Chapter II: River System and Drainage

2.1 Introduction

The sub-Himalayan Jalpaiguri district is endowed with intricate river systems originating from the Sikkim, Darjeeling, Bhutan and Tibetan Himalayas draining across the Himalayas (figure 2.1). The piedmont zone is dissected by mountain streams of various sizes. The proportion of river length and catchment area between zone of erosion and deposition in various types differ considerably (Starkel, L & Sarkar, S, 2002). The river systems of sub-Himalayan Jalpaiguri district have been genetically classified in following 7 types by Starkel et.al, in 2008.

(i) Large transit river originated in high Himalaya. This group is represented by three rivers Tista, Torsa and Sankosh, with perennial discharge, feed both by rain and melt waters. Deep canyons in marginal part and mega-fans in the foreland indicate very high water discharge and high sediment load. Great alluvial fans and braided channels with frequent avulsions extend far up to the river Brahmaputra.

(ii) Rivers dissecting Lesser Himalaya. Only river Jaldhaka under this group drains large catchment, deeply incised also in the Duars, where it is draining the active rising blocks. As a result, its fan surface is developing farther downstream. Other rivers dissecting southern part of Lesser Himalaya with catchments between 50-100 km^2 are located in the belt of higher precipitation (Gish, Chel, Daina, Chamurchi, Reti, Gabur Basra, Jainti etc.) and form large alluvial fans. Aggradations follow upstream into the hills and farther downstream braided channels change to the meandering ones.

(iii) Seasonal or episodic rivers draining only frontal zone of the Himalaya with highly dissected catchments with an area between 10-30 km^2. The area receives the heaviest rainfall (Sukti, Pagli, Pana, Raimatang etc.) and also exhibits steep extensive fans.

(iv) Small creeks starting at the steep scarp of the Himalaya from deep gullies or great landslides, producing large fans with an area of several km^2 modelled by debris flows.

Such creeks usually join some larger river (Dimdima, Dima, Gatia etc.) further downstream.

(v) Rivers draining frontal zone of Himalaya and also the uplifted blocks of piedmont zone. The mountain catchment may differ in size up to 30 km^2, but elevated foreland facilitates down cutting and channels of Neora or Murti rivers are covered by boulders in relatively narrow gullies.

(vi) Rivers starting in middle or lower parts of alluvial fans feed by groundwater and heavy rains have low gradient and meandering pattern. Some of them are localised in the paleo-channels (like along Torsa river) and those are wide and swampy. Most of these rivers is running to the south parallel to the rivers originated in the mountains and finally join them.

(vii) Rivers starting on the flat surfaces or on scarps of tectonically raised blocks and are feed mainly by rain water like Kurti and Sukha jhora between Chel and Jaldhaka river.

Progressing downstream with changing rainfall regime, decreasing discharge, channel gradient and sediment load all rivers gradually change their pattern from braided to meandering. Only the large rivers like Tista, Torsa and Jaldhaka keep their braided character up to the junction with the Brahmaputra. The rivers of Jalpaiguri district belong to two major systems (a) the Brahmaputra River System and (b) the Ganga River System. The major rivers in the Brahmaputra systems in sub-Himalayan North Bengal are:

2.2 The drainage basins and sub-basins

The drainage system of Jalpaiguri district consists part of two major drainage systems namely the Brahmaputra and the Ganga system the two most important drainage basins of the country. The Brahmaputra system is represented in the district by its five major sub-basins i.e., the Tista, Torsa, Jaldhaka, Raidak and the Sankosh sub-system and the Ganga system is represented by the Mahananda sub-system. The maps showing the location of study area and river basins/ sub-basins in North Bengal is given at figure2.2 and tabulated in table 2.1.

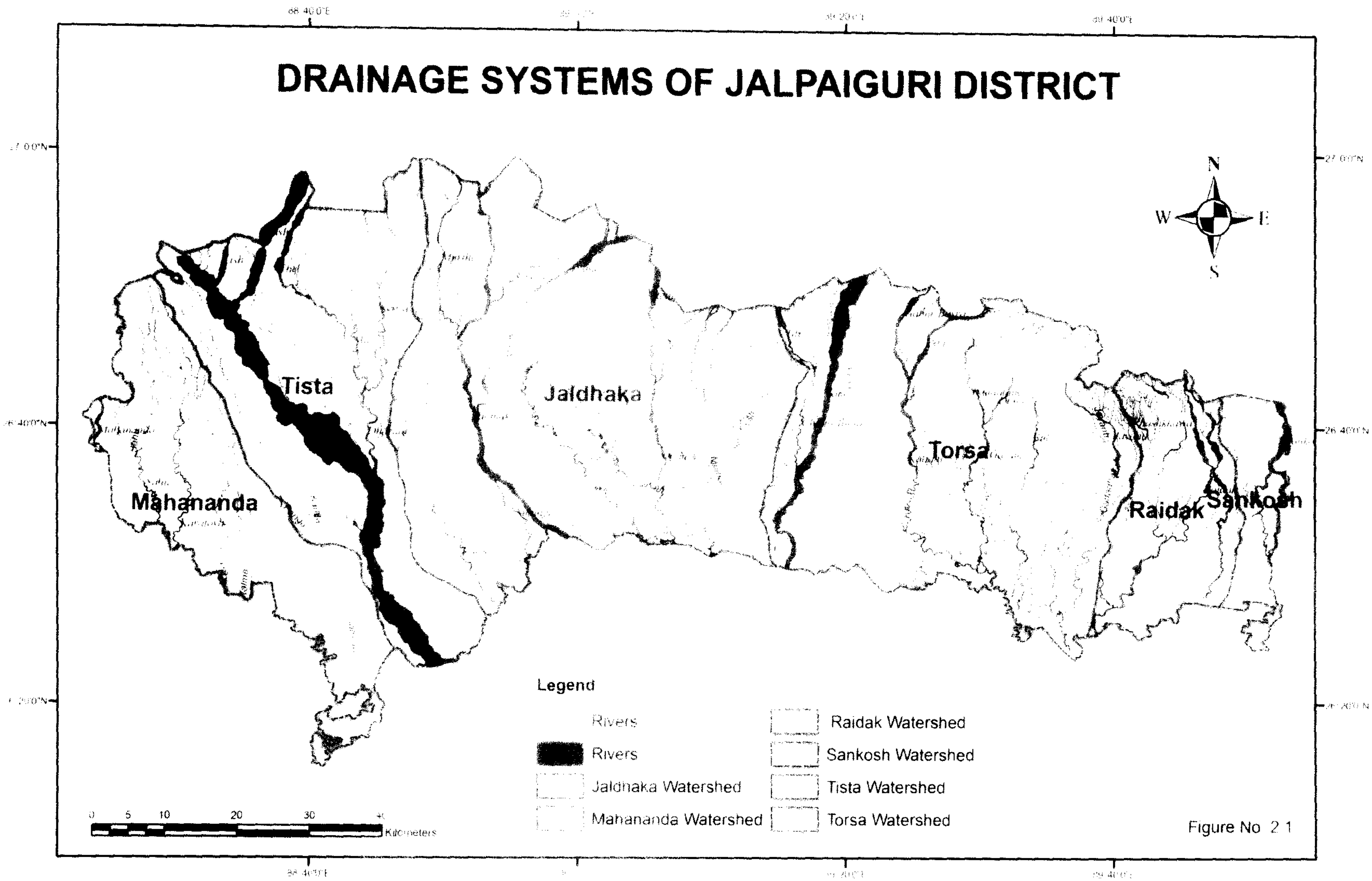
DRAINAGE SYSTEMS OF JALPAIGURI DISTRICT
N
W
E
S
Tista
Jaldhaka
Torsa
Mahananda
Raidak
Sankosh
Legend
Rivers
Rivers
Jaldhaka Watershed
Mahananda Watershed
Raidak Watershed
Sankosh Watershed
Tista Watershed
Torsa Watershed
0 5 10 20 30 40
Kilometers
88 40'0"E
27 0'0"N
26 40'0"N
Figure No 2 1

Table No: 2.1 Area of the watersheds under study

Sl No	Name of Watershed	Watershed Area in Sq. Km.					
		Total	Studied section	West Bengal	Sikkim	Bhutan	Tibet
1	Mahananda	2141*	769	2141	-	-	-
2	Tista	10248**	1206	2855	7393	-	-
3	Jaldhaka	4359**	2028	4281	78	821	-
4	Torsa	7164**	1642	3357	-	2174	1633
5	Raidak	5505**	450	692	-	4813	-
6	Sankosh	10964*	175	473	-	10109	282

* From source to Sub-Himalayan Indian territory; ** From source to Indian territory.

