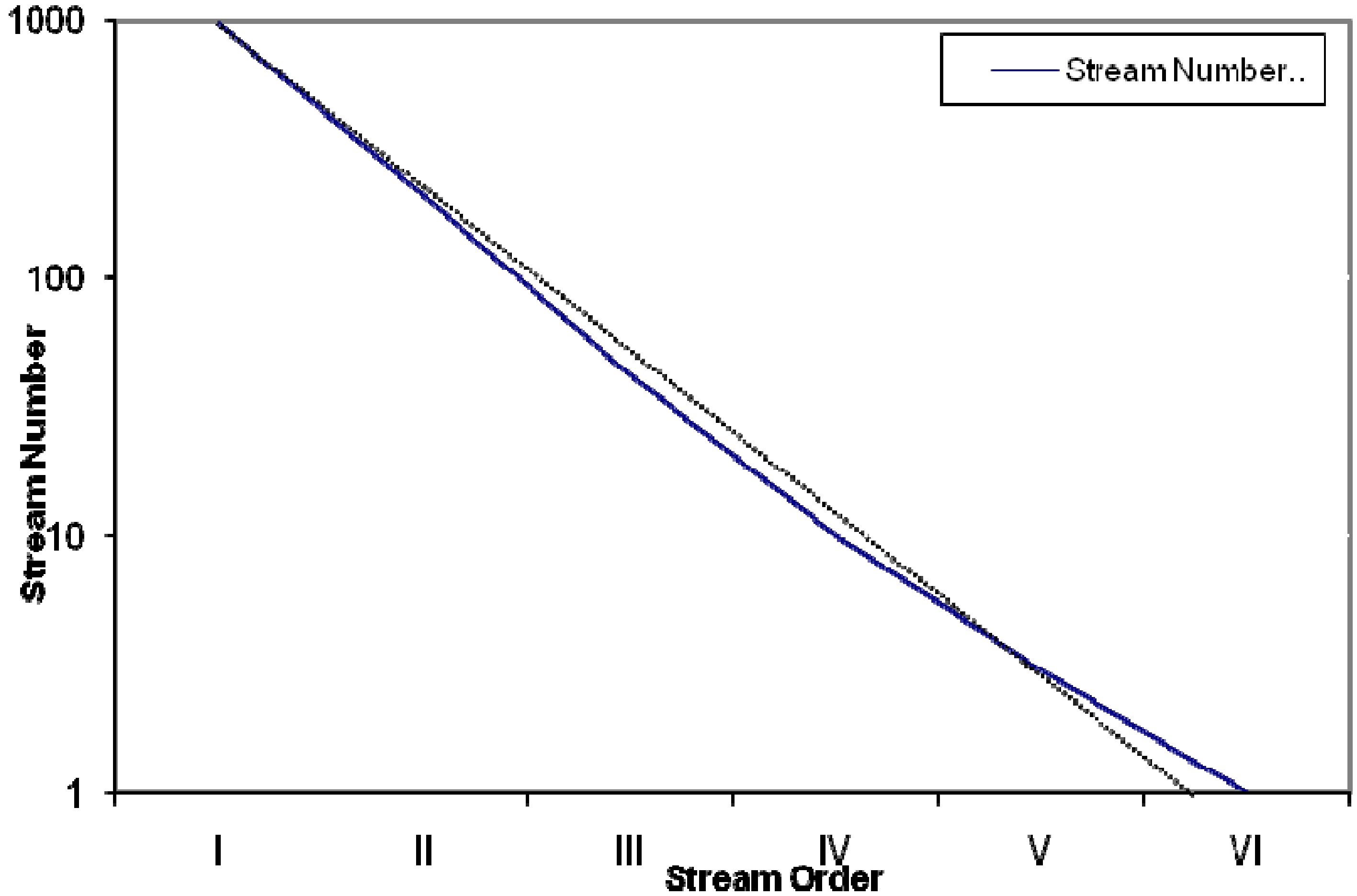
Stream Number Vs Stream Order Graph of Thoubal River



Mean Stream Length Vs Stream Order Graph of Imphal River



Stream Number Vs Stream Order Graph of Imphal River



Slope and Drainage, Combine Analysis

The Imphal River originates from Kangpokpi area. It flows down for a distance of 2 km. (Arial distance) in very steep slope zone and then drains in the strong to steep slope zone for a distance of 5 km. Then Imphal River flows 12 km. in the moderate sloping region up to Motbung. Next it drains through very gently sloping zone for a distance of 9 km. up to Leikinthabi, then Imphal river flows in the nearly level zone.

Iril River originates from the Chingai area of Ukhrul district. It drains for a short distance of 1.25 km. down very steep slope and flows through strong to steep slope for 6 km. and again flowing down steep slope for a distance of 19 km. And Iril River flows through very gently sloping area 8 km. downstream. Then it flows through nearly level area, a distance of around 30 km. upstream from valley boundary.

Thoubal river originates from Ukhrul . It flows for a distance of 30 km. through very steep slope. Then it flows for a distance of 17 km. finally enters nearly level zone at a distance of 6 km. upstream distance from Yairipok.

Wangjing River flows through very steep slope for a distance of 4 km. then 4 km. through very gently sloping area and next drains in the valley area.

Sekmai River drains 9 km. through very steep slope and 2 km. through strong to steep slope, and then flows in the valley area.

Chakpi River has two main tributaries: one flowing north to south and the other flowing south to north direction. The one, which flows north to south, drains 12.5 km. through very steep slope and then 2 km. through strong to steep slope, again 16 km. through very steep slope and then 8 km. through strong to steep slope. The one, which flows south to north, drains 19 km. through very steep slope and then 4 km. through strong to steep slope. The two tributaries confluenced and flow northwestward pass 10 km. of nearly level area before meeting Manipur River.

Most of the rivers, which drain in the Loktak Lake flow from west to east direction and are ranges between 6 km. to 12 km. However Nambul River: the longest river, which falls, in Loktak Lake has 58 km. long. The various river and stream flow 1 to 4 km. through very steep slope and 1 to 2 km. strong to steep slope, then drain 1 to 3 km. in the very gently slope zone, next drains nearly level zone of valley area.

Khuga River flows for a distance of 28 km. in the strong to steep slope then 28 km. through gently sloping zone and next flow in the nearly level area for a distance of 6 km. before confluence with the Manipur River

Discussion

Since, Thoubal River covers longest distance of very steep slope for a distance of 30 km. and 26 km. through strong to steep slope. Hence, Thoubal River practically got highest stream velocity. This may be the reason; Thoubal River gets maximum breach of river embankments. Besides the riverbank bunds of Thoubal River are much higher than the surrounding flood plain area. Breach of riverbank frequently occurred at Okram, Sabaltongba, Khekman, Ningombam, Leisangthem, Phoudel and Haokha.

Comparatively Imphal and Iril River have slower stream velocity and lesser number of breaches of river embankments. However after Imphal river confluences Iril River at Lilong, river becomes more voluminous and speedier. Consequently breach of embankment occurs frequently in the area such as Chajing, Haoreibi, Samurou and Lilong.

The rivers and streams fall in the Loktak Lake originate from western hill range. Since most of the rivers flow in the steep slope for a distance of 40% to 50% , of their journey before drain in the Loktak Lake. Naturally their stream velocities are high. Hence they carry more sediment from the degrading western hills to deposit in the Lotak Lake.

Chakpi River have two main tributaries; one drain from north to south and other drain south to north, finally confluenced and drain north-westward for a distance of 10 km. to join the Manipur River. Since the two tributaries flows 60% to 70% of their length in steep slope zone, their flow velocity will be definitely high, again join Manipur River almost at reverse direction, hence creating flood problems in the adjoining area.

Khuga River flows through strong to steep slope for a distance of 28 km. and then 28 km. through gently sloping surface before joining nearly level surface of the valley. Hence river velocity is moderate to high, creating flood problem in Kumbi and Ithai Village.

Survey Report

We have done survey work along the riverbanks and flood prone areas of Manipur Valley. A brief report is presented as below.

Singjamei to Lilong

Around one km. downstream from Singjamei Bridge along Imphal River former breach of riverbank is encountered. On the opposite side of the river, riverbank slumping is evidenced. At Kyamgei about 5 km. from Singjamei bridge near Kyamgei bridge, evidence of former breach of embankment is found. At the opposite bank cracks are developed. In near future breach of the bank may happen. Very near to this place there are four different places in which similar condition is observe.

Lilong to Wangoi

At about 500 m. downstream from Lilong Bridge; on the convex side, former breach of bank is found. Here slope of the bank is very steep. In some places near this place major cracks are developed, hence question of slumping in near future arises. At Haoreibi at about 2 km. from the above place; on the convex side one place is found similar in condition to the above place. We noted this place to be potential breach site. At Samurou, at the convex side of the Imphal river, near Samurou bazar former breach of river bank is found. The slope of riverbank is very steep. A little further downstream, one former breach site is also found on the other side of the river. The area is found to be maintained nicely with plantation of trees. This will be a good example for remedial measure. At a little distance downstream of Imphal Barrage there is one vulnerable place on the same bank around 300 m. south of the previous place. A large crack is observed parallel to the bank. This place is noted to be potential slump area.

Thoubal Bridge to Leisangthem

At Thoubal, a little distance upstream from Thoubal Bridge, on the western riverbank, which is also on the convex side of the river evidence for former breach of riverbank is also observed. At around 200 m. upstream also on the convex side another potential site is found. From Thoubal Bridge to Leisangthem, most of the convex side of the Thoubal River are exposed to erosion; as a result the places are prone to breach. From Leisangthem, downstream the current of the river becomes a bit slower, and river becomes wider. Hence breach of river embankment is much less.

Yairipok to Thoubal

From Yairipok to Thoubal, the riverbank is more or less at a level with that of surrounding ground level; hence no serious problem for breach of embankments arises. However, most of the convex side are prone to erosion, as we found slumping of riverbanks.

Northern side of Moirang Kampu Bridge :

For the Iril River, in the northern upstream side of Moirang Kampu Bridge, problems for breaches of riverbank are not observed. No doubt a former breach site is found. In this section the terraces are well preserved; vegetation and plantation are dominated.

Moirang Kampu to Lilong Bridge

In the downstream side of the Moirang Kampu Bridge upto Bamon Kampu Bridge, in many places, erosion and slumping of riverbanks are encountered at many places. From Bamon Kampu Bridge to Lilong Bridge there is no serious problem for breach of riverbank except at one or two places.

