CHAPTER - II

PHYSICAL FEATURES

2.0 General

The Kosi-Mechi Intrastate link envisages diversion of part of surplus water of Kosi river for extending irrigation in water short commad areas of Mahananda basin lying between river Parman and Mechi by extending the existing Eastern Kosi Main Canal beyond river Parman and upto river Mechi. The link canal will provide irrigation in new command areas enroute of the link lying in Araria, Kishanganj, Purnia and Katihar districts of Bihar.

2.1 General information about climate and geography of Kosi basin

The Kosi basin mainly falls in the sub-tropical belt and humid zone. The basin experiences very hot summer and severe winters except in the snow bound area and the hills of Nepal. The monsoon period is from middle of June to middle of October. The winter season is from November to March. Heavy rainfall in Kosi catchment occurs during South-West monsoon period (June to Sept).

The normal daily mean temperature of the sub-basin varies from 16.5^0 C to 30.4^0 C in the plains. The maximum temperature observed in the sub-basin is 31.2^0 C during the month of May whereas the minimum temperature observed is 16^0 C in the month of January.

The winds are generally light particularly during the morning hours with a mean speed of the order of 3-5 km/hour. The wind direction is North-Westerly or South-Easterly in the Eastern and Western portion and North-Westerly in the Central area for a few days. When the winds are not calm, the predominant direction is Westerly at Barahkshetra & Okhaldunga and Southerly at Taplejung.

There are three observatories in the vicinity of Kosi basin namely Darbhanga, Sabour and Purnea, where monthly and annual values of potential evapotranspiration are worked out from Penman's formula. Also

the potential evapotranspiration of Bhagalpur station in the adjoining basin is considered according to report No.136 IMD (1971).

Proposed Kosi High Dam:

A 269.0 m high dam namely Kosi High Dam Project is proposed to be constructed on Kosi river in Nepal about 1.6 km upstream of Barahkshetra village. The dam is multipurpose in scope and envisages power generation with an installed capacity of 3000 MW at the dam toe power house. The gross capacity of the proposed dam is 13,450 MCM at MWL of 338.30 m. The live storage capacity is 9370 MCM. The FRL and MDDL of the proposed dam are 335.25 m and 259.0 m respectively. This dam will regulate the required discharges for Chatra barrage canal system.

2.1.1 Climate

The Kosi basin mainly falls in the sub-tropical belt and humid zone. The basin experiences very hot summer and severe winters except in the snow bound area and the hills of Nepal. The monsoon period is from middle of June to middle of October. The winter season is from November to March. Heavy rainfall in Kosi catchment occurs during South-West monsoon period (June to Sept).

2.1.2 Rainfall

The Kosi basin receives most of its rainfall from the South-West monsoon from June to September. Only 12% of the total rainfall is contributed from non-monsoon months from October to May, whereas 88% of the total rainfall occurs in the monsoon season. The average annual rainfall of the Kosi sub-basin is 1347 mm.

The annual rainfall in the basin progressively increases from about 1200 mm at the foot of the hills to more than 3500 mm on the southern slopes of the great Himalayan ranges. The annual precipitation decreases across the Himalayas to less than about 250 mm in the Tibetan portion of watershed. The rainfall in the lower catchment varies from 1380 mm to 1490 mm. During the winter months of January to March, there is another short spell of precipitation under the influence of Western disturbances. Local thunderstorms occur in the catchment during the month of April and May. The rainfall regime of the Kosi catchment is more or less similar to

that of North Bihar and sub Himalayan West Bengal. July is the highest rainfall month, followed by August, June and September, in descending order.

2.1.3 Temperature

The central portion of Purnea district is warmer in June and very cold in January as compared to other districts of basin where maximum and minimum temperatures are 40^0C and 8.35^0C respectively. The nights are comfortable as compared to days during the summer season.

