

CHAPTER-II

Study Area

2. STUDY AREA

2.1 Study area (sub-Himalayan hotspot region of North Bengal, West Bengal, India).

North Bengal (In Bengali language: “Uttarbanga”) is a region that encompasses Northern part of West Bengal and denotes Cooch Behar, Darjeeling, Jalpaiguri, Alipurduar, North Dinajpur, South Dinajpur and Malda districts collectively. It additionally includes parts of Darjeeling Hills. Traditionally, the Hooghly River divides West Bengal into North and South Bengal. North Bengal is in addition divided once more into Terai and Dooars regions. North Bengal can be broadly divided in three sections i.e., the hills consisting of Darjeeling, Kalimpong, Kurseong and Mirik, the plains of Cooch Behar and Malda and the ultimate phase is the Terai place which includes Dooars which is the stretch from the foothills of Himalaya, additionally called sub-Himalayan place of West Bengal. The snow-covered mountain peaks, the dense foothill, the luxuriant green forests, the frothing rivers, the luxurious crop fields, vibrant green tea gardens makes the Terai and Dooars of North Bengal a hotbed of bio-variety or biodiversity hotspot. Siliguri is the centre for buying and selling, tourism, tea and wood; and Jalpaiguri is the headquarter of Dooars. Siliguri is the gateway to the complete of North-East India that consists of seven states and also 4 neighbouring international locations (Nepal, Bangladesh, Bhutan, Tibet and China); and they have their global buying and selling course through Siliguri. This vicinity has many the world's over famous locations and growing very fast and is hooked up to all of the most important cities or towns all throughout the globe. The predominant reason for its infrastructural and the industrial increase is its strategic place. Tea, tourism, wood, transport and trading is probably the possible cause for the increasing development of this location. The region covers the moist and dense riverine forests of the Bengal Dooars (Duars) and the foothills of the snow-covered Kanchenjunga range. The specific climatic and ecological situations make North Bengal a completely unique habitat for a massive wide variety of mega fauna and flowers. The altitudinal zones of plants run from tropical, sub-tropical, moderate to Alpine – a few locations just 10 km in a right away line isolates the palm developing valleys from ceaseless snow.

2.1.1 Terai

The Terai ("moist land") is a belt of mucky meadows, savannas, and woodlands at the bottom of the Himalaya that run in India, Nepal, and Bhutan, from the Yamuna River within

the west to the Brahmaputra River in the east. Over the Terai belt lies the Bhabhar is made up of replacement layers of mud and sand; a forested belt of rock and soil disintegrated from the Himalaya mountain tiers. The excessive water table that lies from 5 to 37 meters down makes numerous springs and wetlands. The Terai zone is immersed every year by way of the rainstorm swollen river streams of the Himalaya. Underneath the Terai lies the good sized alluvial undeniable of the Yamuna, Ganges, Brahmaputra, and their tributaries. [Source: <http://biodiversity-mohanpai.blogspot.in/2008/12/biodiversity-north-bengal.html>]

2.1.2 Dooars

The Dooars or Duars are flood plains at the foothills of the Jap Himalayas in North-East India around Bhutan. In both Assamese and Bengali languages Duar means “Door”. It is the gateway to the North Eastern place of India. This area is divided via the Sankosh river into the eastern and the western Dooars, consisting of an area of 800 square kilometre. This vicinity became part of the Indian states of Assam and West Bengal. There are innumerable streams and rivers flowing thru those plains from the mountains of Bhutan make this undeniable very fertile. In Assam the foremost rivers are Brahmaputra and Manas, and in northern West Bengal the major river is the Teesta and plenty of others like the Jaldhaka, Murti, Ghotia, Torsha, Sankosh, Diana, Raidak, Kaljani etc. The forested regions of northern West Bengal gift a plenty of Wildlife. This blended dry deciduous woodland noticed with fields, harbors the biggest assorted kind of principal fauna in West Bengal. A huge range of foothill forest in North Bengal is referred to as Dooars. Tea Gardens, snow covered landscapes, honest streams; National Parks and the Wildlife Sanctuary make this area a paradise. Wonderful motorable streets slice via profound forest, wealthy with wild lifes. Gentle slopes stay toward the cease of velvet inexperienced fields and the woodland is echoed with the music of winged animals. Dooars is the territory of the unusual Toto clans. The maximum superb passage factor to Dooars is thru Siliguri by street. The primary spots of enthusiasm for Dooars are Jaldapara National Park and Gorumara National Park, Buxa National Park, Mahananda Wildlife Sanctuary, Rasik Bill Bird Sanctuary, Chapramari Wildlife Reserve, Chilapata forest, Jayanti hills, Bindu, Rocky Island. [Source: <http://www.northeastindiatours.in>]

