Relevant Abstract

of

Feasibility Report of Sapta Kosi High Dam Project

Prepared by

Central Water Commission in 1981

CHAPTER – V
CHATRA BARRAGE AND CANAL SYSTEM

5.1 PRESENT & FUTURE IRRIGATION POTENTIAL.

5.1.1 At present, the discharges available in Kosi River are being exploited for irrigation with the construction of two canal systems. An inundation canal takes off on the left bank of Kosi at Chatra to irrigate an area of 0.9 lakh ha (2.24 lakh ac) in Nepal. There is no weir or barrage across Kosi for diversion of water into the canal and flows into the canal depend upon the stage of water in the river.

5.1.2 The other system is the Eastern Kosi Canal taking off from the barrage at Hanuman Nagar about 48 km (30 miles) down stream of Chatra. This canal commands an area of 9.41 lakh ha (23.25 lakh acres) which lies in Bihar in India. Western Canal from this barrage is at present under construction which will have a command of 3.82 lakh ha (9.43 lakh ac) in India and 0.25 lakh ha (0.63 lakh ac) in Nepal.

5.1.3 With the construction of Kosi High Dam, there will be regulated discharges throughout the year which can be used Ex-Chatra as well as Ex-Hanuman Nagar. This will not only bring larger areas under irrigation but also make the present irrigation assured of water supply throughout the year.

5.1.4 The additional gross command that will be brought under irrigation by constructing a barrage at Chatra will be 5.46 lakh ha (13.49 lakh ac) in Nepal and 9.76 lakh ha (24.10 lakh ac) in India (Bihar). These figures include the existing irrigation by the inundation canal at Chatra (for details see Appendix V-I and Drawing No.5-1).

5.1.5 The assured supply of irrigation water would enable to increase the cropping intensity from the present 86.6% to 124.5% as indicated below:

Crop	Existing Intensity	Proposed Intensity
Paddy	57.8%	75%
Wheat	22.8%	30%
Sugar Cane	2.2%	2.5%
Hot weather Paddy	3.3%	5%
Jute	0.5%	12%
Total	**86.6%**	**124.5%**

For the above cropping pattern and intensity, water requirement for irrigation has been worked out on the basis of duties as adopted in the projects in similar areas.

5.1.6 The difference in levels between Chatra ad Hanuman Nagar is of the order of 36.6 m and this differential head will enable the generation of power before the water is let down into the river to be picked up at Hanuman Nagar. This power is proposed to be used for ground exploitation in the area.

5.1.7 The Project, therefore, envisages the construction of new barrage at Chatra which would be 8 km (5 miles) down stream of the proposed Kosi High Dam, with two high levels canals, one on each bank in Nepal. These canals are expected to serve one of the most fertile areas of the terrain in Nepal. Preliminary assessment on the basis of data available shows that it may be possible to cover a Gross command of 11.05 lakh ha (27.29 lakh ac) on the right bank and 4.17 lakh ha (10.30 lakh ac) on the left bank (both in Nepal and India). Another major advantage of providing Kosi waters to the high level canals in Nepal would be that, dependence on smaller rivers which are crossed by these canals would not be necessary and it may be possible to develop these rivers in an integrated manner along with Kosi water which would provide irrigation needs both in Nepal and India and at the same time release waters below Chatra for intensifying irrigation in India.

5.1.8 With the construction of Kosi High Dam, most of the coarse and medium silt will be trapped. With the reduction in the overflows and the reservoir extending over an area of 200 sq km, a sizeable proportion of fine silt will also get entrapped in the reservoir. Also the project envisages afforestation and soil conservation works in the catchment area on the basis of photo interpreted aerial surveys and other field work. This area is also liable to earthquakes and Sun Kosi and Tamur river catchments have a tendency to landslides. Adequate measures to prevent landslides are also proposed. With these measures, it is expected that the silt content of the Kosi waters released from the Dam would be much less and the problem of silt control at Chatra Barrage would be manageable. If, however, certain amount of dredging is necessary in the Barrage this can be attempted along with silt excluders and other hydraulic devices. It is proposed that the canals and distributaries will be lined. The efficiency of the entire sys tem is assumed as 75%.