2.2.1 The Brahmaputra basin

The mighty Brahmaputra emanating from the Himalayas near Mansarovar Lake flows through Tibet in an easterly direction. It is known as the Tsanpo in Tibet and then as the Brahmaputra in Assam and Bangladesh. The Brahmaputra is the central waterway in north-eastern part of India. Besides its potentiality of a vast water resource for agricultural economy, it is one of the few rivers in India that is used for inland navigation. It has also the function as the main carrier channel for flood discharges for a large number of big and small rivers, originating from the Himalayan region and from Sub-Himalayan tracts (Dhar O.N., Nandargi S., 2000; Goswami D.C., 1998).

The Brahmaputra flowing through the Assam valley in a westerly course takes a southern swing near the border region of the States of Assam, West Bengal and Bangladesh. In this region, it is joined by the river Sankosh from the north. The Sankosh, which flows along the border of Assam and West Bengal, it taken as the line of demarcation of these two states, Assam and West Bengal. Among the major rivers flowing through Jalpaiguri district Tista, Jaldhaka, Torsa, Raidak and Sankosh are important.

2.2.1.1 The Tista basin

The river Tista is the biggest river in North Bengal (figure 2.2). It originates from the Tista Source Glacier (*Tista Kanyse*) or, Pauhurni Glacier near Khangehung Lake (latitude 29^0 59' N and longitude 38^0 48' E) in North Sikkim at an altitude of 6200 meter. It meets the Brahmaputra (Jamuna) at Kamarganj in Bangladesh at an elevation of 23 meter. The Tista river system, flanked by the Mahananda and the Jaldhaka on either side present a spectacular convergent and divergent drainage pattern. The convergent pattern terminates around 90 meter contour line, subsequently to which the character assumed to be one of divergent one where from, the rivers is spreading out. While, the 300 meter contour line is curving upward indicating convergence of drainage, the 66 meter line in the extreme south is systematically curved downward indicating large scale fanning out or, divergence of the channels (Mukhopadhyay S.C, 1982).

The river rising from the Himalayan hills is enlarged by the contributions of a quite a number of tributaries in the Himalayan and sub-Himalayan regions. Tracing its course in the hilly catchment, which lies in the Sikkim State, the river gets its name Tista below the confluence of two rivers Lachung from the north-eastern direction and Lachen from the north-western direction. The Lachen is fed by a tributary Zemu from the western end, while the Lachung by the tributary Sabo. The Zemu, in turn, is seen to gain in size from the contributions of two streams Lohnak and Tomya.

The combined flow of the Lachung and Lachen, after emerging from Chungthang is known as the river Tista. Further down, the river receives a tributary named Talung from the north-west, which joins the river Tista near Mangan. The Talung receives the combine flow of two tributary streams, Ringpi and Rangha. In the next lower reach of the Tista, three tributaries Bakcho-Dikchu, Rongni and Rangpo join from the north-eastern direction, one after another in the order mentioned. The confluence of the first is at Dikchu (which is above a placed called Makah), the second at Singtam and the third at Rangpo. The second tributary Rongni is the combined flow of two small streams Roro and Taksam. The third tributary Rangpo has also a tributary Rishi.

Below the confluence with the Rangpo River, the Tista river flow is further augmented by inflow through the Rangit river from the western direction. The great Rangit is principally the combined flow of three streams, Rangit, Ramam and ChottoRangit flowing from the north-west, west and south-west respectively. The outfall of the great Rangit into the Tista river is near Melli Bazar. In the next, reach below Melli Bazar, the Tista river, before it emerges into the sub-Himalayan plains of North Bengal, is joined by two small streams, Rangli and Ranghot from the west and east respectively.

DRAINAGE NETWORK OF THE TISTA BASIN

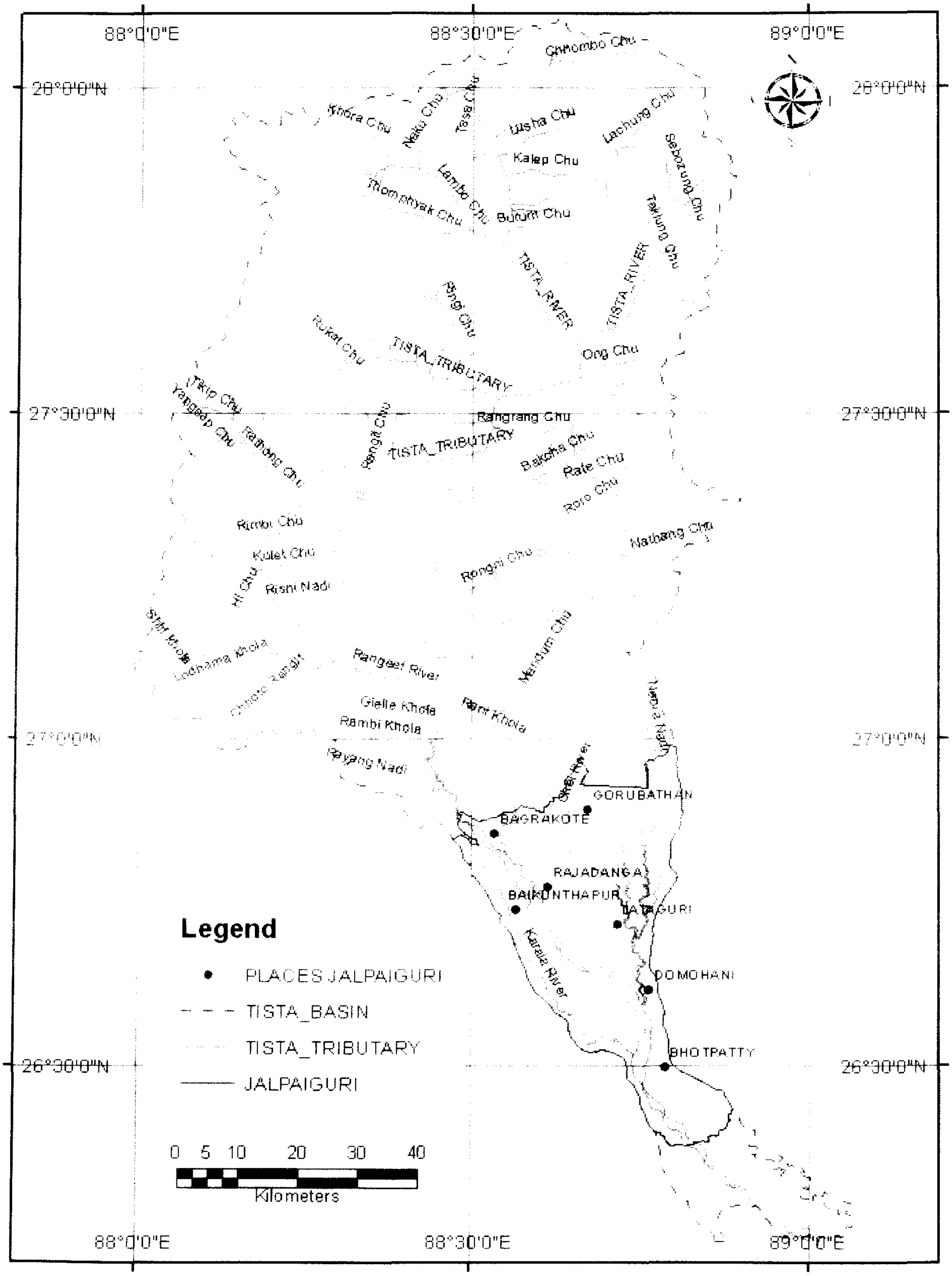

Figure 2.2 Drainage network of the Tista Basin

The river Tista below its confluence with the Rangit flows through the Darjeeling district where two small hills streams join the Tista from the western and eastern directions. The Tista after flowing for about 25 km passes through Sevok before it debauches into the plains of North Bengal. In the sub-Himalayan plains it is again joined by a number of tributaries viz. Lish, Ghish, Chel, Neora from the north-eastern end and the Karala from the north-western end (WAPCOS,2003).

In the mountain gorges, the width of river Tista is not much. At Chungthang, the width of the river is 30 meter and at Singtam 40 meter during autumn. The average depths of water are 1.8 meter and 4.5 meter respectively. Due to formation of too many channels in the plains, the river has widened considerably ranging from 2.4 km to 4.8 km near Jalpaiguri town. From Chungthang to Singtam, the bed slope varies from 35 m/km to 17 m/km. From Rangpo to Tista Bazar, the average slope is 3.8 m/km. The slope of the river at Jalpaiguri is only 0.7 m/km. The velocity is 2.4 m to 5 meter per second. The banks are alternately steep and sloping according to the position of the main channel (Sanyal, C. C. 1967& 1969). The following are the major tributaries of the Tista in Jalpaiguri district.

2.2.1.1.1 River Lish

The Lish Khola has its origin in the Pabringtar KhasMahal Block and Turung khola has its origin in the Samther Forest, highest altitude of which is about 2000m. After the merging of the Lish khola and Turung khola, the Lish river flows southwards and meets Nabgang khola on the eastern side and further 19km down Phan khola on the western side. Lish river then meet Chung khola near the junction of the road to Bagrakote Colliery. The river then flows into Jalpaiguri district and after another 10 kms meets the Tista river at a place near about Kalagaity Tea Estate.

