INCEPTION REPORT
FOR
JOINT INVESTIGATIONS/STUDIES
ON
SAPTA KOSI HIGH DAM MULTIPURPOSE PROJECT
AND
SUNKOSI STORAGE CUM DIVERSION SCHEME

October 2001
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I. BACKGROUND AND OBJECTIVES OF THE STUDY

Based on the understanding reached during the visit of the Rt. Honorable Prime Minister of Nepal to India in December 1991, a Joint Team of Experts (JTE) was constituted to finalize the modalities of investigations and the methods of assessment of benefits for joint studies/investigations of the Sapta Koshi High Dam Multipurpose Project (SKHDM). At the first meeting of the JTE convened in Kathmandu in February 1992, it was agreed that the project should be investigated and studied to meet the following objectives in terms of fulfilling the requirements of both countries from its development:

- Hydropower Generation
- Irrigation Development
- Flood Control/Management

In the meeting the following were also agreed:

- SKHDM would be studied in such a way that other water resources projects in the upstream reach of the Koshi Basin are not adversely affected.
- An Inception Report was to be prepared by Nepal and to be finalized by the JTE.

Consequently, the Inception Report prepared by Nepal was sent to the Government of India (GOI) in November 1992.

During the visit of the Rt. Honorable Prime Minister of India to Nepal in October, 1992, in a joint communique, it was further agreed to investigate and study the aspects of navigation through the River Kosi.

The GOI's comment on the Inception Report prepared by the Nepalese side was received by Nepalese side on September 26, 1993.
During the visit of Hon'ble V.C. Shukla, Minister for Parliamentary Affairs and Water Resources to Nepal in December, 1993 it was agreed that while preparing the Detailed Project Report (DPR) of the projects considered for joint study:

- Water requirements of Nepal shall be given prime consideration.
- Project benefits such as irrigation, flood control, power and navigation, where possible, shall be assessed.

A Revised Inception Report was thus prepared incorporating the above aspects and the issues expressed in the GOI comments on the First Draft Report including Indian Feasibility Report of 1981. The First Draft of the Revised Inception Report was then sent to the GOI in August 1994.

The Second Meeting of JTE was held in Kathmandu on 7-9 January 1997 where the Revised Inception Report was thoroughly discussed and issues related to the detailed studies of Sunkosi Storage cum Diversion Scheme at Kurule and navigation studies from Sapta Kosi to be carried out concurrently with the Sapta Kosi High Dam were agreed. The Inception Report was again discussed by the JTE at its 3rd Meeting at New Delhi on March 21-23, 2001.

The Inception Report was further discussed and finalized at the Fourth Meeting of the JTE held at Kathmandu from 12-13 October 2001.
II. DAM PLANNING

Dam Planning is an important component of the river basin development planning and, hence, needs to be done in a comprehensive manner.

In 1981 the Indian side prepared a feasibility study report considering a high dam at Barahchhetra based upon the geological investigation that had already been conducted in 1946/47. A 269 metres high dam with a total gross reservoir volume of 13,450 million cubic metres has been proposed near Barahchhetra.

The Indian report also refers to three dams on the main tributaries (Sun Kosi, Tamur and Arun) for which only reconnaissance surveys had been done earlier and a favourable dam site on the Sun-Kosi River near Kurule has been identified.

Kosi High Dam planning should not preclude the development possibilities of other important schemes in Kosi tributaries that are listed as top priority projects for development in Nepal. In this context, an extremely important scheme, identified a long time ago by UNDP/FAO and JICA, to divert Sun Kosi water for the irrigation of large part of the Central and the Eastern Terai, Nepal, was mentioned as top priority scheme.

In the second meeting of JTE held at Kathmandu, it was agreed that this scheme should also be investigated and studied concurrently with the Kosi High Dam. Both the Sapta Kosi and Sunkosi Storage Projects shall be studied together and the Projects shall be optimized in relation to each other while preparing the Detailed Project Report.

The Sunkosi Storage cum Diversion Scheme (SSDS) could be planned to benefit even North Bihar by way of bringing under irrigation those areas in North Bihar, which are on the north of the Kosi Western Canal.
III. KEY ISSUES

Although the Himalayan rivers of Nepal are able to provide enormous quantum of sustainable water, most of the irrigation systems so far developed in Nepal are runoff type and receive water from the rainfed rivers. To feed the ever growing population, the need to increase the agricultural production through year-round irrigation water supply for multiple cropping of the limited land has become the utmost priority and, thus, key issue for Nepal. The Terai area, east from Birgunj to the west of Kosi river can, receive dependable year-round irrigation water supply only by diversion of flow from the tributaries of Kosi River, namely, Sun Kosi and not from the Sapta Kosi alone as proposed by India. As the areas can only be irrigated through the diversion of Sun Kosi river, the Sun Kosi Diversion Scheme looms high in the priority. So, field investigation and feasibility study must be conducted in a manner, which could embrace both these schemes.