5.2 BARRAGE SITE

5.2.1 The proposed barrage site near Chatra 8 km (5 miles) downstream of Barahakshetra dam site is found to be the most pitable, for the following reasons:

(i) The natural gorge of Kosi extends to this site obviating the necessity of long lengths of guide bunds which would otherwise be necessary for a site lower down.

(ii) There are no inhabited or cultivated areas or grazing lands which the barrage at Chatra would submerge.

(iii) Building materials such as boulders, shingles, sand, etc are available at hand.

(iv) The central workshops, stores, construction camps and other facilities which will be provided at Chatra for the construction of barrage, will all be available for the construction of the dam on account of its proximity to the dam site.

(v) Larger head available for generation of Hydel power.

5.3 GENERAL FEATURES OF THE BARRAGE

5.3.1 At the barrage site, the river is about 976 m (3200 ft) wide and flows in three distinct channels. During the period of low supply the central channel carries about 60% of the total discharge while the eastern and western channels carry about 10% and 30% respectively. A discharge of 19,970 cumecs (7, 05,000 cusecs) had been estimated for the record flood of 1927. For a maximum probable flood of 42475 cumecs (15 lakh cusecs) in the Kosi River, after moderation, a discharge of the order of 14165 cumecs (5 lakh cusecs) is expected to come in the barrage. The stable waterway required for this discharge as given by Lacey's formula:

Pw (ft) = (8/3)√5lakh cusecs works out to 575 m (1886 ft). A length of 969.9 m (3182 ft) is proposed for the barrage to fit in with the topography. This gives a looseness factor of 1.67, which is considered adequate, keeping in view the stable, well-defined and narrow width of the river in the gorge upstream. The plan, cross section of the river at the barrage site and cross section of Chatra Barrage are given in Drawing No.5-2, 5-3 and 5-4.

5.4 REGULATORS

5.4.1 Two head regulators are provided, one on each bank. The capacities of these regulators will depend upon the irrigation and power planning. For purposes of cost estimating the discharges assumed are 1350 cumecs ((47628 cusecs) for each of the two canals.

5.5 POWER CANAL

5.5.1 A power canal is proposed to take off either from East Chatra Canal or Western Chatra Canal Head Regulator. The design discharge for the Power Canal will depend upon the water planning both for Chatra and; Kosi Canals. However, in this report, the capacity of the power canal is assumed as 1000 cumecs. The canal is proposed to be lined. The cross sections of the power canal head regulator, cross regulator for irrigation canal and West Chatra Regulator are given in Drawings No.5-6, 5-7 and 5-8 respectively.

APPENDIX V-I

GROSS COMMAND AREA

G.C.A in lakh ha (lakh ac)

		India	Nepal	Total
I	Western Canal:			
a.	Between Kosi and Kamla	0.37 (0.91)	1.43 (3.53)	1.80 (4.44)
b.	Between Kamla & Bagmati	3.62 (8.94)	1.08 (2.67)	4.70 (11.61)
c.	Between Bagmati and Buri Gandak	4.10 (10.13)	0.45 (1.11)	4.55 (11.24)
Total of West Chatra Canal		8.09 (19.28)	2.96 (7.31)	11.05 (27.29)
II	Eastern Chatra Canal	1.67 (4.12)	2.50* (6.18)	4.17 (10.30)
Total of Chatra Barrage		9.76 (24.10)	5.46 (13.49)	15.22 (37.59)
* This includes 0.9 lakh ha area under existing inundation irrigation.				

CHAPTER –X

WATERSHED MANAGEMENT IN THE CATCHMENT AREA

10.1 PHYSIOGRAPHY

10.1.1 Out of Nepal's total geographical area of about 145 lakh ha, approximately 115 lakh ha comprise hills and high mountains which are generally exposed to concentrated rainfall over four months during monsoon. These areas are characterized by very weak and unstable geological conditions. The entire area is drained by four main rivers, viz, Sarda, Karnali, Narayani and Kosi. The river Kosi has got three main tributaries, namely, Sun Kosi, Arun and Tamur. The Sun Kosi joins from the West, Tamur from the East and the Arun from the North. The High dam is proposed to be constructed at a place near Barahakshetra, which is below the confluence of these three tributaries. Therefore, the entire catchment of the Kosi River needs to be considered for developing integrated soil conservation plan to protect and preserve the High Dam.