River Lish is 20km in length and drains a total catchment area of 64 sq.km out of which 48 sq.km is hilly. The width of the river in the gorges varies from 60 to 120 m. In the Terai, the width is as great as 1000m at places. The slope of the hills on its banks is very steep varies from 40^0 to 60^0. The bed slope is 24m/km in the hilly region and 11m/km in the Terai region.

2.2.1.1.2 River Gish

The Git khola rises from the Lava Reserved forest and flows between Git beyong on the right and Pankhasari, Samabeyong Khasmahal on the left. Junction of Pembling, Gitubling and Pogrambing, it receives on its right bank, the Reang khola, Nimbong, Nakhi khola, Desi-Khola and Chamu khola are the small tributaries of the river Gish. Another river Lethi originating in the reserved forest, south of Pagrambong Khasmahal meets the Gish in Jalpaiguri district. The river Gish falls into Tista in Jalpaiguri district. The river runs through deep gorges in the hilly region. The catchment area of the river is 160 sq.km and its length is 35km. The width of the river varies from 75 m to 120 m. The bed slope is 22 m/km (Basu S.R. &Ghatowar L., 1986).

2.2.1.1.3 River Chel

The River Chel, a mountain torrent is formed by the amalgamation of two kholas i.e., Chel and Kali khola. The Chel khola originates in the Pankhasari Reserved Forest. While, the Kali Khola rising from the ridge cutting the Gish and Chel catchments on the western part of the Pankhasari Khasmahal Block flows in between the Nim and Pankhasari Khasmahal Block and meets the Chel khola near Ambiok. Ambiok khola, Dalin khola, Sukha khola etc. are the small tributaries of the Chel. South of Mal khasmahal in the Jalpaiguri district it meets Neora and takes the name of Dharala which ultimately falls into Tista above Domohani. The Chel river flows for a length of 54 km. The catchment area is 390 sq.km. The average width of the river is 90 m to 150 m and the slope of the banks is between 30^0 to 60^0. The longitude slope of Chel khola is 52 m/km.

2.2.1.1.4 River Neora

The river Neora originates from Rechilla Chawk of the Neora National Park in Darjeeling district. The river is joined by Thosum Chhu and flows through the National Park and is augmented by several streams in the way. It finally meets the Santhoke khola and Argara khola on the left. The river enters the Jalpaiguri district and meets Chel further down and then with the name Dharala falls into Tista above Domohani. The length of the river is 58km and catchment area 275 sq.km. The width of the river varies from 90 m to 120 m. The valley is mainly on steep hill sides having slopes of 40^0 to 60^0.

2.2.1.1.5 River Karala

The river Karala also known as *Kalla,* one of the tributaries of the river Tista on its right bank, originates from the Baikunthapur forest and flows down to the river Tista at King's Ghat in Jalpaiguri town. To increase the fluvial efficiency of the river Karala, during 1970s, it was re-sectioned, further down slope for 4.5 km. from its original out-fall. Now, the river meets Tista through an artificial waterway near Kadobari, 4 km south of the town. The total catchment area of the river is 141 sq. km. most of which is covered by arable land. The river divides Jalpaiguri town into two halves, the left bank i.e., Karala-Tista interfluve, having administrative offices and the right-bank, occupied by markets, residential and commercial uses

2.2.1.2 The Jaldhaka basin

The river Jaldhaka originates from Bidang Lake in Sikkim at an altitude of 4250 m to 4550 m and is locally known as Dichu in Bhutan. It flows southwards for a length of about 24 km in a straight, steep gradient through mountainous tract up to an elevation of 844 m. At this point, an important tributary namely Assom Khola joins the river Jaldhaka or Dichu on its left bank. Further flowing down, the river meets the river Nichu, a tributary from the right. The river Nichu forms the boundary line between Bhutan and India in this reach (figure 2.3).

The river Jaldhaka then receives an important tributary named Bindu Khola from left. From the confluence of Nichu and Jaldhaka, the main river Jaldhaka itself forms the boundary between West Bengal and Bhutan. The important places near about this point are Godak and Dzongsa Dzong.

From the confluence of Bindu Khola, the river flows down almost southwardly with few minor bends. The river enters into the Indian territory at the confluence of river Jiti which meets the Jaldhaka from the left. No important and major tributary except Jhalong Khola has joined the river Jaldhaka in the reach between Bindu Khola and Jiti.

Just below the confluence of Jiti, the river Jaldhaka bifurcated into two channels and suddenly turns at right angle towards east. Thereafter, two channels unite again. The river turns at right angles towards the south and bifurcates against into two channels namely

Hatinala and Jaldhaka. The Assam Link railway Line crosses the river here. The two channels again join and the combined flow is bridged by the State Highway connecting Chalsa and Nagrakata. From this road bridge, commonly known as Upper Jaldhaka Road Bridge, the river flows in a southwardly direction for 4 km with slight inclination towards west and again bifurcates into two channels. In this portion, the river flows through the reserved forest area and receives the river Ghatia from the left.

The important tributaries of river Jaldhaka are Assom Khola, Nichu Khola, Bindu Khola, Jiti, Ghatia, Kumlai, Diana, Duduya, Mujnai, Dolong, Satanga, Dharala, Girdhari and Murti which are described below:

2.2.1.2.1 River Diana

The river Diana originates in the Bhutan hill at an altitude of about 3,050 m below Dhupi Dara and flows through narrow gorges of Bhutan hills upto the Indo-Bhutan border in a southerly direction. Its length in the territory of Bhutan is 16.1km. The river enters into the Indian Union at an elevation of about 305m and has a high bank on the right which gradually reduces from 38.12 m to 9.15 m. The total length of the river is 25.76km. The bed slope is 110.96 m/km with a total fall of 2851.75 m in a length of 25.76 km. The catchment area of river Diana is 316 sq.km. out of which 222.95 sq.km is falling within the territory of Bhutan.

2.2.1.2.2 River Kumlai

The river Kumlai, also known as a Jhumur in the upper reaches, originates near about Kalabari Tea Garden. It forms the western boundary of the Kalabari Tea Garden and flows due south to the west of Angrabhasha. Total length of the river is 79km. The bed slope of the river is 0.19 m/km having a total fall of 13.12 m in a length of 68.1 km. The total length of the river is 30.59 km. The catchment area of the river is 148 sq.km.

2.2.1.2.3 River Duduya

The river Duduya is flowing on the east of the Jaldhaka and is formed by the union of several small streams like Rangli, Nonai, Rehti Khola and Dim Dima. The total length of Duduya is 33km. The catchment area of river Duduya is 72.5 sq.km.