Nambul River

For Nambul River, there are no prominent riverbank erosional sites. On the southern side from Hiyangthang, the paddy fields, which lie in the flood plain areas are low lying areas. These areas are prone to flood.

Discussion

Most of the southern parts of the Manipur Valley are lying adjacent to wetlands. Hence these areas are prone to flood.

The Chakpi River meets the Manipur River at a reverse direction, thereby checking the current of Manipur River, making inundation of the surrounding area of Sugnu extending upto Wangoo during rainy season.

In the northern part of the Manipur Valley flood occurred due to breached of river embankments, whereas in the southern parts flood occurred due to overtopping of the rivers and also due to water spread of wetlands during rainy season.

Stage – Discharge Relation

We tried to develop the stage-discharge relationship by plotting data of major rivers of Manipur Valley for a period from 1^{st} January 1999 to up date, which is data available to us.

During 2^{nd}-10^{th} September 1999 flood occurred in Manipur Valley. Most of the southern parts of Manipur Valley are affected by the flood.

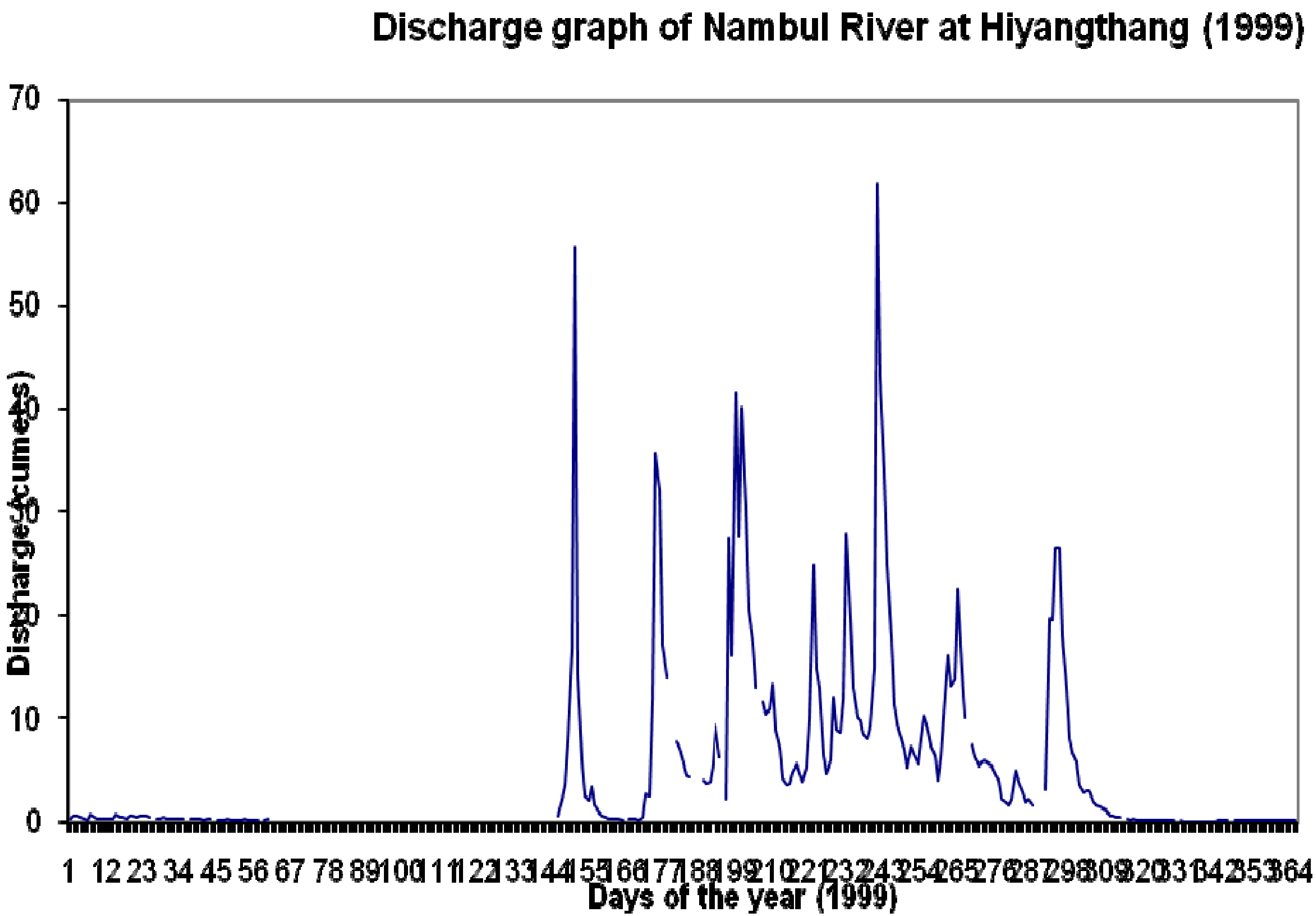
The Thoubal River reached a peak stage of 9.49 metres above datum at Thoubal Bridge on 30^{th} August 1999. And on 2^{nd} September stage reach 9.25 m. The discharge magnitude reaches its maximum value of 391.636 cumecs on 30^{th} August 1999 and on 2^{nd} September with a value of 330.906 cumecs. The Iril River reaches its maximum discharge of 330 cumecs on 2^{nd} September 1999 at Moirang Kampu Bridge. Imphal River reach 105.523 cumecs correspond to stage value of 6.2 metres on 30^{th} August 1999. On 29^{th} August nambul River have discharge value of 61.955 cumecs. The above data are very much relevant with the 2^{nd}-10^{th} September flood 1999.Flood in Manipur Valley occurred during 1^{st} to 9^{th} September 2000. Imphal River discharge 202.006 cumecs corresponds to stage value of 7.3 meters above datum on 2^{nd} September. Iril River reached a peak stage (for 2000) of 11.04 meters above datum at Moirang Kampu on 2^{nd} September, and discharge value reach 532.488 cumecs. For Thoubal River discharge value is 216.672 cumecs with stage value of 8.1 meters above datum on 3^{rd} September. Nambul River discharge 57.723 cumecs on 2^{nd} September.

The stage-discharge relation shows as looped curve nature, as shown on the graphs, which conveys that when a flood wave passes a gauging station in the advancing portion of the wave the approach velocities are larger than the steady flow at corresponding stages. Thus for the same stage, more discharges than in the steady uniform flow occurs. In the retreating phase of flood wave the converse situation occurs.During 2001 flood of low magnitude occurred in Manipur Valley. On 7^{th} June some areas of Nambol are inundated.

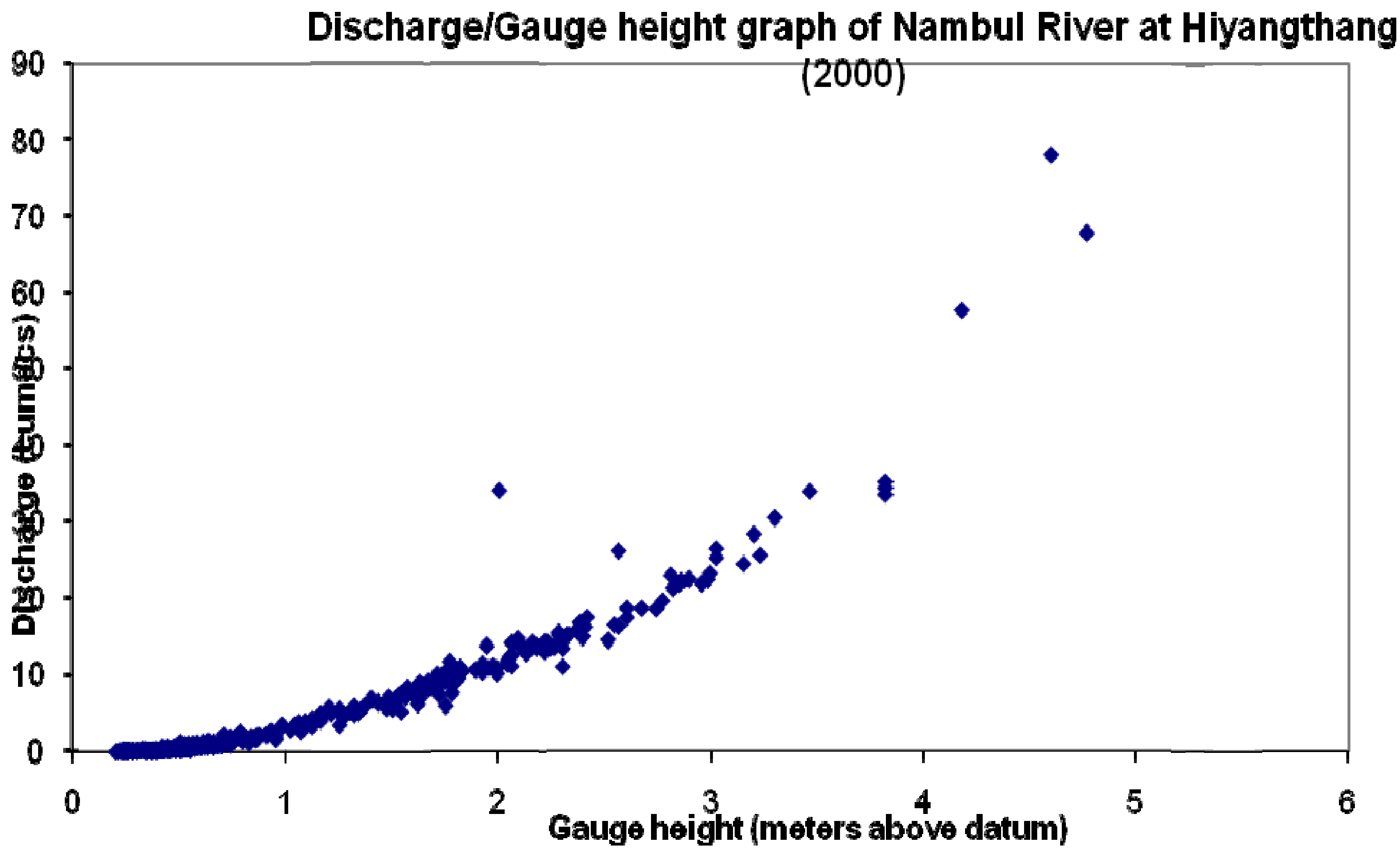
On 3^{rd} July flood inundate 1000 parts of cultivated land at Lilong Chajing, Haoreibi and Karam. On 1^{st} July overflow of Nambul River inundate Uripok and Khwairamban Bazar.