2.1.4 Relative humidity

The relative humidity in the morning and evening is 75 and 57 percent respectively. This type of warm and humid climate is very congenial for growing rice.

2.1.5 Wind speed

Wind speed is recorded at 3 places namely Taplejung, Okhaldunga and Barahkshetra. The winds are generally light particularly during the morning hours with a mean speed of the order of 3-5 km/hour. The wind direction is North-Westerly or South-Easterly in the Eastern and Western portion and North-Westerly in the Central area on a few days. When the winds are not calm, the predominant component is Westerly at Barahkshetra and Okhaldunga and Southerly at Taplejung.

2.1.6 Potential evapotranspiration

The potential evapotranspiration as computed by IMD for Purnea observatory located in the middle of command area has been considered for working out the crop water requirements. As per Purnea observatory, the average monthly evaporation varies between 5.18cm to 17.87cm.

2.1.7 Soils

The Kosi and Mahananda rivers originate and have catchments in Himalayan region, which are not calcareous but rich in acidic minerals. As a result, the soils of this zone are non calcareous. Accumulation of sodium salts and sodium absorption has taken place in areas where the drainage is poor. As Kosi and Mahananda both rivers carry tremendous load of

sediments, the soils are mostly light textured except in back waters of river Ganga and Kosi.

Introduction of irrigation in an area must be preceded by detailed field and laboratory investigations aimed at the classification of the soils of the area to assess their suitability for irrigation and determining appropriate cropping pattern, intensity of irrigation and water delivery requirements. In order to make interpretation for soil-plant-water relationship, the following soil qualities must be determined from the above mentioned surveys and laboratory test.

1. Fertility
2. Productivity
3. Erodibility
4. Drainability
5. Leachability
6. Infiltration rate
7. Available moisture holding capacity

Detailed soil survey of the Kosi basin has not been carried out in recent studies. However, the district wise general soil classifications are given in Table 2.1.

Table: 2.1

District wise general soil types of Kosi basin

Sl. No.	**State/District**	**Type of soil**
	Bihar	
1.	Darbhanga	Alluvial, calcareous alluvial
2.	Munger	Alluvial, calcareous alluvial, peaty and saline peaty.
3.	Saharsa	Alluvial, calcareous alluvial, peaty and saline peaty.
4.	Purnea	Alluvial and Terai
5.	Bhagalpur	Alluvial
6.	Madhubani	Alluvial
7.	Katihar	Alluvial

A brief description, of each soil group is given in the following paragraphs.

2.1.7.1 Alluvial soils

These soils are coarse to finer in texture, deep to very deep and greyish in colour and mostly neutral in reaction. Organic matter content is low to medium. These soils are rich in Calcium. Ground water potential is very high and aquifers are unconfined. These soils are neutral to moderately acidic in reaction. Rice, Wheat and Sugarcane are the main crops which could be successfully grown in these types of soils.

2.1.7.2 Terai soils

These types of soils are mostly lighter in texture with lower base status and contain a good amount of a mixture of partially and fully decomposed organic matter. For this reason the colour of the soil varies from deep black to grey black. Due to the above factors, the soil is acidic in nature and is poor in base status and available plant nutrients. It has been found that the soil is also deficient in micronutrients.

2.1.8 Land irrigability classification

On analyzing the district wise soil types present in the basin, it is evident that the soils of the district of Purnea, Katihar, Bhagalpur and Madhubani are alluvial and hence are neutral to moderately acidic in reaction. Rice, wheat and sugarcane are the main crops which could be successfully grown in these types of soils. The district wise soil fertility status with regard to Nitrogen, Phosphorus and Potash are given in the Table 2.2.