2.2 River systems

The sub-Himalayan North Bengal region is intersected via numerous streams, rivers and rivulets. All their resources are the Darjeeling Himalaya in the north. The rivers in this place are in particular snow fed and rain endorsed. Due to their big catchment location most of the rivers drain good sized quantity of water throughout wet season. All rivers convey massive load of sediment with their water due to excessive price of soil disintegration occur inside the hill location. The greater part of the streams has excessive slope and big measure of water so they're used for the technology of hydroelectricity. Scarcely any hydroelectric ventures are brought in the sloping components of the streams. The streams are separated into high run-off region, excessive infiltration quarter and recharge quarter. Unreasonable rain, expansive catchment territory, low wearing limit and snow melted water all activates frequent floods within the streams. The rivers often changed their course of glide due to unexpected bursting of artificial water garage by using landslides and bank disintegration.

High deforestation occurred due to human interference inside the hills and adjacent region of the Darjeeling place ends in soil degradation, erosion and common landslides which is the characteristic of Darjeeling hills. Many forests are cleared for tea plantation and terrace cultivation for production of plants; leaves last forest inside a danger because of populace enlargement changed into due to excessive rate of immigration from neighboring states and international locations. The rivers with their higher catchment inside the hills have funneled fashioned basin with narrow outlets on the foothills; inside the plains the rivers falls notably and unexpectedly widens. So to resist this condition the rivers adjust themselves by means of converting their courses from erosional to depositional nation to adjust the brand new hydrogeographical necessities brought on by way of the exchange of the gradients as rivers glide from excessive to lower altitude. Development of new channels, shifting of the channels and forsaking the old one are the most common inside the rivers of this place. Often, overflowing of water on one river reasons flood inside the catchment region of nearby rivers. The construction of longitudinal embankment along the rivers has reasons the rise of the river bed level that results in deposition of sediments in many locations of the river bed. This problem is augmented by way of careless diversion of water from rivers for irrigation inside the agricultural fields and different family purposes; these outcomes the rivers incompetent to hold silts and particles. Removal of boulders and twine-guards from the embankment weakens the embankment; consequently, the rivers end up unable to carry massive quantity of water at some point of wet season lead to floods within the nearby region. This activities reason intense financial institution erosion and therefore inundate the adjacent regions.

Scarcity of appropriate habitats pressured the lowland inhabitants to settle their everlasting homes at the stretches river mattress or facets of the banks due to the fact the whole highlands are dedicated to cultivation of various vegetation and teas. Peoples with out a know-how approximately the nature of the North Bengal rivers also build their citizens at the lands which can be generally the beds of vintage abandoned channels.