Another important element to be included in the study is the development of inland waterways. Recently India has begun to take keen interest in developing Inland Water Transport (IWT) and is currently trying to restore large-scale navigation on Ganges River. The Kosi Waterways connecting Chatarra with the seaport has the potential to increase economic activities and pave ground for rapid industrialization in Northern Bihar and Nepal. Hence, detailed engineering planning for the development of Kosi Inland Waterways should be linked with India's National Waterway No.1 connecting Allahabad with Haldia. Such waterways study should also include an economic study.

An important issue to be addressed in the study is Flood and Sediment Control. The GOI 1981 Report has clearly described the flood problems of Kosi River and the extent of widespread damages that could engulf an area extending at least up to Mahananda River on the east and possibly Gandak River mouth on the west. The same report mentions that Sir. C.C. Inglis, then Director of Poona Research Station had identified as early as 1941 the Kosi flood problems as being due to excess charge of the sand that Kosi waterways carry. Only a big storage dam can adequately control Kosi sediments. But, instead of a storage dam, embankments were provided for Kosi flood control. Mr. K.L. Rao, on whose idea the site was shifted to Barrage at Hanumannagar and Kosi flood control embankments were built (according to the GOI 1981 Report) writes in his book (India's Water Wealth) "The Kosi carries heavy silt and in a few years, it may be that the existing construction (embankments) may not prove adequate. Further measures such as detention basins will have to be taken up". The Kosi high Dam Scheme is important because only such schemes can provide lasting relief to the people living in vast tracts of land in north Bihar against recurrence of past flood disasters. If the various benefits including the benefit of flood control, which is so large in this case, is not accounted for, the comparative attractiveness of this project shall be lost. Also it will not be possible to justify the project from investment point of view and it will lose its edge over several other projects of high dam nature.
IV. BENEFITS AND METHODOLOGY FOR ASSESSMENT

The multipurpose benefits of large storage projects implemented in Nepal extend beyond its boundary, while losses associated with submergence and others remain within its territory only. Therefore, while conducting the study of the benefits and losses in specific locations, scale and type need to be identified and assessed in a transparent manner so that the basis for analysis of cost and losses would be ready before proceeding with further arrangements towards implementation of the project.

The major components of benefits to Nepal and India to be evaluated in the project study include:

- Power Benefits
- Irrigation Benefits
- Flood Control Benefits
- Navigation Benefits

The assessment of losses due to submergence and other reasons should be included in the Socio-economic and environmental study of the projects.

**Power Benefits:**

The Kosi High Dam Scheme and the Sun Kosi Storage-cum-Diversion Scheme are large storage projects. Power generation from these projects must be planned for meeting the power demand of both India and Nepal.

The power system of both Nepal and Northern and Eastern power region of India will be the basis for evaluation of power benefits. The power benefits for both Nepal and India will be determined in accordance with norms agreed for other India-Nepal Multipurpose Projects. Net power benefits shall be assessed on the basis of, inter alia, saving in costs to the beneficiaries as compared with relevant alternatives available. Additional transmission and interconnection costs required for evacuation of power, will be included while assessing the power benefits from the Sapta Kosi and Sun Kosi Projects.

**Irrigation Benefits:**

The potential irrigation benefits to both India and Nepal from the development include benefits accruing from incremental production resulting from augmented flows in existing irrigation systems and irrigation benefits accruing from the development of new irrigation water supply systems to cover additional areas.
The benefit evaluation methodology will address mainly the incremental net benefits from existing irrigation schemes and development of new irrigation schemes in both Countries. For evaluation of these benefits, the following analysis, but not limited to, will be required:

i. Estimation of irrigation water requirements for individual crops;

ii. Estimation of costs and benefits of new irrigation systems envisaged for use of surplus regulated flow;

iii. Estimation of differential economic benefits between existing and new cropping patterns;

iv. Calculation of present value of the net irrigation benefits, separately for existing and new systems.