Table 2.2

Soil fertility status of areas lying in Kosi basin

State/Districts		**Nitrogen**	**Phosphorus**	**Potash**
Bihar				
1.	Darbhanga	Low	Medium	Medium
2.	Monghyr	Medium	Low	Medium
3.	Saharsa	Medium	Low	Medium
4.	Purnea	Low	Low	Medium
5.	Bhagalpur	Medium	Low	Medium
6.	Madhubani	Low	Medium	Medium
7.	Katihar	Low	Low	Medium

On examining the above data it indicates that Nitrogen is low in all districts except Munger, Saharasa and Bhagalpur where it is medium. Regarding phosphorus it is medium in Darbhanga and Madhubani and low in other districts. Potash is medium in all the districts of the basin. The soil fertility status will influence the type and quantum of applications of fertilizers. Therefore, while working out the fertilizer requirement for various crops, the nutrient status of the soil has to be considered.

2.1.9 Land holdings

The number and area under different sizes of operational land holdings have been calculated for the basin on proportionate area basis from the district wise figures with percentage of total area is given in the following Table 2.3.

Table 2.3

Nos. and area in different operational land holdings in Kosi basin

Sl. No.	Size of holdings (ha)	Numbers	Area (ha)	% of total area
1.	Marginal (below 1.00)	2285	789	33.06
2.	Small (1.0 to 2.0)	289	387	16.22
3.	Semi-medium (2.00 to 4.00)	217	584	24.46
4.	Medium (4.0 to 10.0)	85	476	19.94
5.	Large (10.0 and above)	9	151	6.32

2.2 General information about climate and geography of Mahananda basin

The river Mahananda is one of the major northern tributary of the river Ganga, passing through Nepal, India and Bangladesh. It is bounded on the North by the Himalayas, the ridges separating it from the Teesta river system in the East, the Ganga on the South and the Kosi river system in the West. It is spread over districts of Purnea, Kishanganj, Araria and Katihar in Bihar and Malda, West Dinajpur and Darjeeling in West Bengal. It drains a total catchment area of 23,700 sqkm over a length of 137 km. The hilly catchment in Nepal pertains to tributaries of the Mahananda river namely Padma, Bekra, Eastern Kankai, Western Kankai and the Mechi,

while that of the main river Mahananda lies in the Darjeeling district of West Bengal.

2.3 General information about climate and geography of Mechi basin

The river Mechi is a major western tributary of Mahananda. The river Mechi a perennial river which rises in the inner valley of the Himalaya in Mahabharat range of hills in Nepal near Sindhuliagarhi at an elevation of 2,423 m at the Latitude 26^0 50′ N and Longitude 88^0 7′ E

2.3.1 Topography, physiography and geology

The topography of the Mechi sub-basin (Mahananda river system) varies from rugged hills of Himalayas (in Nepal) to plains at its outfall into the Mahananda. The upper portion of the catchment extends to an altitude of about 200 m and lies mostly in Himalayas in Nepal (a small portion is also in West Bengal) while portion in plains lies mostly in India. The Northern part of the river system is hilly and the Southern part is all plain lands traced by a number of channels falling into the main river, Mahananda. The reach from origin upto Siliguri is mountainous covered with thick forest upto Sonapurhat 37 km, below Siliguri, the river bed consists of boulder and sand brought by the river during the floods and the banks are remarkably stable.

The geological formations of the Mahananda river system in the hilly area of Darjeeling district consist of unaltered sedimentary rocks confined to the hills on the north consisting of different grades of metamorphic rocks over the rest of the area. The outcrops of the various rocks form a series of bonds more or less to the general line of the Himalayas, dipping one below the other into the hills. The characteristic feature of the Southern area is that the older formations rest on the younger formations, showing complete reversal of the original order of superposition.

The great range was elevated during the tertiary period above the site of an ancient area that had accumulated sediments of different geological ages. The mountains are made of folded rocks piled one over another by a series of north-south horizontal compression movements and

tangential thrusts which also folded the strata on the sea floor and caused their up-heaval by stages. At many places, the formations have been intruded by granites. Frequently, the strains within the range are invested due to the over-turning of the folds and their dislocation. Features of such up-heavals bringing the older beds above the younger characterized the whole length of the outer Himalayas.