2.2.1 Mahananda-Balasan River System

Mahananda River is one of the essential tributary of the Ganga River within the eastern a part of India. The Mahananda River is a trans-boundary river and flows thru the Indian states of West Bengal, Bihar, and crosses Indian boundary to go into Bangladesh. Its proper bank tributary, the Mechi River paperwork part of Nepal's jap boundary with West Bengal, India; while the Kankai flows out of Nepal. The Mahananda originates within the Himalaya's Paglajhora Falls on Mahaldiram Hill near Chimli, east of Kurseong in Darjeeling district at an elevation of two,one hundred metres (6,900 ft) (Jain et al., 2010; *"Rivers in Siliguri". Mahananda River. Siliguri on line. Retrieved 2010-05-14; "Rivers". Darjeeling News.Net. Retrieved 2010-05-14*). It flows across the Mahananda Wildlife Sanctuary and descends to the foothills of Himalayan plains near Siliguri and touches Jalpaiguri district (*"Mahananda Wildlife Sanctuary". nature beyond. Retrieved 2010-05-14*). It enters Bangladesh near Tentulia in Panchagarh District, flows for 3 kilometres after Tentulia and returns to India (*"News from Bangladesh". Retrieved 2010-05-14*). After flowing through Uttar Dinajpur district in West Bengal and Kishanganj and Katihar districts in Bihar, it again enters Malda district in West Bengal (*"Uttar Dinajpur district". Uttar Dinajpur district administration. Retrieved 2010-05-14.; "Kishanganj district". Kishanganj district administration. Retrieved 2010-05-14*). The Mahananda divides the district into two regions — the jap region, known as Barind, consisting specifically of antique alluvial and relatively infertile soil, and the western location, that is in addition subdivided with the aid of the river Kalindri into areas, the northern location is known as "Tal" that is low-mendacity and usually inundated all through wet season; the southern area is "Diara", includes very fertile land and is thickly populated (*"Malda district". Malda district administration. Retrieved 2010-05-14*). It merges with the Ganges at Godagiri in Nawabganj district in Bangladesh after flowing for 360 kilometers (Jain et al., 2010).

The total length of the Mahananda is 360 kilometres (*"Mahananda River". Britannica. Retrieved 2010-05-14*.) out of which 324 kilometres are in India and 36 kilometres are in Bangladesh. The total drainage area of the Mahananda is 20,600 square

kilometres out of which 11,530 square kilometres are in India (Jain et al., 2010). The main tributaries of the Mahananda are Balason, Mechi, Ratwa, Kankai and Kalindri (Jain et al., 2010).

2.2.2 Teesta River System and important tributaries

The 'Teesta' or 'Tista' is the greatest and high tempestuous ice sheet encouraged stream of Darjeeling area. The term 'Teesta' or 'Tista' is a gotten from the Sanskrit word 'Tri-srota', which means, it has three 'srotas' or flows. This most likely in light of the fact that the waterway once (before 1787 A.D.) moved through three diverse stream streams viz., the Atrai, Punarbhaba, and Karatoya, every one of which pursued free courses to the Ganges and Meghna. The Bhutia name for this waterway is 'Tsang-Chhu' or the unadulterated water, while the Lepcha consider it the 'Rangnyung' or the extraordinary straight going water delineates actuality that it proceeds in a straight unaltered course regardless of accepting an incredible load to its water from the Rangit stream joining to it at straight points.

The waterway accepts its ascent as 'Chumbu chu' (the upper most Teesta) in the North-East edges of North Sikkim from Pouhunri (Pouhungri) icy mass at an elevation around 6200 meter. Teesta river out falls into the waterway Brahmaputra (Jamuna) at Kamarganj in Rangpur region of Bangladesh. The waterway is amplified by the converging of a significant expansive number of tributaries in the Himalayan and sub-Himalayan areas. The waterway coursing through the sloping catchment of the Sikkim state, gets its name Teesta underneath the intersection of two streams, Lachung chhu from the north-eastern bearing and Lachen chhu from the north-western heading. The Lachen chhu is bolstered by a snow-encouraged right bank stream of Zemu chhu and the Lachung chhu is nourished by left bank tributary of Sebung chhu. The Lachung chhu and Lachen chhu, subsequent to rising up out of, Chungthang joins to stream with the name of Teesta River. The Teesta shapes the limit of the Darjeeling region from the point where it is joined by the Rangpo chhu to its intersection with the incomparable Rangit. After that it streams completely through a profound canyon of Sivok-Gola go inside the Darjeeling locale until the point when it abandons it at Sivok.