**Flood Control Benefits:**

Potential flood control benefits to both Nepal and India depend on the size of the reservoir that will be created and result mainly from avoidance or reduction of flood losses. Such flood control benefits shall be assessed on the basis of the value of works saved and damages avoided.

**Navigation Benefits:**

Development of an inland river navigation scheme will provide the following potential benefits;

i. Access to Haldia seaport;

ii. Reduced transport for moving freight to and from Nepal;

iii. Reduced transport costs moving to cities within India;


The methodology for valuing these benefits will include an analysis of passenger/goods traffic costs, options and demand with and without the project. The study shall include:

i. Detailed feasibility study for developing inland navigation from Chatara up to the confluence of the Kosi River with the Ganges River using natural course of the Kosi River and also a navigation canal that might be used concurrently for irrigation and power generation. The economic study of the waterways shall also include India’s national inland waterway No. 1 extending from Allahabad to Haldia seaport.

ii. Assessment of the water requirements for development of IWT.
V.  **SCOPE OF WORKS**

The following scope of works lay out the areas to be covered for each of the various field investigation and analytical studies for both the SKHDMP and SSDS including the navigation aspects. The scope of works in this study for the preparation of DPR would include, in general, the following, but will not be limited to:

**Topographical Surveys and Mapping**

- Dam sites (SSDS and SKHDMP) and power houses sites in scale 1:1,000.
- Reservoir areas in scale 1:10,000.
- Areas to be irrigated by the projects in scale 1:10,000.
- Other major structural components of the projects in scale 1:1,000.
- L-Section and X-Section of the river from Barahkchhetra to Kursela.
- Office and residential colony area for the projects.

**Geological and Geotechnical Investigation**

- Increase the level of geotechnical information at both SKHDMP and SSDS sites;
- Carry out geological mapping of the project area.
- Carry out geological investigation as may be required and appropriate to the determination of technical feasibility of these projects and design of specific structures at the feasibility level;
- Conduct core drilling and seismic refraction survey as required at the dam and powerhouse sites of both projects, along the tunnel alignment and borrow areas;
- Identify and investigate geological hazards to the proposed works such as faults, areas of slope instability, weak joint systems and areas subject to liquefaction during seismic events;
- Conduct test aditing for assessment of rock conditions in the dam abutments, tunnel portal area and powerhouse sites as well as rock mechanics test in-situ and in the laboratory.
• Detailed Geological and Geotechnical Investigation would be carried out keeping in view the various options of dams namely Earth and Rockfill dam, Concrete Gravity Dam, R.C.C. dam etc.

**Construction Material Studies**

• Determine quantity and quality of available aggregates. Particular attention should be paid to the strength and chemical stability of the coarse aggregate.

• Determine quantity and characteristic of rockfill, pervious and impervious fill material for the dams, the cofferdams and other use. Determine the gradation, plasticity and compaction characteristics. Specify the borrow areas from which these materials would be obtained and the processing requirements.

• Determine availability and characteristics of the pervious fill for cofferdams and miscellaneous use.

• Locate sand quarry and assess the quality and suitability of material required for the project.

**Seismology Studies**

• Review the pertinent and available geological and seismological data.

• Determine the seismic exposure of the projects.

• Recommend the seismic design parameters for the various elements of the projects.

• Set up a series of seismic stations to locate active faults.

**Hydrology Studies**

• Setup hydrological and meteorological stations at the required sites and collect relevant data.

• Update and carry out a consistency analysis of available data.

• Define Probable Maximum Precipitation (PMP).

• Carry out a Long Term Flow Analysis to determine firm flows, mean monthly flows and flood flows of 100, 1,000 and 10,000 year return periods, and the Probable Maximum Flood (PMF).

• Confirm stage discharge relationships on a routine basis.
• Generate extended mean monthly and analyze dry flow series for power, irrigation and navigation requirements.

• Study evaporation and evapotranspiration using different techniques.

• Collect data and analyze potential GLOF hazards in the basins.

• Collect data for high elevation areas using non-traditional techniques such as remote sensing.

• Revised elevation-area-capacity curves expected after 50 years and 100 years to be prepared.

**Sedimentation Studies**

• Review the sediment transport data currently available in India and Nepal.

• Set up sediment sampling stations of the required sites and collect data on a continuous basis.

• Estimate the volumes and characteristics of the transported and accumulated materials in the reservoir.

• Carry out regional geomorphological studies to determine the erosion sources of the transported materials in the basins.

**Water Balance Studies**

• Carry out water balance studies for SKHDMP and SSDS.