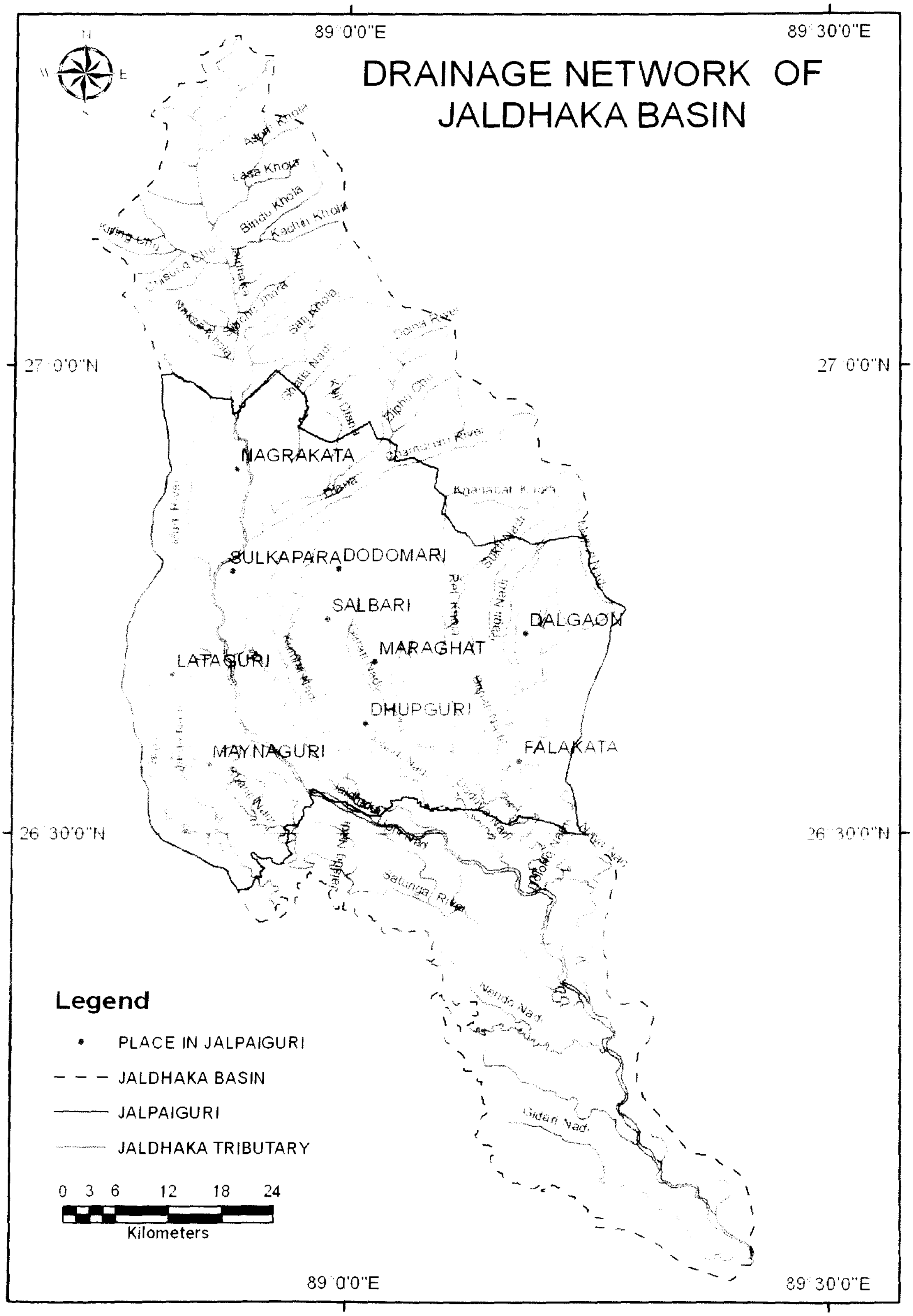

Figure 2.3 Drainage network of the Jaldhaka Basin

2.2.1.2.4 RiverMujnai

The river Mujnai a tributary of river Jaldhaka, originates in the southern slope of the Bhutan Hills. Its upper part is known as Rangari Nadi originating at an elevation of 2,500m just above the Indo-Bhutan Border. The total length of the river is 85.33 km. The bed slope is 32.3 m/km up to the railway bridge and 46 m/km. from railway bridge to the confluence. The catchment area of the river Mujnai is 452.73 sq.km, out of which the area falling in the territory of Bhutan is 31.86 sq.km and the rest 420.88 sq.km. is in the Indian Union.

2.2.1.2.5 River Dolong

The river Dolong originates near the Kadambini Tea Garden in Falakata Police Station of Jalpaiguri District. The river forms the western boundary of the Kadambini Tea Garden. The elevation at this point is 63.44m from the origin and it flows in a southerly direction. The total length of the river is 41.86 km. It flows for a length of 8.05 km in Jalpaiguri district. The catchment area of Dolong is 60.37 sq.km.

2.2.1.2.6 River Satanga

The river Satanga is an offshoot of Jaldhaka River. The river used to carry the spill water of the Jaldhaka through this distributary. A new mouth had been formed during the recent floods at the junction of Jaldhaka river. The total length of the river is 77.28km. The bed slope is 0.475 m/km having a total fall 36.6 m in a length of 77.28 km. The total area of the catchment is 442.89 sq.km.

2.2.1.2.7 Rive Dharala

At one time river Dharala one of the important rivers in North Bengal, used to drain a considerable area. In 1820, Dharala and Buri Dharala were two district rivers and flowed almost parallel to each other till they met near Gitaldah. Since then the Dharala appears to have moved westward and gradually intercepted the bed to Buri Dharala. The Dharala River on the right side originates in the upper blocks of lower Tondu reserved Forest drains a major portion of the forest. The river Dharala on the left side is known as Torsa in its upper reaches and takes off from Torsa near Kodalkheti. The river is also connected with the Jaldhaka at its junction with Dolong Nadi. This connecting channel used to be a portion of Mansai. This has now been connected to Jaldhaka near Kodalkheti.The Total length of the river is 68 km. The river lies entirely in the plains.

2.2.1.2.8 River Murti

The river Murti has been formed by the combination of several hilly jhoras, all rising from the Neora National park in the hills of Kalimpong. The origin of the river is approximately at an altitude of 2,500 m. The total length of the river from its origin upto its confluence with the Jaldhaka within Gorumara forest is about 47.5 km most of its catchment area consists of deep forest. The width varies from about 15.25 m to 475.5 m. and the natural waterway has been blocked in many places through accumulation of big boulders. These boulders have come down from the upper reaches during high floods. Due to the accretion of silt and sand in the bed of the river in the plains, the river has to take out a new course every now and then. Thus, the river cannot flow within a defined course. This is the cause of the meandering characteristic of the river. The catchment area of the river Murti at its confluence is 176.64 sq.km. and mostly consists of forests.

2.2.1.3 The Torsa basin

The river Torsa in North Bengal is notorious for the flood and unpredictable behaviour. The Torsa flows over a considerable length in the Bhutan State. However, the problem starts only when it enters the Jalpaiguri and Koch Bihar districts in the Sub-Himalayan region. The river channel in this region is wide and shallow and the slope is flat. There are a number of spill channels of the Torsa in this region and the flow in this spill channels (during high flood in the Torsa) often exceed their respective carrying capacity. As a consequence, the banks of the river Torsa overtopped and adjoining areas are inundated. The river carries large load of suspended silt, whenever deposited on the bed of the river or of the tributaries, obstruct the flow along the normal course and cause diversion along different paths. The inherent meandering tendency of these streams is in a way due to this silt loads.

The river Torsa originates in the Chumbi valley in Tibet (China) is a trans-Himalayan river in true sense. The Torsa river catchment belongs to one of the largest in the Sikkimese-

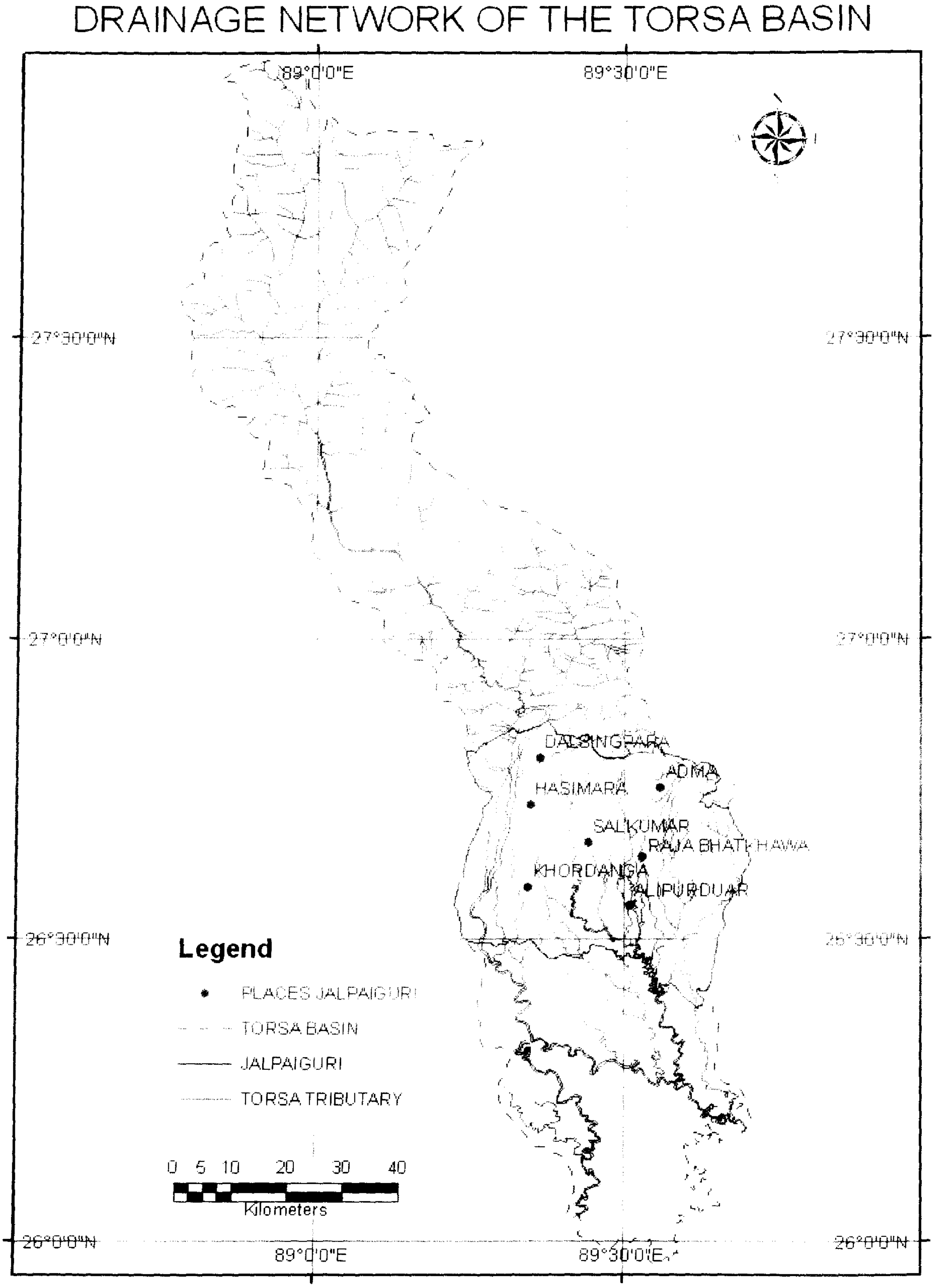

Figure 2.4 Drainage network of the Torsa Basin

Bhutanese Himalaya and drains the highest range rising to 7065 m.s.l. Its mountain catchment till Phuntsholing exceeds 4000 km^2. On the 172 km long mountain reach the Torsa (called Amo in Bhutan) is deeply cut in various metamorphic rocks partly meandering with tendency to aggradations in the marginal part of mountains. The length of the river is of the order of 365 km from its furthest extremity in Bhutan State to the Koch Bihar town (figure 2.4).