Through its course, the Teesta waterway has removed crevasses and gulches in Sikkim twisting through the slants of Kalimpong lying essentially off the stream. Variegated vegetation can be seen along this course. At lower statures, tropical deciduous trees and brambles cover the enveloping inclines; elevated vegetation is seen at the upper statures. The

stream bank is flanked by white sand and rock which is utilized for the development business in this district. Huge rocks are found around the waters make it perfect for waterway raftingrafting aficionados. Close to the Rangpo town the railroad connects (prevalently called Lohapul or iron extension) was developed as it enters the fields at Sevoke. Towns like Teesta Bazaar and MelliMelli situated here. Despite the fact that the stream looks gentle in this district yet hidden current is extremely solid. Frequently, a pontoon struck a halfway concealed stone underneath the waterway water and was sucked in by a whirlpool, leaving no trace of the occupants. In the midst of the rainstorm, Teesta stream develops its banks; both in size and unsettling influence. Torrential slides in this region as often as possible dam up parts of the conduit in this season. Amid the period since 1500 CE, amazing changes have happened over the range of a bit of the streams in Bengal and the bordering zones. Albeit positive verification is missing, similar changes can be acknowledged in the remoter past. The Teesta River is one of the streams that have changed consistently (Majumder, 1971).

Already three channels, viz., the Karatoya toward the east, the Punarbhaba in the west and the Atrai in the middle kept running from Jalpaiguri conceivably gave the name to the waterway as Trisrota "had of three streams" which has been abbreviated to Teesta. Later on the Punarbhaba joined the Mahananda. In the wake of going through a huge boggy territory known as Chalan Beel, Atrai waterway joined the Karatoya and the assembled stream converged to the Padma (Ganges) close Jafarganj. After the dangerous surges of 1787, the Teesta stream relinquishes its old channel and streaming south-east to join the Brahmaputra. As indicated by the guide developed by James Rennell (1764 and 1777) Teesta is appeared as coursing through North Bengal in a few branches—Punarbhaba, Atrai, Karatoya, and so on. Every one of these streams consolidated let down with the Mahananda in North Bengal, and taking the name of Hoorsagar at long last released into the Ganges at Jafarganj. The Hoorsagar waterway still in nearness, being the united outfall of the Baral, a spill channel of the Ganges, the Atrai, the Jamuna or Jamuneswari, and the Karatoya, rather than falling into the Ganges, it falls into the essential Jamuna, several miles over its crossing point with the Padma at Goalundo (Majumder, 1941).

2.2.3 Jaldhaka River System and important tributaries

The Jaldhaka River similarly alluded to previously as Dichu River, is a trans-restrict conduit with a length of 192 kilometers that starts from the Kupup or Bitang Lake in southeastern Sikkim in the eastern Himalayas and moves through Bhutan; and the Kalimpong, Jalpaiguri and Cooch Behar districts of West Bengal, India (Sharma and

Aharma, 2005). By then the stream enters Bangladesh through the Lalmonirhat District and after that joins with the Dharla River until the point when the moment that the Dharla converges into the Brahmaputra River near the Kurigram District. The waterway's floating more than a few universal fringes, hence, just a little length of the stream exists in Bangladesh (Murshed, 2012).

The Jaldhaka River is surrounded by the mix of three streams at Bindu, the end reason for the Jaldhaka Police Station at Kalimpong district in West Bengal. The three streams are known as Bindu Khola, Dudh Pokhri and Jaldhaka that starts from the Kupup Lake, a little sub zero lake in Sikkim. The joined streams meet at Bindu to shape the Jaldhaka River, along these lines surrounding a riverine restrict with India and Bhutan in the left bank. The crucial tributaries that join the stream in its right bank are the Murti, the Naksal Khola, the Sutunga and the Jarda in the lower reach. The Diana, Rehti-Duduya and Mujnai are the principal left bank tributaries. The stream courses through the three North Bengal regions of Kalimpong, Jalpaiguri and Cooch Bihar. The entire watershed is the most productive provincial zone close by the Teesta Basin. The upper course is commended for harvests like ginger, remedial herbs and normal items like oranges and pomegranate. The inside course containing Jalpaiguri region is by and large tea and corn overpowered and the lower course is governed by rice, jute and tobacco. The between stream molded territories are produced with harvests like bamboo and tangle sticks. In the lower bowl, the between stream lands are produced with banana. The stream enters Bangladesh at Ghoksadanga area to meet the Brahmaputra or the Jamuna.