• Carry out reservoir simulation for both projects to determine monthly distribution of water for the following:
  - Power generation
  - Irrigation water demand
  - Pre-release for flood control
  - Navigation

These are studied under following conditions:

- Various reservoir levels
- Long term average flow conditions
- Low annual run off conditions
- High annual run off conditions
- Various rate of sediment flow in reservoir
Power System Studies

- Review power market in Nepal and Northern & Eastern Power Regions of India.
- Review the seasonal variation of energy and capacity demand and the ability of the two power systems to meet the energy and capacity demand.
- Review the system load curves and load forecast for Northern & Eastern Power Region of India and Nepal.
- Examine the existing and planned additions and alternative supply option in Northern & Eastern Power Region of India and Nepal. Establish the capital and operating costs for the alternative generation options.
- Provide a reference scenario for India and Nepal. Determine the Long Run Average Marginal Cost for serving the load.
- Determine various modes of operation for the generation units within the systems of Northern and Eastern Power Regions of India and of Nepal.
- Describe the selected mode of operation
  - Capacity and energy available for each month of the year.
  - Scheduling of unit maintenance, duration, capacity and energy available in those months.
  - Secondary generation policy when the reservoir is at or near full level.
  - Non-power consideration, which requires potential water releases from the reservoir such as for irrigation and navigation and to provide storage volume for flood control.
- Determine power (capacity and energy) benefits for project optimization
  - Power benefits for various reservoir sizes.
  - Power benefits compared with relevant alternatives available.
  - Power benefits under alternate load forecasts.
  - Power benefits with different discount rates.
- Power facilities design
  - Determine the optimum size and number of generation units taking into account the optimal installed capacity, transportation constraint and manufacturing capability. The power system studies and absorption
capability studies of the system shall also be carried out to ensure that the installed capacity matches with the system demand.
- Determine the station control and powerhouse substation.
- Carry out the preliminary electrical and mechanical designs for the power plant facilities.

- Power Evacuation
  - Carry out load flow and system studies.
  - Determine transmission requirements to transmit power to the load centres in Nepal and Northern & Eastern India.
  - Determine substation requirements.

**Flood Control Studies**

- Determine the damages from the floods based on the value of works saved and damages avoided
- Determine design flood to be routed through the reservoirs.
- Determine spillway capacity and outflow from the reservoirs.
- Determine the modifications that can be made to downstream flood conveyance channels.

**Irrigation Studies**

- Review Nepal's existing planned and potential for irrigation development in Central and Eastern Development Regions and India's existing, planned and potential for irrigation development in Bihar.
- Assess the surface water availability for irrigation from the existing diversion points and the potential for diversions from the SKHMP and the SSDS to augment the shortages and to provide for expansion of the developed systems for year round irrigation water supply in Nepal Terai extending from Birgunj to the east of Kosi River to the extent possible and adjoining region in India in the south.
- Carry out water balance studies to provide initial estimates of ultimate water resources potential for irrigation development
- Establish the limit to irrigation development imposed by water availability.
- Determine the irrigation benefits, in existing and new command areas.
• Determine the costs required for developing the diversion tunnels and irrigation canals for new irrigation systems.

• Carry out studies relating to drainage in the command area for suggesting appropriate measures, if required.

• Development of irrigation distribution network

• Carry out detailed soil survey of the command area for planning the cropping pattern and determining the susceptibility of soil intensification considering constraint imposed by drainage problems.

Navigation Studies

• Review India's plan for large-scale navigation in the Ganges River (including Bhagirathi and Hooghly) and the future potential for navigation in the Kosi River.

• Determine the improvement to the navigability of the river channel through regularization of the flow, channel stability and other measures. Plan a separate canal for navigation that might also be used for irrigation and power generation and assess the economic viability of these two alternatives and also compare with other alternative modes of transportation.

• Determine the existing road and rail traffics movement and estimates the cost of goods movement by these modes of transport.

• Estimate the future traffic movement and the tonnage that might be appropriate for river vessel movements. Determine the navigation cost of these goods traffic.

• Estimate the potential future benefits from inland river navigation.

• Determine the infrastructure required to develop navigation on the Kosi River and navigation canal including their costs.

• Carry out all other relevant economic studies of inland navigation from Chatara up to the confluence of the Kosi River with Ganges River.

• Determine the flow requirement that will be required for maintaining navigation depths in the Kosi River or navigation canal from Chatara up to confluence of the Kosi River with the Ganges River.