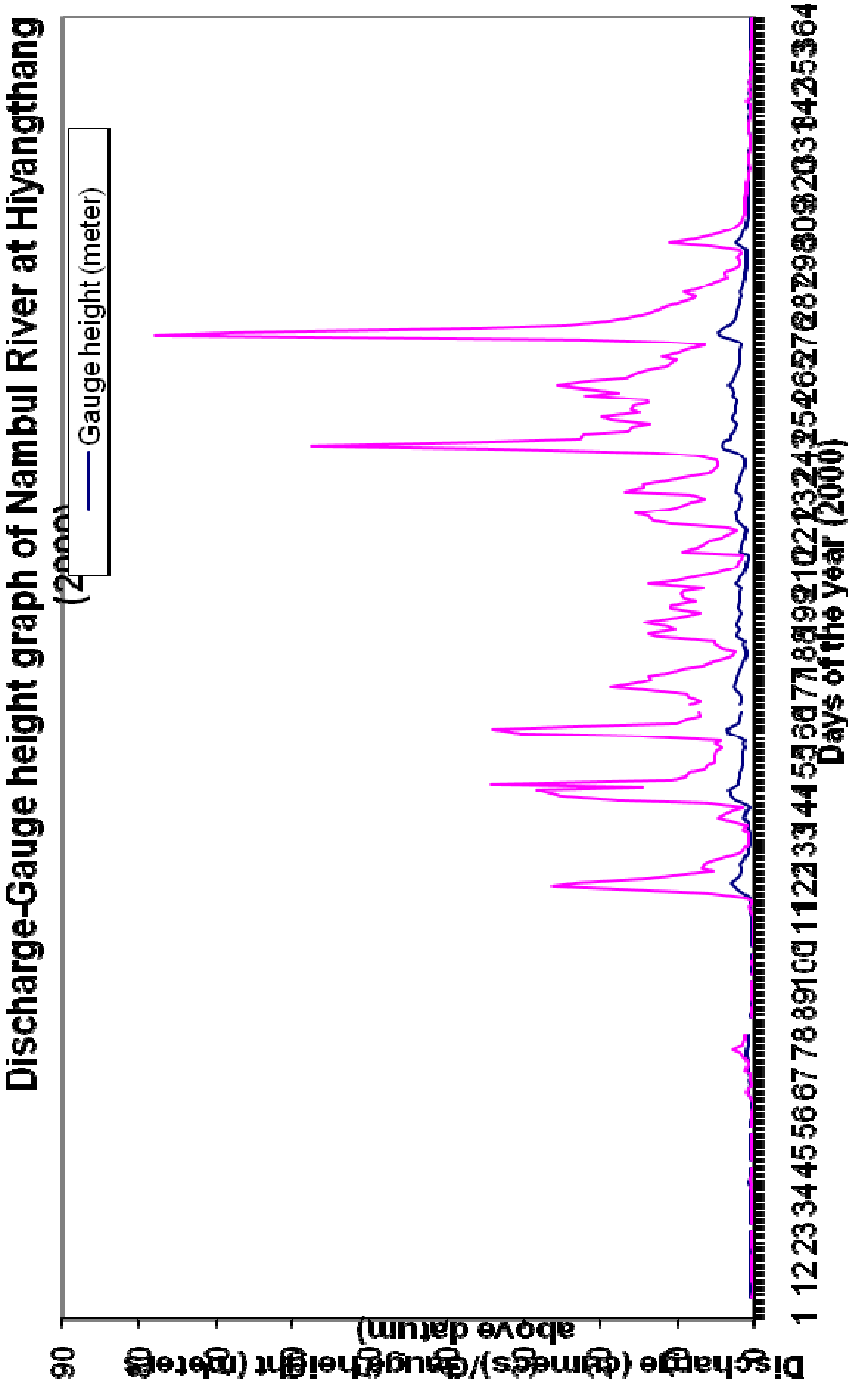
Imphal River has a discharge of 154.611 cumecs on 5^{th} June with a stage value of 7.92 meters above datum. Discharge of Iril River has 200.969 cumecs with 7.92 meters above datum 2^{nd} July. Thoubal River reach its stage, 7.8 meters above datum correspond to a discharge of 171.644 cumecs on 2^{nd} July. Nambul River have 68.495 cumecs discharge and 4.7 meters above datum on 2^{nd} July.

From the Stage-Discharge graph of 2001, it depicts that the flood waves are not much prominent. There is no major flood in the Valley in the year 2001.

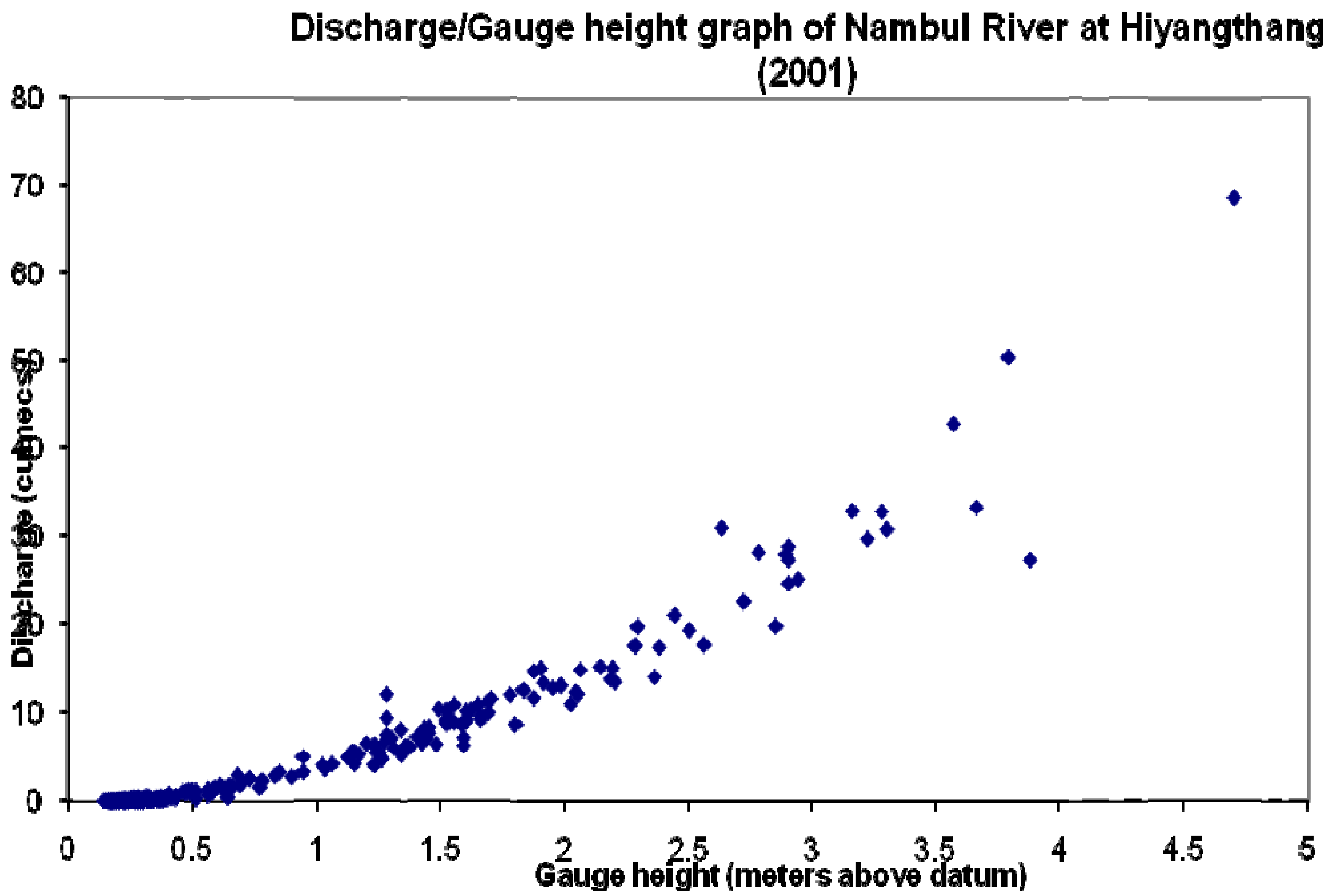


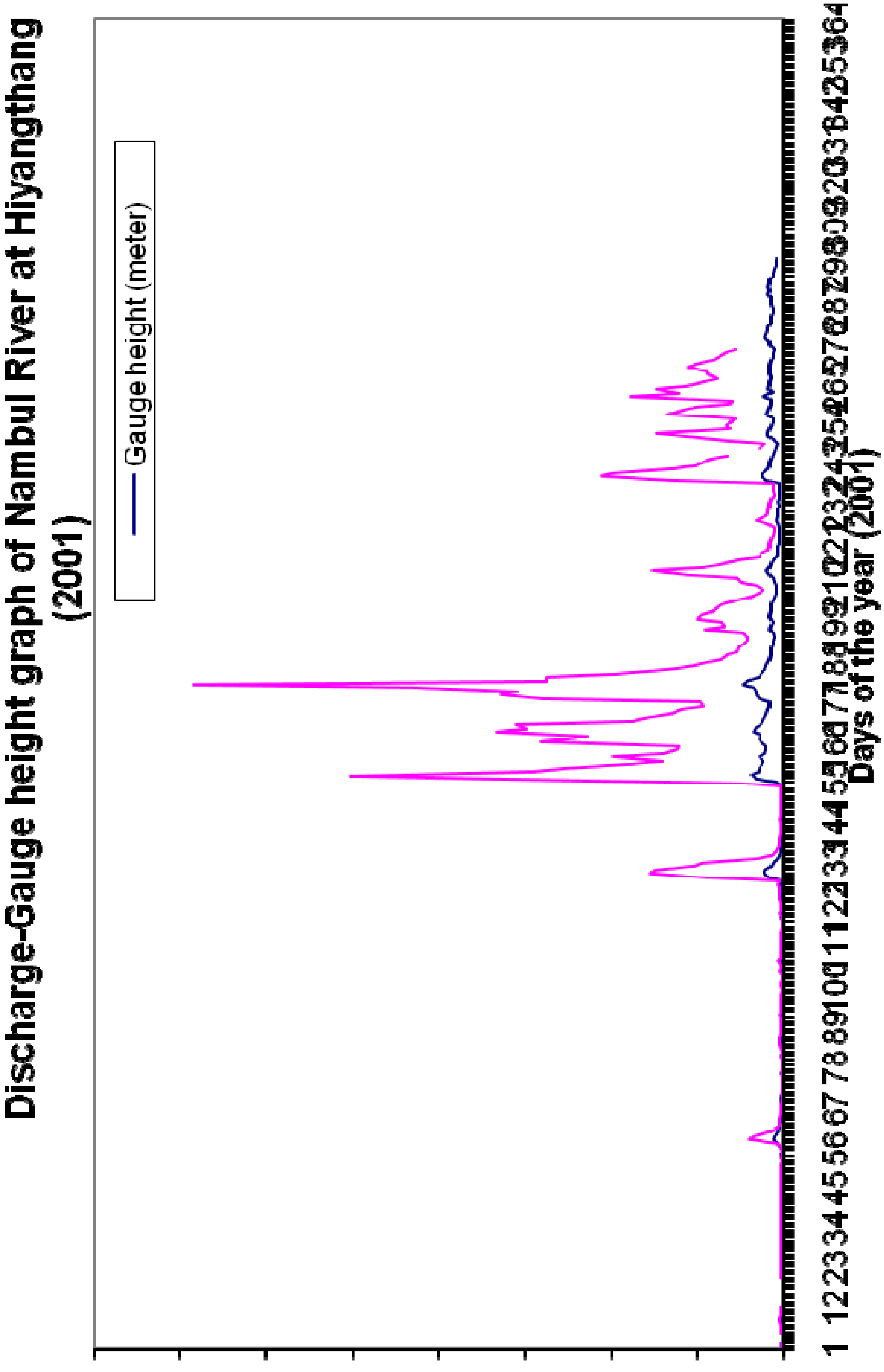
Discharge graph of Nambul River at Hiyangthang (1999)
Discharge (cumecs)
Days of the year (1999)