Through its course, the Teesta waterway has removed chasms and gorge in Sikkim twisting through the slants of Kalimpong lying basically off the stream. Variegated vegetation can be seen along this course. At lower statures, tropical deciduous trees and shrubs cover the including inclines; high vegetation is seen at the upper statures. The stream bank is flanked by white sand and rock which is utilized for the development business in this locale. Huge stones are found around the waters make it perfect for waterway raftingrafting devotees. Next to the Rangpo town the railroad connect (famously called Lohapul or iron extension) was developed as it enters the fields at Sevoke. Towns like Teesta Bazaar and MelliMelli situated here. Despite the fact that the waterway looks gentle in this locale however, fundamental momentum is exceptionally solid. Regularly, a vessel struck a halfway concealed rock underneath the waterway water and was sucked in by a whirlpool, leaving no trace of the occupants. In the midst of the rainstorm, Teesta stream grows its banks; both in size and unsettling influence. Torrential slides in this area often dam up parts of the conduit

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2.3 Detailed Map of the Study Area showing sample collection sites

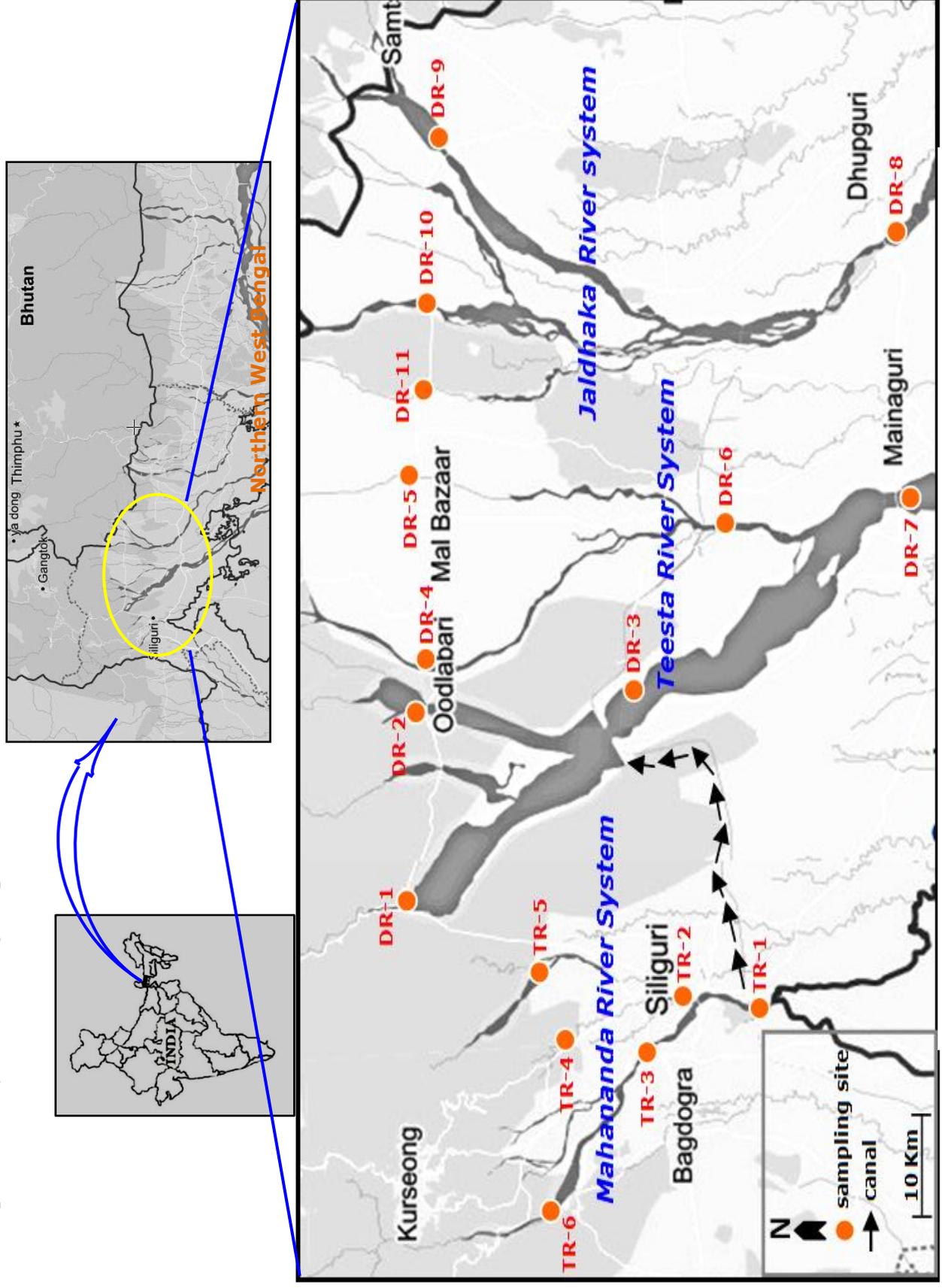


Figure 6. map of the Study area showing sample collection sites

2.4 Local Names of sample collection site showing geographical coordinates of each site.