• Carry out economic study of India's national waterway No.1 extending from Allahabad to Haldia seaport.
Project Optimization

The potential development scenario to be considered for optimization of the SKHDMP with the SSDS with guaranteed year-round irrigation water supply in Nepal Terai and keeping in view India's requirements.

Optimization of Development

In a multipurpose project, the primary objective is the optimal development of the project so as to maximize the net benefit from the project from various project components. The SKHDMP along with the SSDS should be designed to serve a number of basic purposes. They are as follows:

- Power Generation
- Irrigation
- Flood control
- Navigation

Interdependence of the various objectives affects the optimization of the project. A key factor in multipurpose project optimization is determining the interrelationship and finally achieving compromise. The success in achieving joint use of storage capacity depends upon the extent the various purposes are compatible. It is helpful to review the requirement of the various uses and to consider the ways in which these uses may be coordinated.

Power Generation: Electric power generation will have a marked variation as per the seasonal and daily water availability. The water passed through turbines can be used for irrigation and navigation. The installed capacity and power requirements from these projects would be based upon the optimization studies and the power system studies including power absorption studies. This may necessitate a reservoir and a reregulating dam downstream of the main dam in order to allow more regular flow for downstream irrigation and/or navigation uses.

Irrigation: Water requirements for irrigation are usually seasonal with the heavy demands occurring during the time of plantation, and flowering and during failure of monsoons as well as during the dry season. Water requirements do not vary greatly from year to year although in low rainfall years the demand for irrigation water is generally higher.

Navigation: Reservoirs designed to provide flow for downstream navigation will require water releases during the dry period. Water released for navigation cannot be used for irrigation as the water is required to maintain adequate water depth in the river channel.
**Flood:** The basic requirement for flood control is sufficient empty space in the reservoir during monsoon season so as to permit holding back expected flood water during the flood season and/or regulation of water storage in the reservoirs.

**Optimization of Project Components**

The essential facts of the project optimization are as follows:

- Dam height
- Full supply level
- Reservoir drawdown
- Installed generating capacity/monthly firm energy generation
- Spillway capacity
- Irrigation command area
- Reserve storage capacity for flood
- Navigation release
- Minimum water release
- Reregulation dam
- Dead storage

To optimize various aspects, it will be necessary to develop the costs and the benefits for the different project alternatives. Cost and benefit curves can be determined for the project components and the overall project. From the cost and benefit curves, the sizing of the individual components will be based on the marginal costs and marginal benefits. The individual components of the project will be at an optimum when the marginal benefits for that component are equal to the marginal costs. The height of the dam is the main component to be optimized taking into consideration dead, live and flood storage.

Irrigation, power and navigation benefits are a function of the firm seasonal water yield, which is available from the reservoir. This yield depends on the hydrology, as well as on the degree of river regulation, which can be obtained with varying amounts of live storage at Sapta Kosi, Sun Kosi and other potential upstream storage projects. Due to the high rate of sedimentation, the amount of live storage will decrease over time as the sediment encroaches on this volume, long before it fills the dead storage volume. An engineering estimate of the live storage loss rate through the economic life of the project will be used to account for this effect in the economic analysis.

Maximization of low flow augmentation benefits depends on the monthly release pattern throughout the year. Water releases could be:

- According to irrigation demand;
- According to the seasonal power demand pattern;
- According to the daily power demand;
According to navigation requirements;

- Composites, which smooth out differing seasonal peak requirements; and compromises between irrigation, navigation and power demands.

Optimization of the dam height will begin by calculating the firm seasonal water yield from the reservoir as a function of dam height. For each dam height, firm seasonal water yield from the reservoir will be determined as the flows available each month at an appropriate level of acceptable hydrological risk for each water release pattern, based on the period of hydrological record. For each firm seasonal water yield and water release pattern, the value of the benefits due to low flow augmentation will be estimated. For the purpose of benefit evaluation, estimates of average benefit per unit of firm seasonal water yield will be used to derive the total annual low flow augmentation benefits. This is an approximation as it depends on the value and the quantity of the flow to each of the uses.

As the live storage volume declines due to the effects of sedimentation, the benefits will decrease. It is necessary, therefore, to calculate the Present Value (PV) of low flow augmentation benefits as a function of dam height for comparison with the PV of costs for each dam height, taking into account the loss of live storage and the influence of upstream storage projects on flow regulation. The optimum dam height will then be determined as the height for which marginal capital cost equals the marginal PV of benefits or the long run marginal benefit.