10.2 LAND USE

10.2.1 Only a part of the catchment area was covered under a reconnaissance survey in the late 40's and early 50's which, however, do not provide any break up of the area under various land uses. However, based on some rough estimates, it is assessed that abandoned land (culturable waste land) constitutes about 38%. These areas are generally cultivated up and down the slope for a few years before they are abandoned due to loss of productivity. 15% of the area remains snow bound and 6% is estimated to be under alpine pastures at high altitude. About 25% of the total area is estimated to be under cultivation.

10.3 PROBLEM OF FLASH FLOODS, EROSION AND SEDIMENT.

10.3.1 Due to concentrated rainfall during four months, discharges through the rivers and its tributaries vary widely. The flow during the monsoon is about 10 to 12 times the dry season run-off. During the floods discharge can be as high as 1000 times the dry season flow. Floods in the tributaries particularly are flashy and therefore, more hazardous.

10.3.2 The people are basically agriculturists or pastoral and therefore, biotic pressure on the land is heavy. Consequently, its productivity has been steadily declining. The combined effect of unstable geology, high rainfall and population pressure on land is severe erosion and degradation of land resources. The extent of erosion can be estimated from the fact that about 1258 lakh ha of sediments was brought down from Nepal hills by the Kosi River during 1948-59. This would result in deposition of a metre high layer over 1,258 lakh ha. The following types of erosion are commonly observed in the catchment:

(i) Heavy sheet erosion: High intensity rains and faulty land management practices result in heavy erosion and silt load in overland and river flow.

(ii) Extensive gully erosion: Gullies of every possible size up to several 100 m wide with elevation difference sometimes more than 1000 m between the head and its confluence with torrents exist.

(iii) Landslide in hill slopes is very common. In certain locations with specific soil profile conditions, soil creep and slips are also extensively found. Some of these land slides and slips cause deep penetrations into the rock layers and results in discharging considerable mud into the valley.

(iv) Soil erosion due to faulty irrigation channels: Construction of irrigation channels along steep slopes carry significant flood flows because of unregulated supply from the torrents. Such heavy flows in the irrigation channels often cause problems of erosion along steep slopes and formation of gullies. Wherever canals are on the geologically unstable slopes, they result in heavy percolation and over-saturation of the hill slopes making them unstable. This results into landslides.

(v) Alignment and construction of hill roads across the contiguous valley often change the drainage pattern and thus cause flood or water logging. Inadequacy in the cross drainage works and inadequate attention to the stabilization of cut and fill sections often cause over saturation of the slopes resulting in land slides.

10.4 EXTENT OF TRCATABLE AREA

10.4.1 Though the sub catchments of all the three tributaries need to be treated, that of Tamur deserves to receive maximum attention. The erosion problem is far more acute in this sub catchment and it is evident from the large volume of silt flowing through this tributary which also includes boulders. This sub catchment has more population density (though exact figures are available) which has resulted in greater biotic activities and consequent increased land degradation. The sub catchment appears to be entirely within Nepal, which would help in preparing complete plan and implementing the same as thought necessary by H.M.C of Nepal. This, however, does not preclude the need for treating vulnerable watersheds in the other two sub catchments. It is estimated that 75% of the effort as outlined in the programme here under is to be directed to the sub catchment of Tamur while 25% to the selected priority watersheds in the other two sub catchments which could be detected to have high sediment yield potential after proper surveys and investigations.

10.4.2 There has been no systematic information available on the extent of areas under various land use classes which could be considered vulnerable and, therefore, should be treated. However, according to some estimates 75% of the cultivated land and 90% of the abandoned cultivated land is highly erodible ones. From the experience gained in the river valley project catchments in India, areas under very high and high priorities which should be treated within the shortest span of time could vary between 20% and 50% of the total catchment area. The exact extent of areas to be treated can only be obtained after priority surveys, as designed by the All India Soil and Land Use survey are carried out. These surveys could be expedited through the usage of satellite imageries.