The upper reach of the river Torsa is in the State of Bhutan is known as "Amo" river, the name given to the combined flow of two hill streams at the furthest extremity, viz. the Kangpo and Kylang rivers from the northwestern and northeastern directions respectively. The "Amo" river in its next lower course is joined from the northwestern directions by three tributaries, Chimkiphu, Tangka, Namchu khola and five tributaries from the northeastern direction i.e., Tromo, Yak, Ripoloy khola, Piuna khola and Pa rivers.

The "Amo" river thus enlarged by the contribution of the above tributaries enters the Sub-Himalayan plains of the Jalpaiguri district under the name "Torsa". The "Amo" river having glacial regions at the source derives its flow from snowmelt as also from runoff from rainfall during the monsoons.

Immediately before entering the Jalpaiguri district, the "Amo" river flows in a loop path and below this loop, it flows in a southern direction through the Jalpaiguri district. There is a railway bridge over it, below this loop at Madarihat, near Hasimara. Below this bridge, the Torsa throws off a spill channel on the southeast called Sil Torsa, which rejoins the Torsa at a point south of the National Highway road running across both the Torsa and Sil Torsa rivers. In the reach between Madarihat railway bridge and National Highway road bridge on the Torsa, the Torsa is joined from the north-west by the Chhoto Torsa, this Chhoto Torsa is the combined flow of two streams, one Titi and another decayed spill channel of the Torsa. There is also a distributary thrown off from the Chhoto Torsa called "Buri Torsa" which joins the Jaldhaka River below Falakata. The Buri Torsa has an important tributary called Majnai from the Western Direction.

Below the National Highway Road Bridge, The Torsa river turns to the south-eastern direction and follows a zig-zag course, indicating of an inherent meandering tendency. The Torsa also flows by the Koch Bihar town. Shortly before its approach to this town, it throws off a distributary called the Dharala on the south, which joins the Jaldhaka-Dharala River below. Erosion and encroachment of the Torsa River to Koch Bihar town is a problem that has been engaging the attention of the engineers for a long time. It is said that as early as 1887, the royal palace was once endangered and the then State Engineer introduced a cut so as to divert the bulk of flow along the *Mora Torsa*. This arrangement, however, did not stand long and the Torsa river began to meander once again.

In the south-eastern course below the Koch Bihar town, the Torsa river is joined by four rivers from the north. These are the Gharghari, Kaljani, Gadadhar and the Raidak. The course of the river Torsa below the confluence with the Raidak, is known as Raidak. The Raidak is a tributary of the Brahmaputra River.

2.2.1.4 The Raidak basin

The river Raidak originates from the ice field of the Jomolhari (7270m the highest peak in Bhutan) – Kungphu (6894m) – Takaphu (6493m) massive of the Great Himalaya in Bhutan.The altitude of the source of Raidak is 6400m. Within the Bhutanese territory the head stream of the Raidak is known as Wong Chu. It receives two major tributary the Paro Chu and the Ha Chu. The catchment of area covers an area of 5505.2 sq. km out of which 4813 sq. km lies in Bhutan, 692 sq. km within sub-Himalayan North Bengal and only 450 sq. km is situated within the study area of Jalpaiguri district (figure 2.5).

The Wong Chu enlarged by the contribution of the Peping Chu a left hand tributary before it enters the Sub-Himalayan plains of the Jalpaiguri district under the name "Raidak". The river Raidak having ice field regions at the source derives its flow from snowmelt as also from runoff from rainfall during the monsoons.The length of Raidak river is 266.5 km out of which 167.2 km is situated in mountainous terrain of Bhutan, 99.2 km is situated in West Bengal. The present study area of Jalpaiguri district covers on 50 km stretch of its course.

The gradient of Raidak river is estimated to be 1:41.837 from its source to its confluence with the Sankosh. The gradient is much higher in the Bhutan Himalaya which has been estimated to be 1:26.786 and much lower in the West Bengal plain which has been calculated to be 1:775.0. The gradient of Raidak river in the studied section of Jalpaiguri district is 1:760.0.

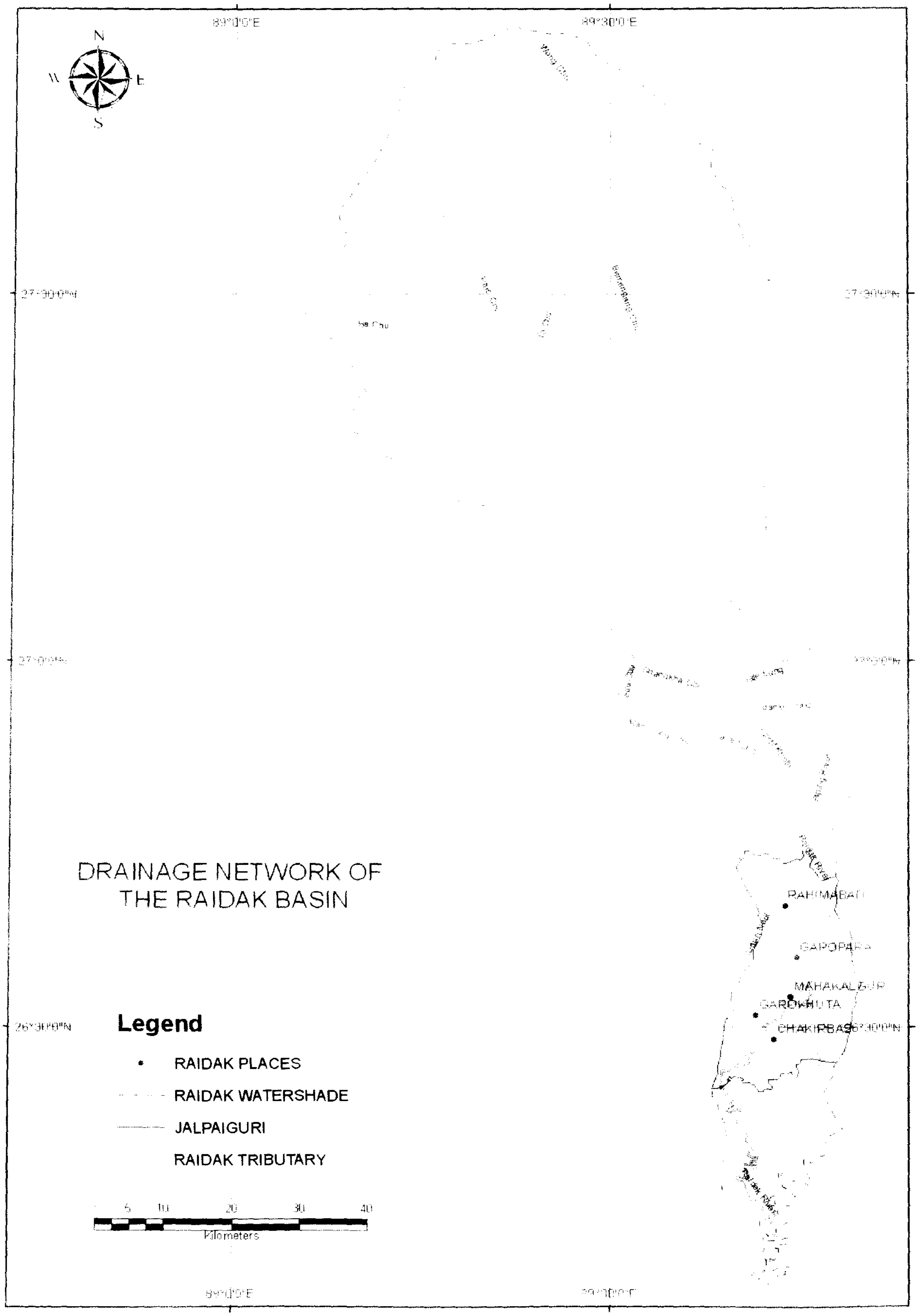

Figure 2.5 Drainage network of the Raidak Basin

2.2.1.5 The Sankosh basin

The river Sankosh originates from the Bhutan Himalaya and marks the eastern boundary of West Bengal. The catchment area covers an area of 8521 sq. km. out of which only 295.0 sq. km lies in sub-Himalayan North Bengal. The mean annual runoff of the river has been estimated to be 25000 million cubic meter. The base flow of the river has been estimated to be 85 cumecs and the mean discharge during the monsoon months is 1500 cumecs (figure 2.6).