Discharge/Gauge height graph of Nambul River at Hiyangthang
(2000)
90
80
70
60
10
0
0
1
2
3
4
5
6
Gauge height (meters above datum)

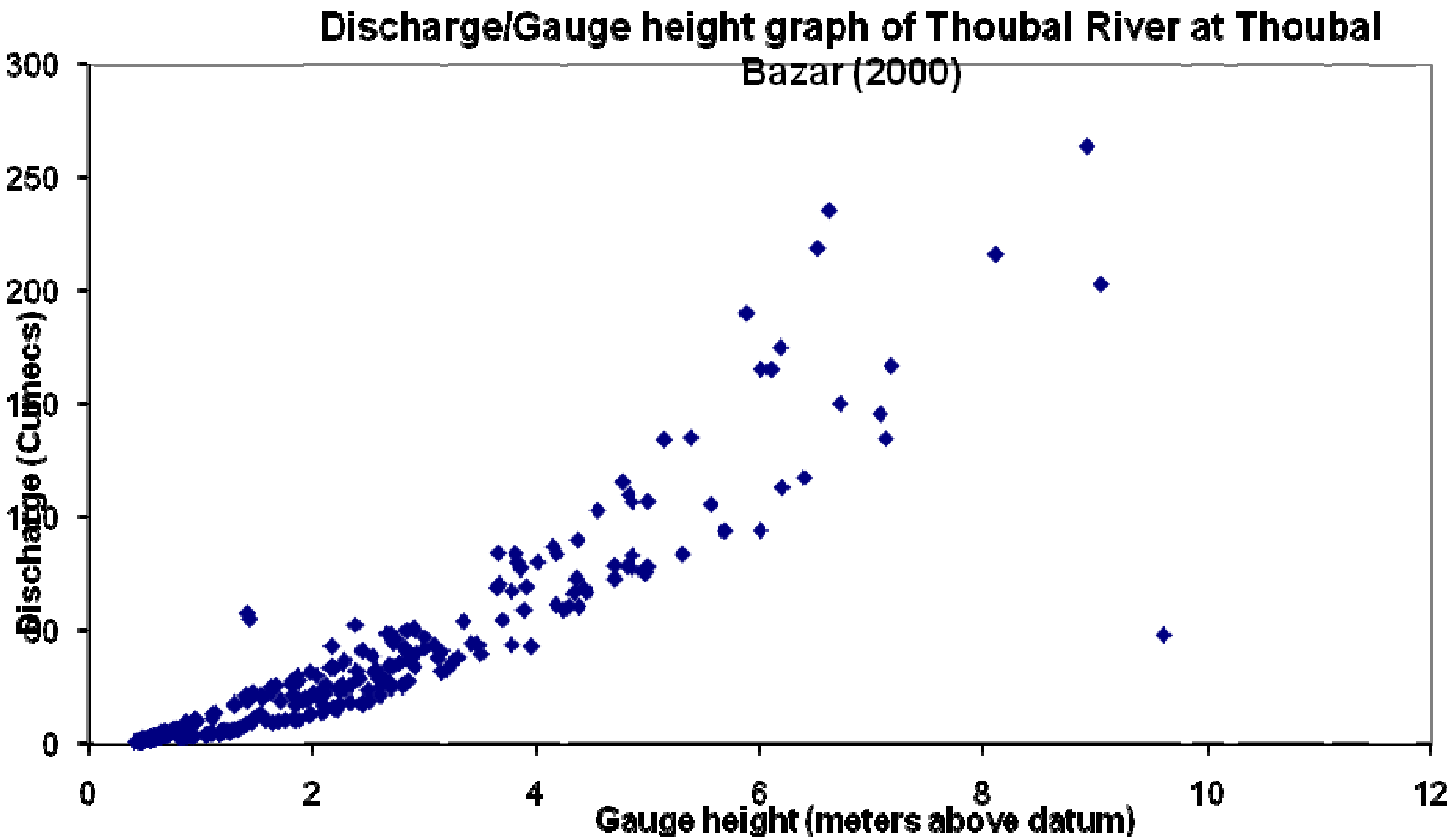


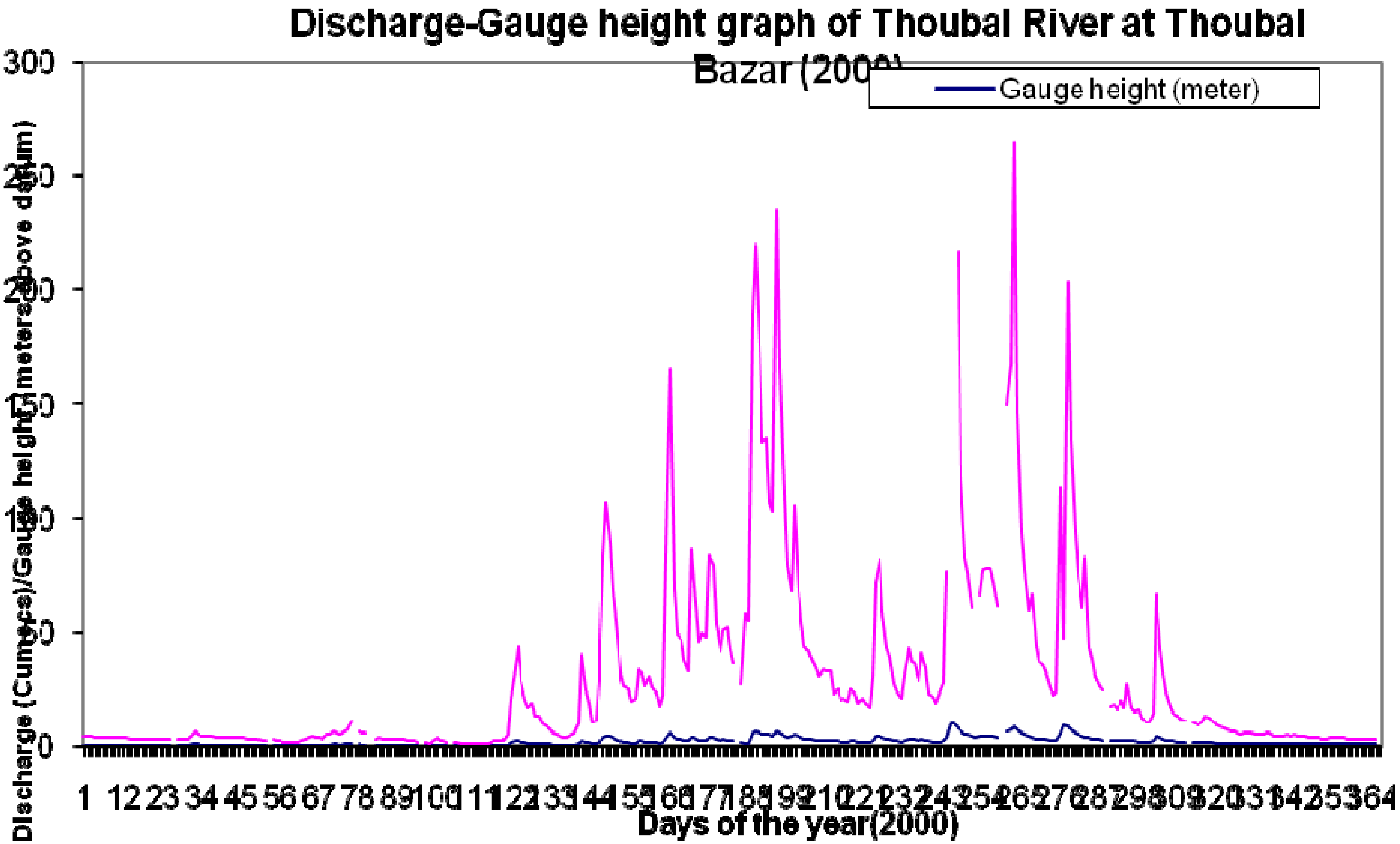
Discharge-Gauge height graph of Nambul River at Hiyangthang (2000)
Gauge height (meter)
Days of the year (2000)