10.5 PROGRAMME CONTENTS

10.5.1 The programme should ensure stable base for productive agriculture and horticulture so as to reduce the pressure of population on the land. Considerable part of 'abandoned cultivated lands' thus can be made available for retiring into productive pastures or forest area. The possible strategy for soil conservation should be as follows:

(i) Gullies need to be checked and reclaimed so as to provide some stable productive base and create temporary water resource for diverting available water to the productive lands.

(ii) Land slides and slips will have to be given equal attention with a combination of biological and engineering measures.

(iii) The programme of controlling landslide and land slips will have to be dovetailed with the programme of torrent training with a combination of biological and engineering measures.

(iv) Bench terracing needs to be adopted not only for agriculture but may also be necessary in a different manner for developing large scale orchard for which much of the areas may be suitable. Besides, appropriate run-off disposal and water resource management plan has to be integrated with such a programme.

(v) Horticultural activities may have to be preferred in many situations as, unlike agriculture, no recurrent disturbance to the land surfaces is done in the case of horticultural crops. Rising of plantation crops, particularly ginger, cardamom etc could also be explored.

(vi) The 'abandoned cultivated lands' should be afforested with suitable species providing adequate cover to the land and for meeting the ever-increasing.

(vii) In addition to improving the alpine pastures, some of the 'abandoned cultivated lands' will have to be developed into pasture land as animal husbandry is an established vocation of the hilly region of Nepal. Development of such pastures can also be combined with growing of fodder tree species which may provide firewood and fodder to the community. Both for afforestation as well as pasture development, one of the essential requirements will be protecting such lands against biotic interference during the initial years of their establishment. This will call for closure and controlled grazing. In addition, at certain locations, structures will be necessary for preventing erosion, arresting silt storing excess rain water, etc.

10.6 SUGGESTED PROGRAMME FOR TEN YEARS.

10.6.1 In the absence of any survey giving the areas requiring treatment a tentative programme for treating about 3 lakh ha area constituting about 11% of the total catchment area lying in Nepal has been framed. Out of this 3 lakh ha, 2.25 lakh ha will be in the sub catchment of Tamur and the rest will be in the selected watersheds of other two sub catchments having direct bearing on sediment production into the reservoir at Barahakshetra. The breaks up of different types of works are given below:

<table>
<tr><th>Sl.No</th><th>Work Items</th><th>Area in ha</th><th>Years</th></tr>
<tr><td>1</td><td>Agricultural land-bench terracing, etc</td><td>50,000</td><td>10 years</td></tr>
<tr><td>2</td><td>Development of orchard, plantation crops</td><td>25,000</td><td>10 years</td></tr>
<tr><td>3</td><td>Afforestation/pasture development</td><td>1,50,000</td><td>10 years</td></tr>
<tr><td>4</td><td>Landslides in 110 km length (including Kholas)</td><td rowspan="2">Covers additional area of 75,000 ha</td><td rowspan="2">10 years</td></tr>
<tr><td>5</td><td>Gully plugs/check dams for 14 Kholas only remaining to be worked out after the survey is over.</td></tr>
<tr><td>6</td><td>Survey and categorization</td><td>About 6 lakh ha</td><td>2 years</td></tr>
<tr><td colspan="2">Total</td><td>3,00,000</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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10.7 PROGRAMME APPROACH

10.7.1 A practical approach to ensure steady treatment of the catchment areas with available financial and personnel resources with call decline of the catchments into small watersheds of notional sizes between 2000-4000 ha and fixing the inter-se priorities of these watersheds. This work needs to be carried out in the first two years. In order to ensure that the programme formulation and implementation may start immediately, some of the watersheds will have top be identified with the direct knowledge of the field at the very outset.

10.7.2 The critical/priority watersheds one identified will be taken up for preparation of integrated watershed management plan for all types of lands and associated drainage system. Based on projects so formulated realistic estimates and phasing of physical targets as well as outlays can be provided.