The river Sankosh is considered to be highly notorious for their unpredictable nature, letting loose fury of flood and problem of extensive and regular bank erosion, course shifting, render thousands of homeless during the rainy season. The catchment area in Bhutan is mostly uninhabited and is covered by natural forest. However, along the Himalayan southern margin bordering with India, mining and so called development activities like construction of roads etc. have already induced large scale degradation. During heavy and concentrated rainfall, innumerable landslides are caused transporting huge amount of sediment to the river.

During summer, the observed increment of the size of bars and shoals downstream to the piedmont area proves such a contention. In order to avoid such numerous islands in midst of the channel, the rivers, in their lower reaches thus, attains the significant physical characteristic of braiding which may be attributed to both incompetence and incapacity of the rivers. That is, most of the rivers can transport neither the total amount of debris nor the size of debris that is supplied to it as bed load. As a result, the bed of the river is rising at some sections in the plains, resulting in the lessening of cross-sectional areas which being incapable of arresting the unusual monsoon discharge and allow water to spill, causing floods. Moreover, the narrow road and railway bridges, spanning the rivers as well as the pillars supporting them, are always considered to be the barriers, interrupting natural load movement behavior of the rivers. This often cause accelerated deposition at the bottom of the bridge and thereby, narrowing the outlets of the rivers gradually. Such constrictions, sometimes due more to the entanglement of uprooted trees to the voluminous flows of the flood, often multiply its effects many times damaging the bridges, human habitations and firm lands.

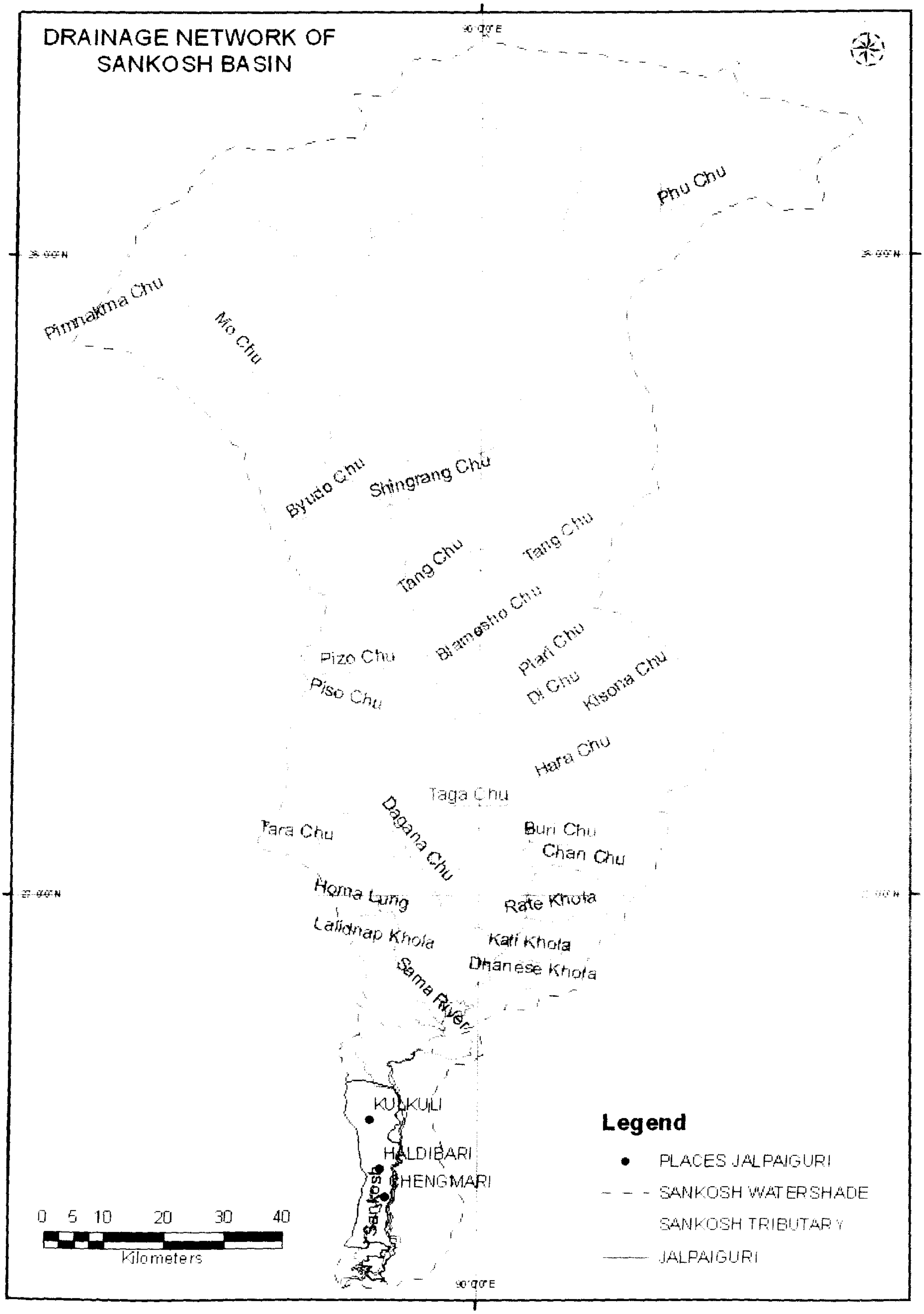

Figure 2.6 Drainage network of the Sankosh Basin

Rainfall pattern is monsoon dominated, characterized by high intensity, short duration rain storm causing transportation of huge sediment load, followed by devastating flood. Mean annual rainfall in different major segments of the watershed is given below

i) South hill margin and plains	: 3500 millimeter
ii) Lower Bhutan Himalayan	: 3000 millimeter
iii) Upper Catchment in Bhutan	: 1500 millimeter

2.2.2 The Ganga basin

The Ganga basin is bounded on the north by the Himalayas and on the south by the Vindhya Mountains. The rivers flow almost northwest to southwest. The region covers partly or fully the State of Himachal Pradesh, Hariyana, Rajsthan, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal and the Union Territory of Delhi. The first four and the West Bengal from geographical parts of other rivers basins also. The river Mahananda is the only major tributary of the Ganga system draining in Jalpaiguri district.

2.2.2.1 The Mahananda basin

The river Mahananda is a major northern tributary of the Ganga system. passing through Nepal, India and Bangladesh. It is bounded on the north by the Himalayas. the ridges separating it from the Tista river system in the east, the Ganga on the south and the Koshi river system in the west. It drains a total catchment area of 25,043 sq. km over a length of 376 km from its origin near Chimali in the Mahalidram hills to its confluence with the river Ganga (figure 2.7).

The Mahananda originates from the Mahalidram hills of the Darjeeling Himalaya near Chimali at an altitude of 2060 meter at about 6.4 km northeast of Kurseong town of West Bengal. It is also known as Mahanadi river in the hill. After flowing nearly 20 km in the hills of Darjeeling, the river enters plains near Siliguri and flows in a southwesterly direction till it is joined by the Balason river on its right bank about 4.0 km downstream of Siliguri (Sarkar, S. 1996& 1997). It forms more or less the border between India and Bangladesh between Phansidewa and Tetulia. Number of tributaries of Mahananda system is drained extreme western part of Jalpaiguri district i.e., Karotoya, Panga, Jamuna and Sahu are noteworthy.