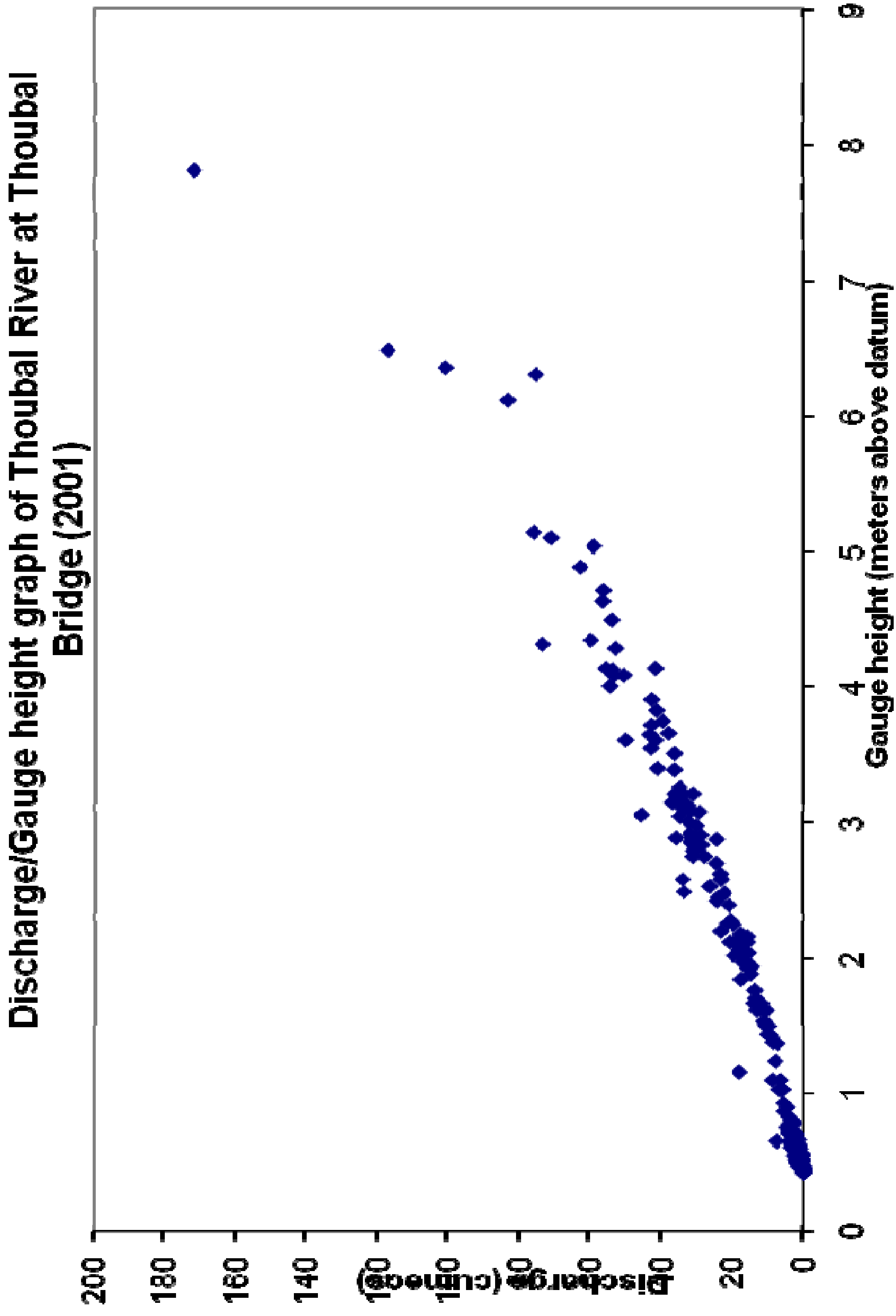

Discharge/Gauge height graph of Nambul River at Hiyangthang
(2001)
Discharge (cumecs)
80
70
60
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Gauge height (meters above datum)



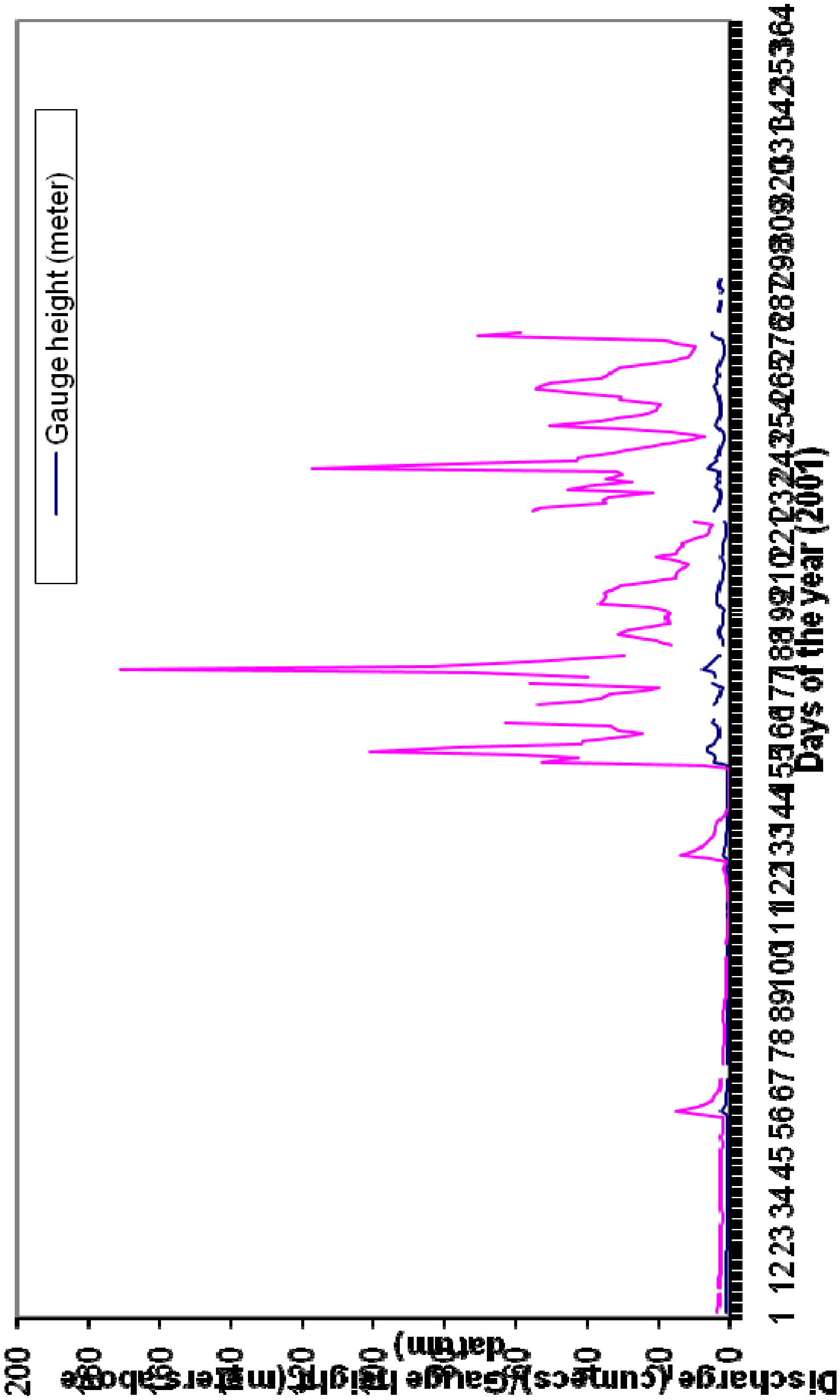
Discharge-Gauge height graph of Nambul River at Hiyangthang (2001)
Gauge height (meter)
Days of the year (2001)

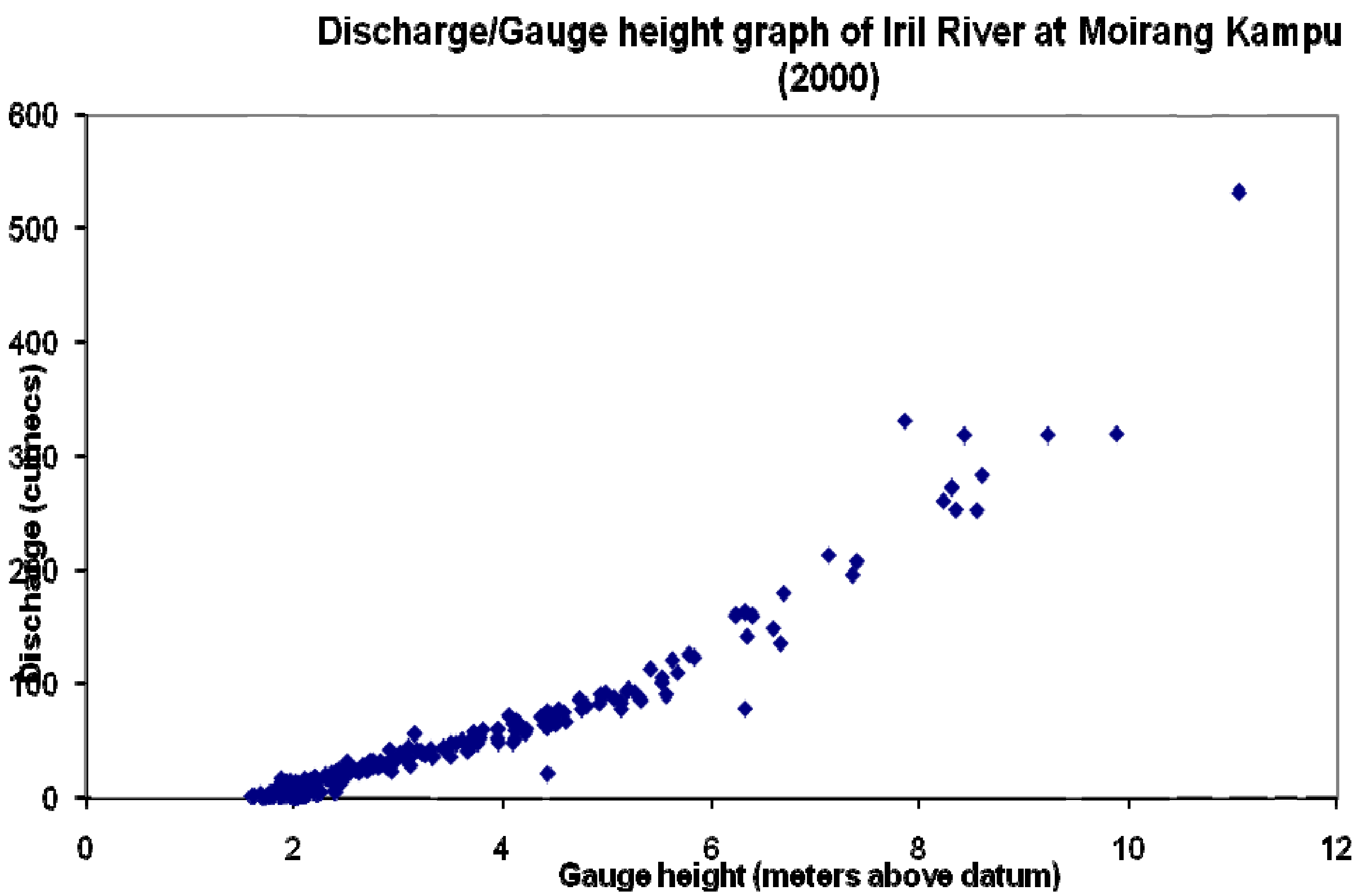

Discharge/Gauge height graph of Thoubal River at Thoubal Bazar (2000)
Discharge (Cumecs)
Gauge height (meters above datum)
0
50
100
150
200
250
300
0
2
4
6
8
10
12