10.7.3 The organizational base will have to be created within the first two years and expanded in subsequent years to create additional capabilities so that the above programme is completed within the stipulated period of ten years. The entire programme implementation, therefore, have to be placed under the charge of a senior expert of the comparable rank of Chief Engineer/Chief Conservator of Forests/Director, Soil conservation. He could be assisted by the Regional officers of the rank of Superintending Engineer/Conservator of Forests/ Jt. Director and each region could be provided with two to three Divisions and each Division with 4-5 Sub divisions. The details of organizational pattern and the requirement of personnel of specific background could be determined at a later stage. However, the organization will have to be multi-disciplinary comprising the personnel of the background of soil and land use survey, agronomy and agrostology, forestry, horticulture and plantation crops, agricultural engineering, conservation economics and statistics and other supporting staff.

10.8 RESEARCH SUPPORT.

10.8.1 The programme formulation will call for utilizing certain norms which have been made available by the research organization. In so far as Himalayan region is concerned, the available information in India could supplement the data/information collected locally for formulation of water shed management plans. However, the research support will be provided by Soil Conservation Research Centre at Chatra in Nepal. In order to make this Centre more useful, it has to be strengthened suitable so that it can carry useful investigations and research programme with a view to provide local input data for further programme formulation suiting to the conditions of Nepal.

10.9 TRAINING

10.9.1 The magnitude of the programme as given under 10.6.1 is quite large. It will call for professionally competent staff in various disciplines at different levels. These professionals will, however, require orientation in integrated planning and coordinated implementation of the programme. This training will enable the professionals to appreciate the role of allied disciplines and mutual dependence in formulation and implementation of integrated programmes of watershed management. Therefore, training programme will have to be prepared for the officers, assistants and sub assistants on a regular basis. For the officers and assistants, facilities available with the ICAR could be utilized. For the sub assistants, training facilities have to be created either at Chatra Centre or elsewhere in Nepal.

10.10 STUDY TOUR

10.10.1The research efforts and field experience gained by the Indian side will be useful to the Nepalese counterparts in examining their own problems and identifying options technical, organizational and financial. It would, therefore, be desirable for Nepalese officers concerned with this programme to visit research institutes and the States where integrated soil conservation programmes are being implemented in India. Indian officers, who would be associated in drawing up the watershed management plan, should also visit Nepal to acquaint themselves with the terrain, technical problems and other allied aspects.

Joint Project Office – Sapta Kosi Sun Kosi Investigation
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Brief Details

of

Sapta Kosi High Dam Multipurpose Project

And

Sun Kosi Storage-cum-Diversion, Nepal

Brief Details of Sapta Kosi High Dam Multipurpose Project And Sun Kosi Storage cum Diversion, Nepal.

The brief details of Sapta Kosi High Dam Multipurpose Project based on Feasibility Report prepared by Central Water Commission, MoWR, GoI in 1981 and brief details of Sun Kosi Storage cum Diversion Scheme based on the Report of Master Plan Study on Kosi River Water Resources Development in Nepal prepared by Japan International Corporation Agency (JICA) in 1985 on the behalf of GoN are given below:

1.0 SAPTA KOSI HIGH DAM MULTIPURPOSE PROJECT

1.1 Sapta Kosi River Basin.

The Sapta Kosi River basin lies between 85^0 and 89^0 east longitude and 25^0-20' and 29^0 north latitude. It is bound on the north by the ridge separating it from the Tsangpo (Brahmaputra), on the south by the Ganges, on the east by ridge separating it form the Mahananda and on the West by the ridge separating it from the Gandak/Burhi Gandak. In Nepal, this river is also called 'Sapta Kosi', deriving its name from the seven streams which unite together above Tribeni to form the main river. The seven tributaries are the Sun Kosi, the Tama Kosi, the Dudh Kosi, the Indrawati, the Likhu, the Arun and the Tamur. The Sapta Kosi River, after it enters India, is known as 'Kosi River.'

Downstream of Tribeni, it flows through a 10 km long narrow gorge before debouching into plain ear Chatra in Nepal. The Sapta Kosi/Kosi River is the third largest Himalayan River. The total length of the Kosi River is about 720 km draining a Catchment Area of 92,538 sq.km in Tibet, Nepal and India upto its confluence with the Ganga at Kursela in Bihar State of India.