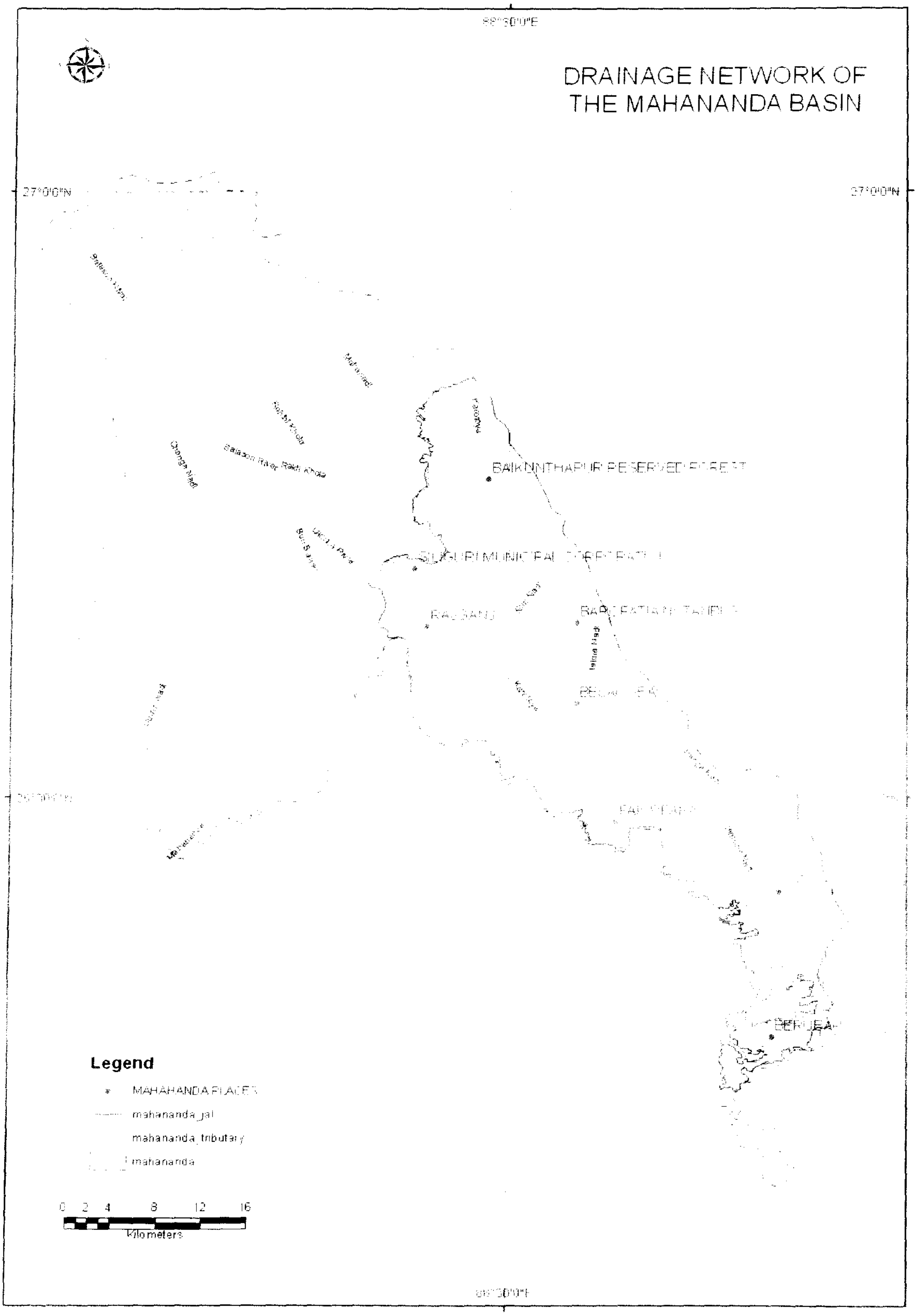

Figure 2.7 Drainage network of the Mahananda Basin

2.3. Morphological characteristics

Morphology of a river channel is associated primarily with the study of the size (bed width and depth), shape and pattern of river to be supplemented by study of structure of basin and the texture of its drainage area. Both engineers and geomorphologists are primarily concerned with the basic principles of river morphology. A river channel at any single location reflects the geology, geomorphology, biology, climate and hydrology of drainage basins that may extend hundreds of miles upstream. The whole approach of study of river morphology and river mechanics aims at evolving a long term and the most economical and permanent solution of a river problem for the utilization of the river waters for the most economical purposes. Though, solution is time taking requiring detailed and enormous efforts by all the concerned, a proper scientific engineering solution of a problem of river for its economical control is necessary (Moriswa, M, 1968; Newson, M. 1994). Morphological features of important rivers are discussed below:

2.3.1 River Tista

Unique in its complex and diverse drainage characteristics, the antecedent Tista offers a fascinating study of the evolutionary process of the Himalayan drainage under fluvial environment. The landform and drainage pattern include four-tier terraces, canyon, gorge, like valley at different altitudes, asymmetric valley, poly-profile U-shapes valley, trough lake, alluvial cone truncated ridge, spur and terraces.

The catchment has a complex hydrographic network of branching streams in hierarchical orders from its smallest tributaries to the trunk stream. The temporal variations of the Tista flow manifest watershed characteristics, which influence its run-off. The Tista, with its major tributaries maintaining a continual degradation of its course across the rising Himalayan ranges, is representative of antecedent drainage or in other sense antecedent to all the contemporary landforms in the rejuvenated Sikkim and Darjeeling (Starkel et. al., 2000).

Record reveals that up to 1787, the river Tista and Karotoya were the same river which flowed through the Atrai-Punarbhaba into the Ganga system. Neo-tectonic activity coupled with high intensity rainfall induced flash-flood caused massive shifting of the river. The so-called whale backed sub-surface ridge of the Baikunthapur- Fulbari became active and the Tista migrated eastward bifurcating he river Karotoya. Major Rennel's Atlas of 1770s shows the old course of the river and he states the Tista is a large river which runs almost parallel to the Ganges by two distinct channels situated above twenty miles from each other, and a third channel at same time discharges itself into the Meghna; but during the season of flood the Ganga runs into the Tista, whose outlet is then continued to the channel that communicates with the Meghna (Sen S., 1968; Jain V., Sinha R., 2003).

Dr. Buchanon Hamilton (1810) wrote *I must previously observed that the flood of 1787 seem totally have changed the appearance of this part of the country and to have covered it so with beds of sand that of old channels can be traced for any distance and the river that remain seldom retain the same name for above three or four miles in any part of this course. The name Karotoya, in particular is completely lost for a spea of about 20 miles and is discovered a little south from Durwani. Karotoya then continues its course to the SE fro about three miles, when it joins the old Tista and losses its name although it is at present the considerable stream but the immense sandy channel of the Tista announces its recent grandeur.* In fact when Major Rennel made this survey, the great body of the Tista came this way and joined the Atreyi; but in the destructive flood which happens in 1787, the greater part of the water of the Tista returned to its ancient bed, and has left his immense channel almost dry. During the period 1951 to 1963, the meandering width of the river increased by about 1500 m (Dash. AJ. 1947).

The new Tista flowed through Rangdhamali-Jalpaiguri-Haldibari and meets Karotoya again. Thus, the once wide Tista-Karotoya valley dried up and only two narrow channels namely Karotoya and Sahu are still visible. During the flood of 1788-89, the Tista shifted further east and reached Permekhligunje- Jaldhaka of present Bangladesh. The flood of 1897 caused huge deposition and terminated the ferry service between Jalpaiguri to Barnes Ghat. The 1922-23 flood caused further eastward migration of the river and Barnes Railway Junction and town was destroyed. Floods, during several subsequent years viz., 1948, 1950, 1952 and 1954 caused bank failure, widening and elevating the riverbed. During the period 1951 to 1963, the meandering width of the river increased by about 1500m

The 1968 flood caused massive bank failure and deposition. Temporary westward migration was also visible as the water flowed through Karala-Gadadhar-Panga-Jamuna-Karotoya. In 1969, the Tista water flowed through the Kharkharia and entered into the Panga that became a large river.

In the plain below Sevok on the Tista, the tributaries Lish, Gish, Chel, Neora originating from the foothills on the north are swollen by monsoon rains. The outfalls of these streams are into the river Tista. A high water level in the Tista often retards the speedy outflow from these rivers. As these streams also carry quite a large quantity of silt and sand, still deposition during slack current is frequent which in turns, causes shifts in their course. This silt deposition however, has a fertilizing effect on the soils. It is basically because of this reason that the basins of these streams are very fertile, and bumper crops are raised here. These basins are therefore regarded as granaries of North Bengal.

2.3.2 The Jaldhaka river

The river Jaldhaka has two distinct characteristics viz., its behaviour in the upper mountains tract right from its origin upto Nagrakata and its behaviour in its passes thorough the plains of Jalpaiguri and Koch Bihar Districts upto the confluence with the river Brahmaputra in Bangladesh.

In the hilly tract of Sikkim and Bhutan, the river receives a large number of tributaries and the river is locally known as the Dichu. It passes through steep, narrow gorges and consequently it has no scope to change its course. In this tract the bed slope is very steep. The slope exceeds at some places causing great velocity of flow particularly during high floods. Though the gorges are very deep and narrow, these consist of rock, which are soft and denuded and cannot withstand the high velocity during floods. Consequently, land slips occur rather frequently. Large quantities of detritus came down into the river and are carried down into the lower regions. The silt charge of the river increases many times during flood.

These landslips sometimes assume such proportion as to block the waterway of the channel completely and temporarily cause formation of lakes. Ultimately the dam caused by the land slip is itself pushed down and the intensity of flood in the lower regions is increased many times by the simultaneous release of the water stored in the temporary lakes. Such occurrence is almost an annual feature. During the monsoon of 1964, such a temporary lake was formed. During this year, there had been heavy downpour on the 1st, 2nd and 3rd of August in the upper Jaldhaka catchment. On the 3rd August, a huge land slide just on the appropriate bank of the river measuring about 1000m X 300m X150m was caused on the left bank of the river Jaldhaka. The cause of this land slide, as locally ascertained, was due to erosion of the bed and denudation of forest cover on the steep hill side. The river was dammed up by the land slide and a temporary lake was formed for about 1½ to 2 hours. The water level rose about 9 m. on the upstream side of the "Dam" collapse suddenly, as it must, causing serious damage to the roads and properties of the downstream area.