The present relief of high peaks and deep valleys has been carved by three principal agents of denudation, namely wind, water and snow. The resulting products of disintegration of mountains are swept; over the sub-mountainous tract as the rivers debouch into the plains. The terai and the plains at the foot of the Himalayas assumed their present form after the final up-heavals of the range and consist of almost the horizontal layers of un-consolidated sand, silt, pebbles and gravel. Igneous, metamorphic rocks are the varieties available all along the range, which are commonly known as Darjeeling gneiss and are composed of mica, schists and gneiss. The sedimentary variety of Darjeeling contains minerals such as garnet, sillimanite, kyanite etc. The presence of which indicates that the rocks were subjected to higher temperature and pressure.

2.3.2 Climate

The Mahananda river system in Darjeeling district experiences varied climatic condition. Occasionally snow falls in January and February at high altitude for a few hours. During April and May there is short lived summer accompanied by summer rain, for three months from June to August and the catchment is drenched with rain. The catchment in Jalpaiguri district experiences heavy rainfall. Its temperature is rarely excessive due to the proximity of the hills and so the catchment is always green. The climate of the river system in Purnea, Kishanganj, Araria, Katihar and West Dinajpur districts is cold from November to February and hot from March to middle of June due to strong westerly wind. With the setting in of the monsoon in the middle of October, the nights become appreciably cooler, though the days remain hot, sometimes longer. The relative humidity varies from 20% to 85%. It is the lowest during April and May and the highest in the months of June to September.

2.3.3 Rainfall

The average annual rainfall in Mahananda river system in India is about 2050 mm. About 80% of the rainfall is during the monsoon months. The usual direction of moisture laden current is generally northward. The annual rainfall in the upper catchment ranges from 100 mm to 1400 mm. As per the Bihar Statistical Hand Book-2012, annual normal rainfalls in the districts of Araria, Purnea, Kishanganj and Katihar are between 1218 mm to 2041 mm and during monsoon the average annual rainfall is between 1067 mm to 1785 mm. The average numbers of rainy days in monsoon period are 55 in case of these districts.

Maximum rainfall occurs in the month of July during monsoon, which is of the order of 542 mm and the minimum rainfall in the month of June is of the order of 251 mm in Purnea.

Some rainfall occurs during the non-monsoon in the districts of Kishanganj, Araria and Purnea. The average monthly rainfall during the non-monsoon period is about 110 mm. The Minimum rainfall occurs in month of December

2.3.4 Temperature

Except in the snow bound areas and the hills of Nepal, the basin experiences both hot summer and cold winters. The month of May is the hottest with the maximum temperature upto 40°c. The winter temperature goes down to nearly 4°c in January in the plains in the lower reaches while in the hills, it is still lower. There are two hydrometerological observatories in the Mahananda catchment one at Purnea and the other at Malda.

2.3.5 Wind Velocity

Mean monthly wind velocity values observed at the Purnea, West Dinajpur and Darjeeling observatories are furnished in annexure 2.2 to 2.4. These show that wind blows at medium speed varying from 1.4 km/hr to 7.0 km/hr.

2.3.6 Humidity

The relative humidity values observed at Purnea, West Dinajpur and Darjeeling stations varies from 39% to 88%. As per Purnea observatory,

the monthly mean evaporation in the command varies between 5.18 cm to 17.87 cm.

2.3.7 Cloud Cover

The cloud cover in the basin varies from 0.87 Oktas to 6.37 Oktas.

2.3.8 Soils

The Mahananda originates and have catchments in Himalayan region, which are not calcareous but rich in acidic minerals. As a result, the soils of this zone are non calcareous. Accumulation of sodium salts and sodium absorption has taken place in areas where the drainage is poor. As Kosi and Mahananda both carries tremendous load of sediments, the soils are mostly light textured except in back waters of river Ganga and Kosi.