The river flows past the historical and sacred temple at Barahkshetra in Nepal and enters into the plains at Chatra, Nepal. At Chatra gorge, the river drains a catchment of about 59,540 sq.km out of which 5700 sq.km is under glaciers. The width of Sapta Kosi River at Chatra, just at the foot; hills is about 900m. It is a perennial river with three main tributaries, the Sun Kosi from the west, the Arun from the North and the Tamur from the East, the three meeting at Tribeni about 5 km upstream of Barahkshetra and form the 'Sapta Kosi River'. The 'Arun river' the longest of the tributaries has cut through a gorge in the great Himalayan range and drains under the name of 'Phung Chu' the entire Tibetan trough from Gassian Than to Kanchan Junga. It drains the highest Himalayan peak, Mt. Everest. The 'Tamur River' drains the second highest peak 'Kanchan Junga' and the 'Sun Kosi River' drains the eastern Kathmandu Valley.

Further down, the river runs in almost flat plains of Nepal Terai for a length of about 50 km from Chatra to Hanuman Nagar. Below Hanuman Nagar, it enters Indian Territory. The Nepal Terai extends practically all along the foot hills and upto the southern boundary of Nepal with India.

1.2 Sapta Kosi High Dam Project:

This project is known as the Sapta Kosi High Dam Multipurpose Project and envisages power generation, irrigation of vast agricultural land both in Nepal and India and flood control. Further, it envisages navigational facility from Sapta Kosi reservoir to Kursela, the confluence of Kosi with Ganga and its integration with Inland Waterway No.1 of India, which extends from Haldia Port in West Bengal to Allahabad in Uttar Pradesh.

The project comprises the construction of a 269 m high dam above foundation rock level across Sapta Kosi river about 1.6 km upstream of Barahkshetra to generate about 16000 million units of electricity with 3000 MW installed capacity at 50% load factor. A barrage of about 1000m length, near Chatra, 8 km downstream of Barahkshetra Dam site and canal system is also envisaged. Besides, three power houses along the power canal taking off from 6.4 km downstream of Eastern head regulator of Chatra barrage with 100 MW installed capacity of each powerhouse are also contemplated.

With the construction of the Sapta Kosi High Dam, there will be regulated discharges throughout the year which can be re-regulated at Chatra. This will not only bring large areas under irrigation both in Nepal & India but also make the present irrigation assured of the water supply for round the year irrigation and thus will encourage double cropping.

The construction of Chatra Barrage would enable diversion of Kosi waters through right and left bank high level canals in Nepal. These canals are expected to serve one of the most fertile land of the terai area in Nepal and plain of north Bihar.

The Kosi High Dam will also trap the bulk of the coarse and medium silt carried by the river and a sizeable portion of fine silt will also get entrapped in the reservoir. This will help in stabilizing the river in Nepal and India and reduce the overflows.

1.3 Water Availability

No gauge and discharge observation is recorded on the Sapta Kosi River prior to 1947. From January, 1947 onwards discharge sites were established, one at the Chatra gorge and one each on the three tributaries and continuous observations were made. Daily discharge at Barahkshetra dam site is available from 1947 till 1978. Beyond this period, Government of Bihar has been maintaining a Gauge site near Barahkshetra and computing the discharge with the help of Stage – Discharge table.

On the basis of the hydrological records covering the period 1947 to 1978, the average annual yield of Sapta Kosi River at Dam site is estimated to be about 51.43 BCM. The minimum annual run-off during this period was about 38.89 BCM. The gross storage at the proposed high dam is approximately 13.45 BCM at FRL +335.25 m. In view of the abundant runoff in the river, the reservoir would be full at the end of the monsoon in 100% of the years making it a very attractive project. The probable maximum flood is approximately estimated at 42,475 Cumecs (15 lakhs cusecs) from frequency analysis on the basis of annual floods during 1948-78. A sediment rate of

1430 cu m/sq.km/year is assessed on the basis of detailed study of observed suspension load in the river from 1948-77 at dam site.