The behaviour of the river in the lower reach is a history of the frequent changes of its course. The river is known as Mansai, Singhimari and Dharala in its different reaches. It had changed it course frequently during the last century. The most important changes however, took place in the portion of the river which is called Mansai.

2.3.3 The river Torsa

The main problem of the river is heavy bank erosion followed by inundation. The Torsa shifted its course several times during the last century and a half and occupied different position over a tract of about 20 km from East to West in the district of Jalpaiguri and Koch Bihar. The silt charge during flood being very heavy, its cross section changes almost every season and the bed has an aggradation tendency. The meandering of the river is considerable in the alluvial tracts of North Bengal Plains. As soon as the river debauches into the plains, the slope decreases sharply with the result that big boulder and shingles are deposited on the bed. The less heavy materials are carried further down stream and get deposited on the bed as well as on the country side where the river spills over its banks, damaging vast area of cultivable land and valuable Tea gardens and forests.

The silt is deposited in the bed does even a greater damage, in such a way that it causes the bed to rise every year with consequent reduction in the water way and rise in the flood level causing greater inundation. At the same time, the river has a tendency to get wider by eroding its banks due to rising bed (Sarkar S., 2004, 2007 & 2008).

2.3.4 The river Raidak

The river Raidak has two distinct characteristics viz., its behaviour in the upper mountains tract right from its origin up to Bhutanghat and its behaviour in its passes thorough the plains of Jalpaiguri and Koch Bihar Districts up to the confluence with the river Brahmaputra.

In the hilly tract of Bhutan, the river receives a large number of tributaries and the river is locally known as the Wong Chu, Paro Chu and Ha Chu. It passes through steep, narrow gorges and consequently it has no scope to change its course. In this tract the bed slope is very steep. The slope exceeds at some places causing great velocity of flow particularly during high floods. Though the gorges are very deep and narrow, these consist of rock, which are soft and denuded and cannot withstand the high velocity during floods. Consequently, land slips occur rather frequently. Large quantities of detritus came down into the river and are carried down into the lower regions. The silt discharge of the river increases many times during flood. The behaviour of the river in the lower reach is a history of the frequent changes of its course. The river is bifurcated into Raidak I and Raidak II in Jalpaiguri district. It had changed it course frequently during the last century.

2.3.5 The river Sankosh

The river Sankosh originates from the Bhutan Himalaya and marks the eastern boundary of West Bengal. The catchment area covers an area of 10534 sq. km. out of which only 295.0 sq. km lies in sub-Himalaya North Bengal. The mean annual runoff of the river has been estimated to be 25000 million cubic meter. The base flow of the river has been estimated to be 85 cumecs and the mean discharge during the monsoon months is 1500 cumecs.

The river Sankosh is considered to be highly notorious for their unpredictable nature, letting loose fury of flood and problem of extensive and regular bank erosion, course shifting, render thousands of homeless during the rainy season. The catchment area in Bhutan is mostly uninhabited and is covered by natural forest. However, along the Himalayan southern margin bordering with India, mining and so called development activities like construction of roads etc. have already induced large scale degradation. During heavy and concentrated rainfall, innumerable landslides are caused transporting huge amount of sediment to the river. Most of such landslides have never been treated scientifically with proper protective measures and as such those are in the habit of expanding their territories during monsoon and thereby adding more and more silt to the rivers, which are incapable of transporting the loads efficiently under the existing hydrological conditions, especially areas beyond the foothill zone.

During summer, the observed increment of the size of bars and shoals downstream to the piedmont area proves such a contention. In order to avoid such numerous islands in midst of the channel, the rivers, in their lower reaches thus, attains the significant physical characteristic of braiding which may be attributed to both incompetence and incapacity of the rivers. That is, most of the rivers can transport neither the total amount of debris nor the size of debris that is supplied to it as bed load. As a result, the bed of the river is rising at some sections in the plains, resulting in the lessening of cross-sectional areas which being incapable of arresting the unusual monsoon discharge and allow water to spill, causing floods. Moreover, the narrow road and railway bridges, spanning the rivers as well as the pillars supporting them, are always considered to be the barriers, interrupting natural load movement behavior of the rivers. This often causes accelerated deposition at the bottom of the bridge and thereby, narrowing the outlets of the rivers gradually. Such constrictions, sometimes due more to the entanglement of uprooted trees to the voluminous flows of the flood, often multiply its effects many times damaging the bridges, human habitations and firm lands.

2.3.6 The river Mahananda

It is well known that a phenomenon of oscillation of the principal Himalayan river over long ranges is associated with the process of building up of the alluvial Gangetic plains of North India. The oscillation process has been going on from time to time immemorial. Unfortunately, complete records of this process are not available. Some information about the oscillation of Mahananda tributaries in the distant past is available from the old records.

In addition to the shifting tendency, the river usually overflows it banks. The river and its tributaries bring heavy quantity of silt load, which gets deposited in the middle and lower reaches. Thus, the section of the river gets reduced. The flood discharge, which is not accommodated by the river section, gets spilled over the bank and inundates vast area. The river has also got erosive tendency. In 1950, very important areas at Siliguri town on the left bank of Mahananda were eroded. The bridge along the national Highway from Siliguri to Jalpaiguri was also attacked. It was considered that if this erosion was not arrested, severe damage would be cost to the town itself in addition to damaging the National Highway bridge and the railway bridge below it. There was considerable erosion of about 610 m. on the right bank of Mahananda at Phansidewa.

2.4 Conclusion

The Sub-Himalayan river under study are considered to be highly notorious for their unpredictable nature, letting loose fury of flood and problem of extensive and regular bank erosion, avulsion and flood followed by massive aggradations renders thousands of homeless during the rainy season. The majority of the river originates from the Himalayas and enters from a north to northwesterly direction and flows south to southeasterly direction. As many of the rivers originate at the same hill, flood often occurs simultaneously in many rivers and the rivers coalesce to form a single vast sheet of water.

The rivers, in their lower reaches attain the significant physical characteristic of braiding which may be attributed to both incompetence and incapacity of the rivers. That is, most of the rivers can transport neither the total amount of debris nor the size of debris that is supplied to it as bed load. As a result, the riverbeds are rising at some sections in the plains, resulting in the lessening of cross-sectional areas which being incapable of arresting the unusual monsoon discharge and allow water to spill, causing floods.

The rivers under study may be divided into two major groups: (a) large transit rivers originated in high Himalaya represented by three rivers Tista, Torsa and Sankosh with perennial discharge, feed both by rain and melt waters. Deep canyons in marginal part and mega-fans in the foreland indicate very high water discharge and high sediment load. Great alluvial fans and braided channels with frequent avulsions extend far up to the river Brahmaputra and (b) rivers dissecting Lesser Himalaya. The river Jaldhaka and Mahananda fall under this group drains large catchment, deeply incised also in the piedmont, where it is draining the active rising blocks. As a result, its fan surface is developing farther downstream.

The rivers under study are not stable and process of erosion in the steep hilly catchment, transportation of sediment in the river and its subsequent progressive deposition lower down in the river with flatter slope is a continuous phenomenon. In the upper reaches in the plains, the river and their tributaries have got steeper slopes as compared to the lower reaches, thus, the carrying capacity for the silt load in the upper reaches in the plains is comparatively more than in the lower reaches. The river bed, just after it debauches into the plains, consists of shingle and sand, whereas further down in the flatter plains, the alluvial channels mostly consist of coarse and medium silt. Pronounced development of conjugal alluvial fan, produced by diverging drainage system in the catchment area of the Mahananda and Jaldhaka is very much conspicuous in the western and central part of the piedmont zone.

Most of the rivers in this region are rather straight streams. The average slope ratio of the river channel in general cases is much lower indicating an obviously steeper gradient. Average gradient of the channel varies from 1:342 in the Tista to 1:4611 in the Torsa. The river Sankosh with a gradient of 1:1833 followed by the river Jaldhaka with a gradient of 1:3129 within the active plain is rather swift river. The Tista, the largest river in the north of the Ganga-Padma system in West Bengal, although infested with innumerable island and shoals in its wide channel, is still flowing fairly fast within the studied section a gradient of 1:342.

The length of cross-sections varies considerably from one cross section to another at different locations. There is significant variation in the area of flow from one year to another indicating deposition or erosion at each of the cross sections. Smaller area of section occurs where velocity is higher. The estimation of deposition & erosion, the volume of sediment deposit or scoured over a period of time have been computed and it reveals that the average depth of deposition or scour varies from 1 cm to 18 cm in case of the river Tista, while the same is substantial in case of the river Jaldhaka and Torsa which varies from 6 cm to 72 cm and 17 cm to 72 cm respectively. There is, however, very high scouring observed in the river Sankosh of the order of 165 cm over a period of 14 years from 1986 to 2000. The above studies are only indicative in nature and in no way, can form a basis for planning of any remedial measures

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