2.4 Existing Hanuman Nagar barrage

As per agreement signed between Govt. of India and the then H.M.G. of Nepal in 1953, Kosi barrage was constructed as a component of Kosi Project 1953. The agreement signed between Govt. of India and H.M.G. of Nepal in 1953 as given in chapter-3, Annexure-3.1. Accordingly 1149 m long Hanuman Nagar barrage (Kosi barrage) was constructed near Bhimnagar village located at $26^{o}11'$ N and $86^{o}55'$ E and 48 km below Chatra with pond level of 74.69 meters (245 Feet).It consist of 76 bays of 30 feet each with 7 feet piers and under sluices portion consist of 5 bays of 30 feet each. Provision of one fish ladder has also been made in the main spillway. The crest of under sluices is kept at R. L. 222 feet and is 3 feet lower than that of the weir. However the U/S apron and D/S stilling pool levels are same in both portions. The basic purpose of the barrage is:

(i) To raise the water level in the Barrage sufficiently to cause flattening the slope of the river during flood.

(ii) To create such a pond level as to enable flow irrigation water through the Eastern and Western Main canals off-taking from the head regulators situated at both ends of the barrage.

(iii) To generate hydro electric power (A hydro electric generation power plant was constructed at R.D. 3.66 km of Eastern Kosi Main canal having power generation capacity of 19.20 MW)

The construction of the barrage was started in 1959 and completed in March- 1963.

The Kosi-Mechi intra state link will offtake from left head regulator of existing Hanuman Nagar barrage. In its initial reach, the link canal will utilize entire length of existing Eastern Kosi Main Canal after its remodelling to provide adequate water supply to new command.

2.5 Link command area

The link canal will provide irrigation in new command areas lying in Araria, Kishanganj, Purnea and Katihar districts of Bihar. The district wise details of link command are given in Table 2.4.

Table 2.4

District wise break up of gross command area

Unit: ha

Sl. No.	Name of district	Area falling in the command	% of total command area	Area of the district	% of the district	Area under command
1	Araria	88000	31.98	271712	32.38723	88000
2	Purnea	65885	23.95	313883	20.99031	65885
3	Katihar	69100	25.11	291349	23.71726	69100
4	Kishanganj	52150	18.95	189080	27.58092	52150
		275135	100.00			275135

2.6 River system enroute to link canal

The link canal crosses a number of streams beyond river Parman. These all the streams are the tributaries of river Mahananda. The new command area is well drained. These all the rivers originate in Nepal. The Parman, Tehri, Lohandra, Bhalua, Bakra, Ghaghi, Pahara, Nona, Ratua, Kawal, and Kankai are the main rivers enroute the link canal. Most of the rivers have stable banks. However river Kankai and River Kawal carries a tremendous sediment load. The catchment areas and other salient details of these rivers are given in Table 2.5.

Table 2.5

Salient Details of Enroute Rivers

Sl. No.	Name of river	Crossing of link canal at RD (km)	Catchment area (sqkm)	Width of river (m)	Remarks
1	Parman	44.20	798	110	
2	Tehri	55.150	392	50	
3	Lohandra	56.930	97	18	
4	Bhalua	60.450	44	118	
5	Bakra	65.925	207	100	
6	Ghaghi	68.630	76	35	
7	Pahara	71.900	75	20	
8	Nona	77.850	442	100	
9	Ratua/Gerua	89.300	586	140	Combined
10	Kawal	95.900	870	1140	Meandered
11	Kankai	103.05	107	65	
12	Sarrah	107.725	60	50	
13	Kankai river	111.735	662	50	Another Kankai

The river Kawal is combined with a stream of river Kankai which joins in upstream of link alignment. This river carries a considerable sediment load which is responsible for heavy silt deposition in the flatter plains causing frequent meandering. Other rivers are of firm and stable banks and contain lesser quantum of silt.