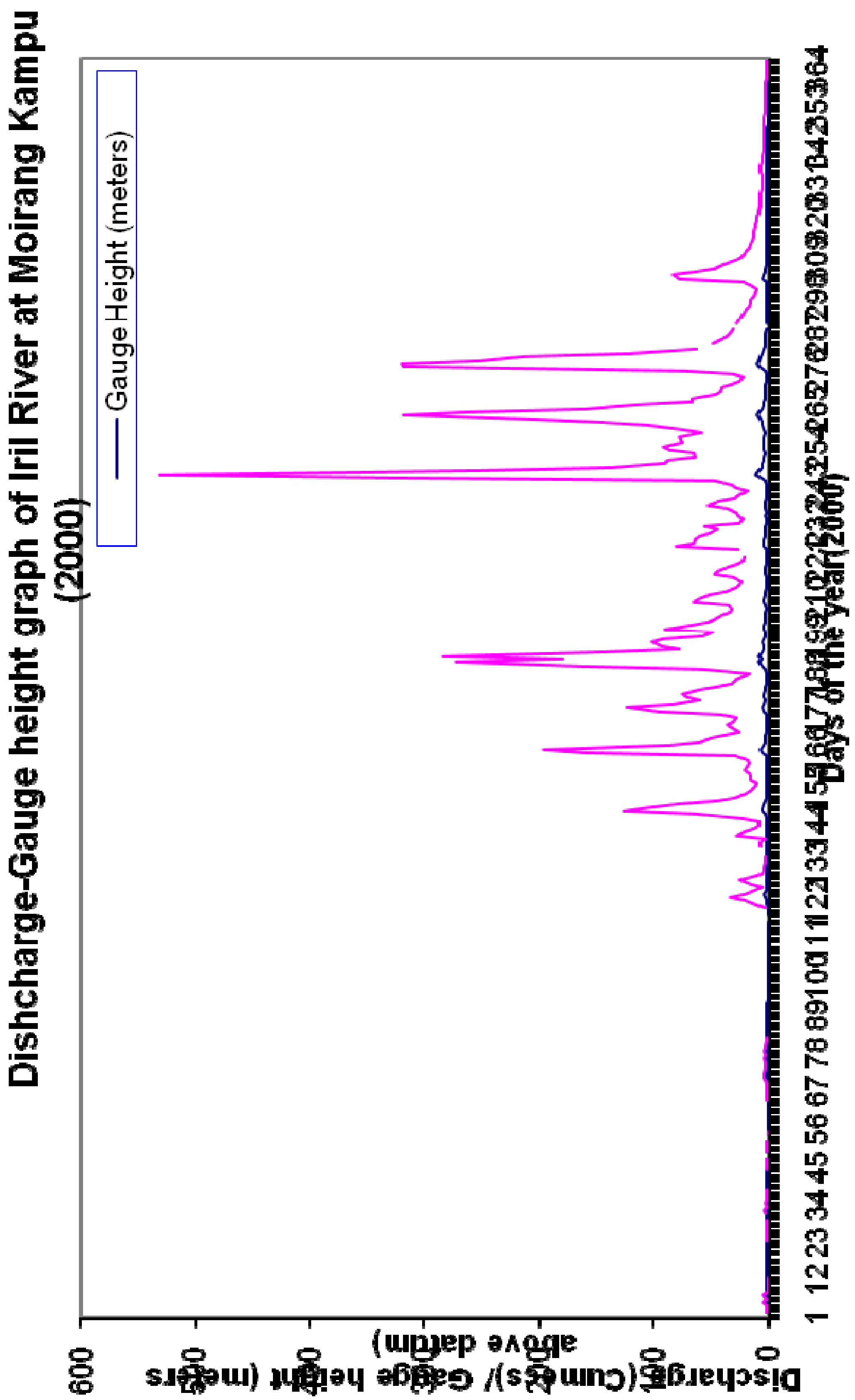

Discharge-Gauge height graph of Thoubal River at Thoubal Bazar (2000)
Gauge height (meter)
Discharge (Cumecs)/Gauge height (meters above datum)
Days of the year(2000)
300
250
200
150
100
50
0


Discharge/Gauge height graph of Thoubal River at Thoubal Bridge (2001)
Discharge (cumecs)
0
20
40
60
80
100
120
140
160
180
200
Gauge height (meters above datum)
0
1
2
3
4
5
6
7
8
9

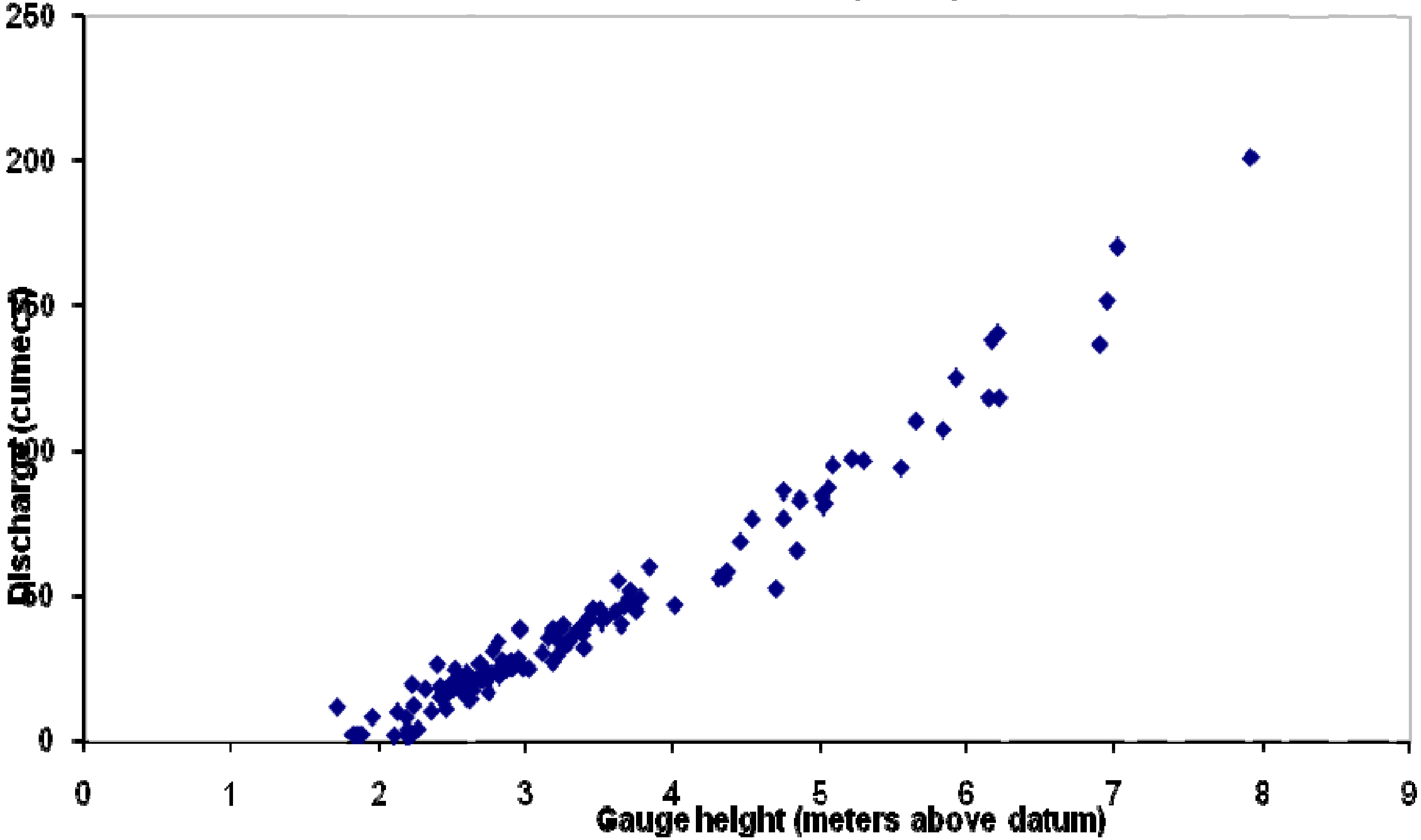
Discharge-Gauge height graph of Thoubal River at Thoubal Bridge (2001)