The annual flow at dam site for various dependability based on the flow duration analysis are as given below:

Percentage	**Annual Flow**
25%	57.78 BCM
50%	51.00 BCM
75%	45.73 BCM
90%	42.85 BCM
98%	41.57 BCM

1.4 **Floods**

The highest observed flood in Sapta Kosi River occurred on 5th October, 1968. The water started rising from 3rd October and continued to rise till 5th resulting in a record peak discharge of 25,880 cumecs (9.13 lakh cusecs). Another high flood was observed on 24th August, 1954. The water started rising from the night on 23rd August, 1954 resulting in a peak discharge of 24,235 cumecs (8.55 lakh cusecs). the peak gauge remained constant for a short time and then gradually receded. Due to a lot of scouring of the river bed and under cutting of banks between Barahkshetra and Chatra, the discharge on this site could be roughly estimated. This flood was preceded in July of the same year with magnitude of 19,450 cumecs (6.16 lakhs cusecs). The minimum annual peak of 5420 cumecs (1.91 lakh cusecs) was recorded in 1951. The normal annual peak flood is 10,180 cumecs (3, 59,427 cusecs) from the observed data of 1948-78.

1.5 **Sedimentation**

The Kosi carries enormous quantities of detritus and it has been held that the major cause of the troubles caused by the river is its heavy silt charge. No discharge and sediment data of this river and its tributaries were available prior to 1947. The investigations were first started in 1947 alongwith gauge and discharge observations on a scientific and rational basis were also made and data analyzed. The average annual silt load at dam site is estimated to be in the order of 95.50 MCM. Taking into consideration 15% of bed load, the average annual silt load works out to 109.73 MCM.

1.6 **Dam Type**

Based on the geology and topography of the area, the following two types of dam are proposed to be investigated at proposed dam site.

(a) Rock-fill Dam

(b) Concrete Gravity Dam.

1.7 Dam Power House

Depending on the geological conditions and topography, the following two types of power houses are proposed to be investigated:

(a) Underground Power House

(b) Surface Power House.

1.9 **Salient Features of Sapta Kosi High Dam Multipurpose Project.**

As per feasibility report prepared by Central Water Commission, the salient features of Sapta Kosi High Dam Multipurpose Project are as follows. The project parameters shall be finalised after completion of undergoing detailed study:

1	**LOCATION**	**SAPTA KOSI RIVER**
(a)	Dam	1.6 km upstream of Barahkshetra on Sapta Kosi River in Nepal.
(b)	Barrage	Near Chatra Village, 8 Km. down-stream of Barahakshetra Dam Site. Now changed to Near Sisauli Village, 12 km downstream of Barahakshetra Dam site.
2	**HYDROLOGY**	
(i)	Catchment area at the Dam site	59539 sq.km
(ii)	Mean annual rainfall	158.6 cm
(iii)	Probable Maximum Flood	42475 cumecs (15 lakh cusecs)
(iv)	75% dependable annual yield	45.10 BCM
(v)	90% dependable Annual yield	42.80 BCM
3	**DAM & APPURTENANT WORKS**	
(i)	Type of Dam	Straight Gravity concrete/Rock Fill Dam. Now confirmed as Rockfill Dam
(ii)	Maximum height above rock foundation	269 m (883 ft)
(iii)	Top of dam	EL 342 m (1122 ft)
(iv)	F.R.L	EL 335.25 m (1100 ft)
(v)	M.W.L	EL 338.3 m (1110 ft)
(vi)	M.D.D.L	EL 259.00 m (849.50 ft)
(vii)	Gross Storage	13.45 BCM (10.908 maft)
(viii)	Live storage	9.37 BCM
(ix)	Dead Storage (Storage upto the expected N.Z.E of 100 years at 861 ft)	4.087 BCM
4	**POWER HOUSE**	
(i)	Installed capacity of Dam Power House	3000 MW at 50% Load Factor (6 units of 500 MW each)
(ii)	Installed capacity of Canal Power House	300 MW (3 Power House each having 2 units of 50 MW)
(iii)	Type of Dam Power House Turbine	High speed vertical shaft Francis Turbine.
(iv)	Type of Canal Power House Turbine	Bulb Turbine
(v)	Length of the Power Canal	45 km (28 miles)
(vi)	Drop available at each power house	12.2 m (40 ft) approximate
(vii)	Annual power generation (a) Dam Power House (b) Canal Power House	 15.732 twh 1.875 twh
5	**BARRAGE**	
	Length	969.9 m (3182 ft)