Table 1. Geographical coordinates recorded with the help of hand-held GPS device			
Sl/No.	Population Code	Name of the River and adjacent place	Geographic position and GPS Record
1	TR-1	Mahananda Barrage, Fulbari.	26°38.884'N; 88°24.125'E; Elevation 319 AMSL
2	TR-2	Mahananda-Panchanoi River Junction, Siliguri.	26°42.125'N; 88°24.717'E; Elevation 620 AMSL
3	TR-3	Balason River, Palpara, Matigara.	26°43.177'N; 88°22.825'E; Elevation 646 AMSL
4	TR-4	Panchanoi River, Siliguri.	26°43.007'N; 88°24.396'E; Elevation 666 AMSL
5	TR-5	Mahananda River, Champasari, Siliguri.	26°44.452'N; 88°25.497'E; Elevation 717 AMSL
6	TR-6	Balason River, Tarabari.	26°45.632'N; 88°18.912'E; Elevation 731 AMSL
7	DR-1	Sevok (Teesta River)	N 26°53'043, E 88°28'367 Elevation 480 AMSL
8	DR-2	Ghish River	N 26°52'327, E 88°36'355 Elevation 536 AMSL
9	DR-3	Gajoldoba (Teesta River Barrage)	N 26°44'584, E 88°35'314 Elevation 354 AMSL
10	DR-4	Chel River	N 26°51'499, E 88°38'048 Elevation 522 AMSL
11	DR-5	Neora River	N 26°52'486, E 88°46'205 Elevation 527 AMSL
12	DR-6	Dharla River	N 26°40'496, E 88°44'126 Elevation 299 AMSL
13	DR-7	Jalpaiguri (Teesta River)	N 26°33'499, E 88°45'369 Elevation 274 AMSL
14	DR-8	Jaldhaka River	26°34'13.17 N, 88°56'14.26 E Elevation 267 AMSL
15	DR-9	Murti River	26°52'57.73 N, 88°49'44.98 E Elevation 578 AMSL
16	DR-10	Ghotia River	26°52'14.89 N, 88°53'37.98 E Elevation 540 AMSL
17	DR-11	Diana River	26°51'37.96 N, 89°00'07.40 E Elevation 647 AMSL
*AMSL= Above Mean Sea Level			