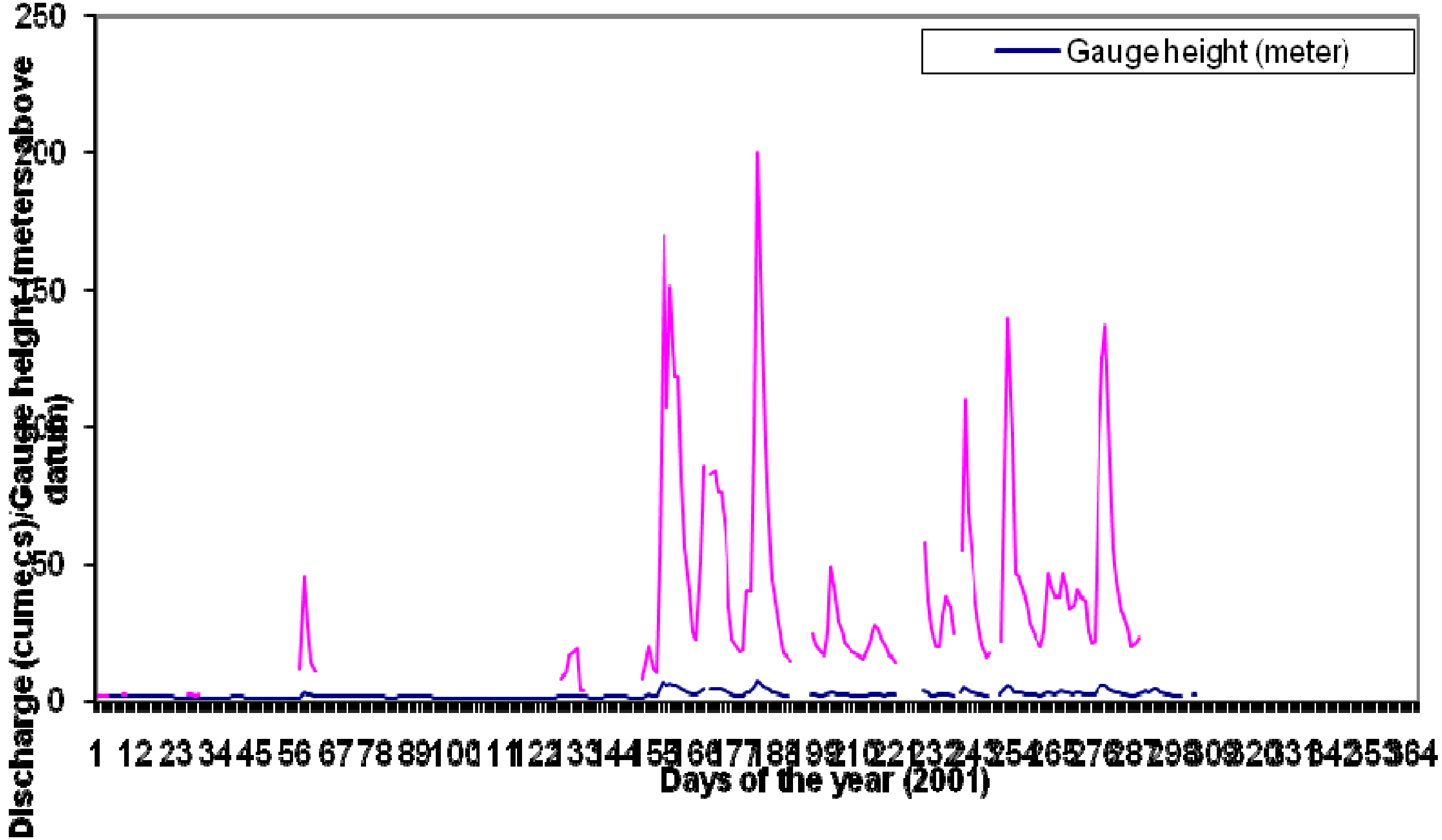

Discharge/Gauge height graph of Iril River at Moirang Kampu
(2000)
Discharge (cumecs)
600
500
400
300
200
100
0
0
2
4
6
8
10
12
Gauge height (meters above datum)

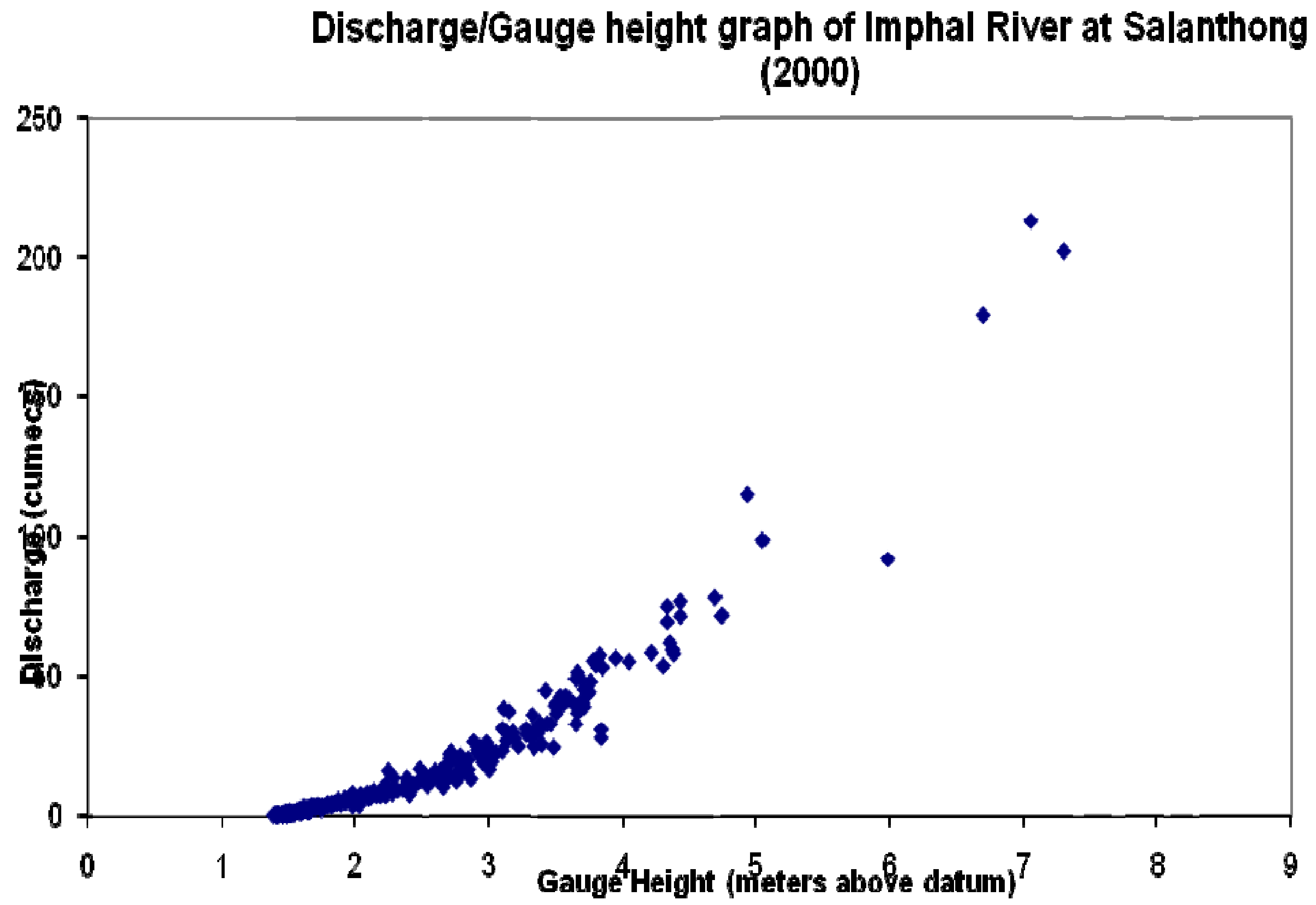

Dishcharge-Gauge height graph of Iril River at Moirang Kampu
(2000)
Gauge Height (meters)
Days of the Year(2000)
above datum)
0
600

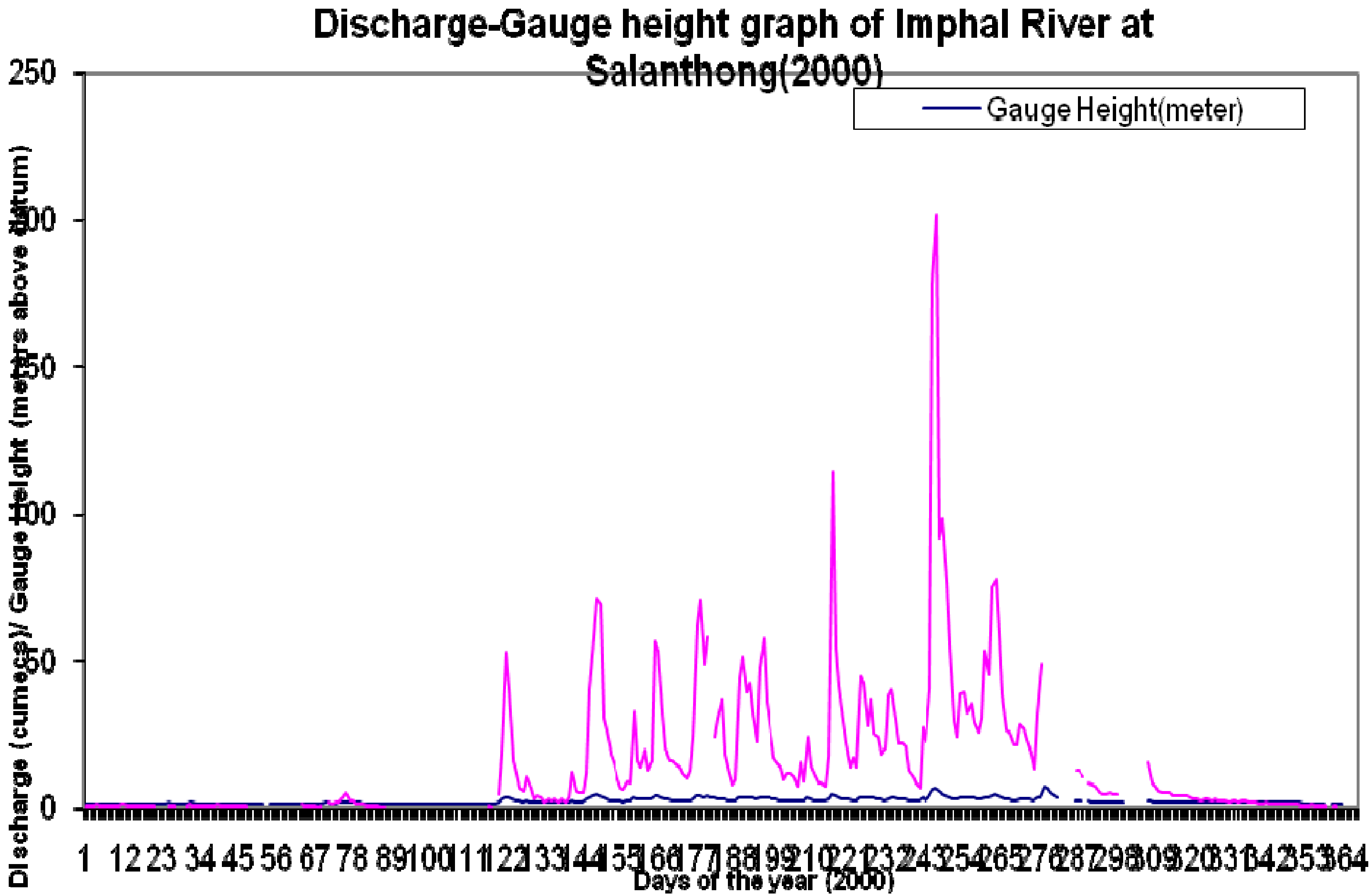
Discharge/Gauge height graph of Iril River at Moirang Kampu (2001)