6	**IRRIGATION**	
(i)	G.C.A	15.22 lakh hectares
(ii)	C.C.A	12.17 lakh hectares
(iii)	G.C.A in Nepal	5346 lakh hectares
(iv)	G.C.A in India	9.76 lakh hectares. Now confirmed after detailed study as 10.53 lakh ha.

2.0 SUN KOSI STORAGE CUM DIVERSION SCHEME

2.1 Introduction

Sun Kosi storage cum Diversion Scheme is a multipurpose project having irrigation, hydropower & flood control benefits. The scheme will contribute greatly to the integrated socio-economic development of Nepal by creating a round the year irrigation facility in the eastern terai of Nepal and part of north Bihar.

As lean season flow in the River Kamla is not significant, its discharge have to be augmented to meet the irrigation water requirement in eastern terai of Nepal and part of north Bihar. Keeping these objectives, JICA in its Master Plan Study of Kosi River basin has recommended that lean season flow of river Kamla should be augmented by diverting water from River Sun Kosi through a diversion tunnel by constructing a diversion dam on river Sun Kosi near Kurule and constructing a storage dam on River Kamala near Timnai village. This dam will not only augment natural flow of Kamla River but also store the diverted water from Sun Kosi River and regulate the flow from the dam as per irrigation requirement.

2.2 River System

2.2.1 Sun Kosi River

Sun Kosi River is a major tributary of Sapta Kosi River. It originated in Tibet which flows for 375 km till its confluence with Sapta Kosi at Tribeni in Nepal. The total Catchment area of Sun Kosi upto its confluence at Tribeni is about 18785 sq.km.

2.2.2 Kamla River

Kamala River originates from Mahabharat mountain range, which flows southwards through the Mahabharat and Siwalik ranges for 117 km, and touches the Terai plain near Chisapani. It is almost 2 km wide as soon as it flows through the Chisapani gorge where it is only about 300 m and as it flows south it becomes narrower cutting down into alluvium formation. The river is shallow in its upper reach and overflows the banks at many places during high floods.

The catchment area at the point where it touches the plain is 1550 sq.km. The river is situated between the Bagmati and the Sapta Kosi rivers. It also forms the district boundary between Siraha on the east and Dhanusha on the west in the Terai.

2.3 Salient Features Sun Kosi Storage Cum Diversion Scheme.

The salient features of Sun Kosi Storage cum Diversion Scheme as per JICA Report of 1985 are as follows. Kamala Dam Multipurpose Project is a part of Sun Kosi

Storage cum Diversion Scheme as per JICA's Report. The project parameters shall be finalised after detailed investigation.

(a) **Diversion Dam at River Sun Kosi near Kurule**

Dam type	Concrete gravity
Dam height	48.9 m

(b) **Diversion Tunnel**

Length	16.6 km now realigned for 22.35 km.
Design Discharge	72m^3/s

(c) **Diversion Power Station**

Maximum discharge	72 m^3/s
Head	102.5 m
Maximum power	61.4 MW
Generated energy	511 GWh

(d) **Kamala Dam and Reservoir**

C.A	1,450 km^2
HWL	EL 178 m
LWL	EL 163 m
Gross Storage	713 million cu.m
Live storage	493 million cu.m
Dam type	Gravity fill
Dam height	51.0 m

(e) **Kamala Dam Power Station**

Maximum Discharge	120 m^3/s
Head	32 m
Maximum power	32 MW

(f) **Irrigation Development in Terai Area**

(i) **Chisapani Barrage** Height 3 m (Now changed to Uttarayani Barrage with height 13 m)

	Length	300 m

(ii) **Main Canal**	Length	Design Discharge
Right bank	78.4 km	135 m^3/s
Left bank	74.1 km	84 m^3/s

(iii) **G.C.A in Terai Area of Nepal**

1,75,000 hectares.