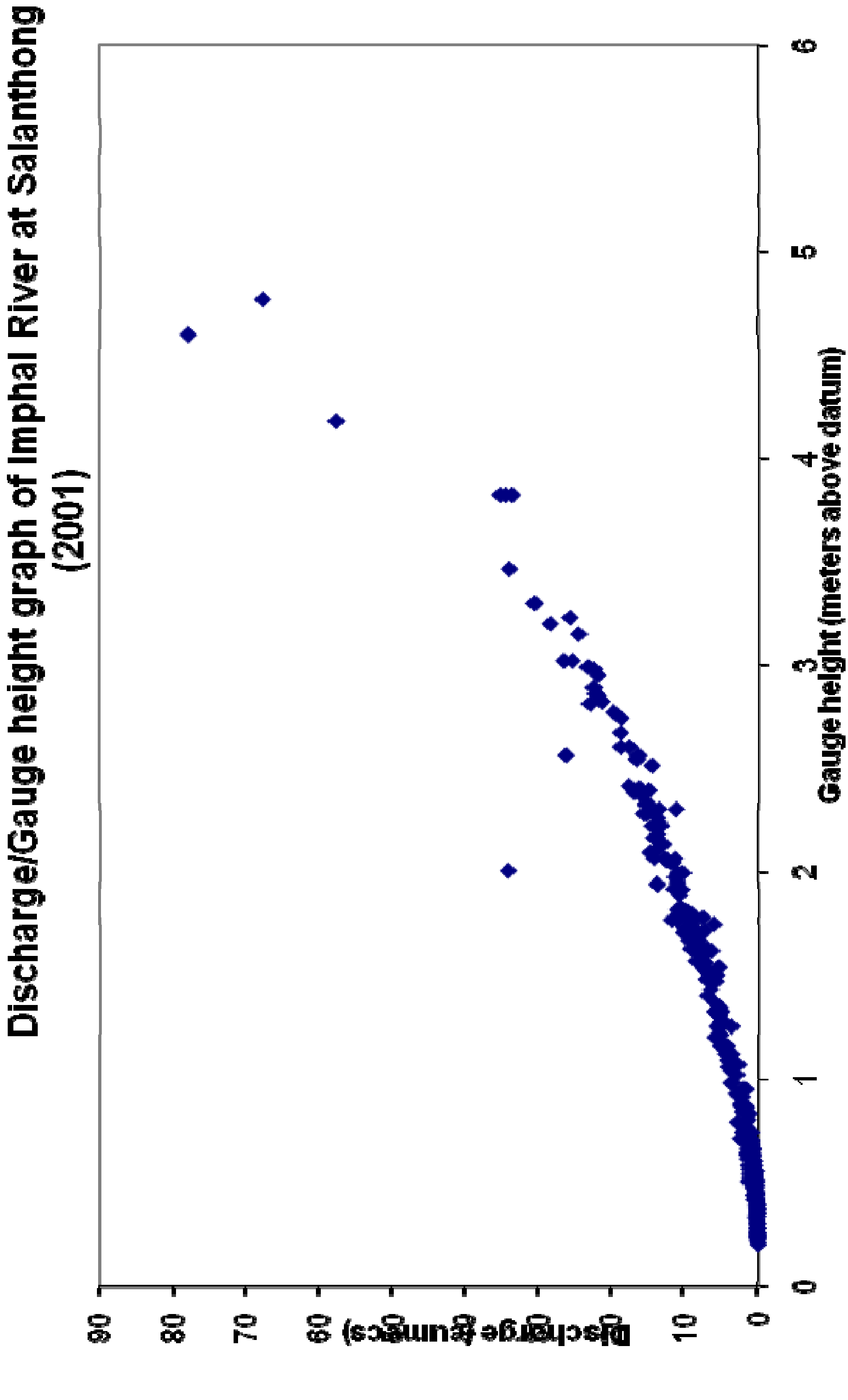
Discharge-Gauge height graph of Iril River at Moirang Kampu (2001)




Discharge/Gauge height graph of Imphal River at Salanthong
(2000)
Discharge (cumecs)
0
50
100
150
200
250
0
1
2
3
4
5
6
7
8
9
Gauge Height (meters above datum)

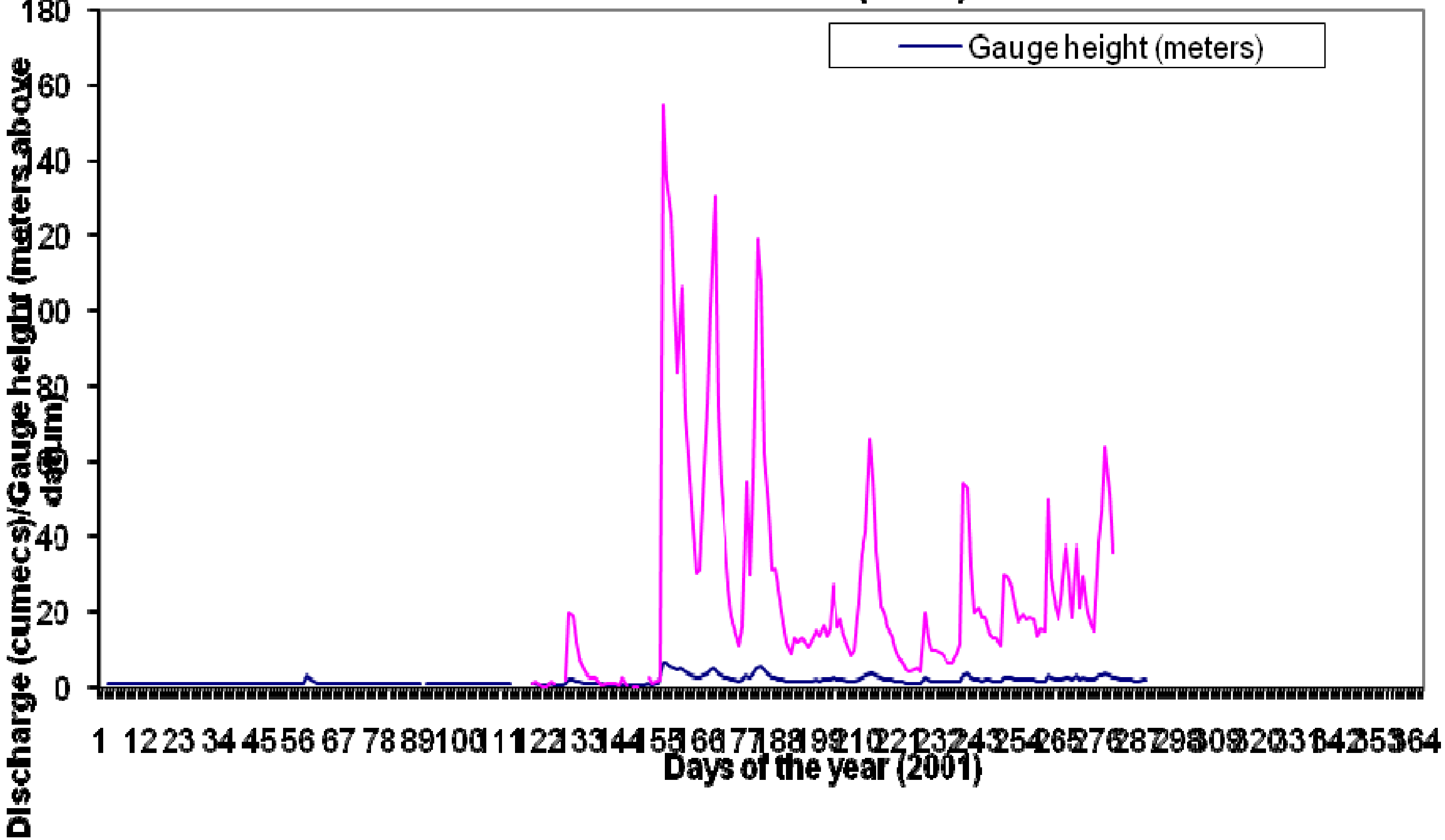


Discharge-Gauge height graph of Imphal River at Salanthong(2000)
Gauge Height(meter)
Discharge (cumecs)/ Gauge Height (meters above datum)
Days of the year (2000)
250
0
1



Discharge/Gauge height graph of Imphal River at Salanthong
(2001)
Discharge (cumecs)
0
10
60
70
80
90
0
1
2
3
4
5
6
Gauge height (meters above datum)

Discharge-Gauge height graph of Imphal River at Salanthong (2001)



Discussion

Flood in Manipur Valley is primarily due to heavy rainfall in the upper catchment areas. Intensity of rainfalls is higher in the hilly region than in the plain region. Hilly region, surrounding the valley region occupies 4432 sq. km. which is 70% of the total catchment area and area of Manipur Valley is 1900 sq. km. which is 30% only. Thus Manipur Valley has large upper catchment area where rainfall is normally high. These good amounts of rainfall feed many streams and rivers, which finally drain, through Manipur Valley. In the hilly region very steep slope nature occupies the major portion. Besides, degraded land areas occupy 1545 sq. km.which is 24 p.c. of total catchment area and 35 p.c. of hilly region, enhancing more erosion and run off. Again from geological point of view; Disang, which is predominantly shale, occupies almost 85 p.c. of the hilly region, have less infiltration and more run off. From the study of soil erosional pattern, high and moderate to high soil erosional class cover 51 p.c. of the study area. From the above findings, we came to know that, streams and rivers carry a good amount of running water and sediment load from the upper reaches and rainy season, resulting flood in the valley area.

Resulting from the high sedimentary load, river course becomes shallower. From field survey report, most of the river embankments are poorly maintained. At least there are 11 vulnerable points in the Imphal River; 14 in the Thoubal River; and 5 in the Iril River are observed.

Increase in population in Manipur Valley, more particularly building population; and no proper drainage condition, is also one of the factors that creates flash flood in the urban area.

Loktak Lake, the largest fresh water lake in the entire north-east, and associated with swamp/waterlogged area occupies an area of 246.72 sq. km. Apart from the Loktak, there are many lakes and swampy areas. Total area of these lakes and swampy areas comes to 480 sq. km. These areas are becoming shallower and as a result their water holding capacity (water) is reducing. During the rainy season the adjoining areas are frequently flooded due to spreading of water from these lakes.

Recommendations

There are many vulnerable points along the riverbanks of the major rivers of Manipur Valley. In these areas; erosion, sliding and slumping of the banks are common; causing breach of riverbanks to these points during rainy season. Proper maintenance of these riverbanks is very much necessary and retaining walls are to be constructed. Plantation of trees will help to some extent.

Out of the total catchment area, hilly areas occupy 70 p.c., which is the upper catchment areas of the rivers draining off through Manipur Valley. Construction of check dams in the junction of valley and plain areas at suitable places is recommended. This will regulate inflow of water in the rivers; this will also check siltation/sedimentation in the river courses.

Plantation of fast growing trees on the upper catchment areas are required to reduce soil loss. Encouraging terrace cultivation in the hills slope is also advisable. Proper guidance should be given to the hill people against practicing of jhoom cultivation.

Careful action viz. contour canals, subsurface dykes, gully plugging, terracing should be taken up whenever suitable.

The lakes of the valley, acts as inland basins for many rivers and streams. It will be very helpful if proper action could be taken up for deepening of these lake beds.