Finally, the influence of other upstream projects will be examined for any significant impact on optimum dam height. Upstream storage would provide additional regulation and, therefore, firm flow and flood control benefits as well as providing more sediment storage, which would prolong the life of live storage at Sapta Kosi. The impact of upstream developments can be found without reference to specific heights by carrying out a sensitivity analysis using a range of values for live storage and sediment trap efficiency. Optimum dam height would remain unchanged if the total net benefit curve as a function of dam height moves upward with no lateral displacement, for reasonable combinations of upstream project parameters.

**Flood Storage**

The optimum level of flood control benefits will be determined by the optimum dam height, which determines jointly the low flow augmentation and flood control benefits. Adequate flood cushion shall also be provided, if required, while optimizing the dam height. Incremental benefits from the provision of flood cushion shall be taken into account.
**Power**

Firm energy depends on live storage and minimum net available head, which in turn depend on dam height and maximum permissible drawdown. Maximum permissible drawdown depends upon the operating characteristics of the turbine best suited for the range of available heads in the range of the reservoir selected. In determining power and energy output it should be realized that the average cost of energy produced is lowest when it is equal to the marginal cost of increasing the output.

The operating constraints, which relate to the possible development scenarios, are:

i. Fill interconnection with two-way power exchanges;

ii. One-way sale, with sales to India ranging from 100 percent of total output to a portion of total output, with the balance being taken by Nepal.

In the latter case, the allocation to each partner would need to be in accordance with some agreed criterion such as optimization at the point where the long run marginal cost for power system development in Nepal would equal the long run marginal cost in India. As noted previously, this criterion would no doubt be the subject of negotiation between Nepal and India, and it may thus be necessary to consider several alternative criteria. The preference of each party may not be identified until the outcomes of several assumed criteria are available for study by them. Guidance from the Joint Team of Experts (JTE) will be required early in the study to formulate the alternative criteria to be considered initially.

The power system planning analysis will seek to minimize total PV costs for Nepal and India, for each of the above scenarios under the following conditions:

i. Nepal by itself without project case,

ii. Northern and Eastern Indian grid by itself without project case and,

iii. The two systems interconnected with varying portions of energy from the SKHDMAP and the SSDS taken by each country.

A detailed analysis must be carried out to simulate the optimum power system development in each country based on detailed data concerning:

i. Existing and future generating facilities, their capacities, operating costs, etc;

ii. Existing transmission facilities and expansion plans;

iii. Historical and forecast demand by category and load centre;

iv. Load duration characteristics, historical and forecast;

v. Plant retirement schedules.
Irrigation

Irrigation development will be considered up to the level corresponding to maximum available water in the critical season, depending upon water requirements and the water release pattern chosen. Optimization of irrigation will be done as a subsystem up to the constraint of either available land or available water.

While carrying out optimization studies for power it will be ensured that release pattern from Sapta Kosi and Sunkosi dams is such that the existing irrigation requirements and other requirements of both the countries, not exceeding the average natural flow of the river, are fully protected.

Navigation

The inclusion of navigation in the project optimization would be done by calculating the benefits from navigation based on potential traffic and the infrastructure and operating costs for moving it by road or rail.

Reregulating Dam

The optimum degree of reregulating will depend upon the following factors:

i. Ability of the irrigation off-takes to capture water;

ii. Navigation requirements;

iii. Safety considerations along the river banks and waterways as a function of daily flow fluctuations in water levels and currents;

iv. Installed capacity and optimum requirements for power and energy in the power systems.

v. Environmental requirements

Item (i) and (ii) depend upon the marginal costs of increasing the degree of reregulation and the marginal benefits to be derived. The degree of reregulation will be optimum when total marginal benefits equal total marginal costs. Item (iii) depends upon the extent of influence downstream and the degree of risk. Reregulating dam cost will be treated as a component of cost of the project.

Overall project optimization

The optimization for the various project components will be done so that the marginal benefits of the components are equal to the marginal costs. The overall objective is for the maximization of the NPV of the project. As there is an
interdependence of the various project components, the optimum project may not be realized under the various sub system optimization. This difficulty can be addressed by way of simulation.

The overall optimization of the project will be done using a simulation model. The model will represent the physical functioning of the project under various conditions and will estimate the resulting economic effects for the project. The model would be operated under different scenarios, such as dam heights, load forecasts, hydrology conditions, irrigation and flood control requirements and the economic benefits calculated.

The project setup which provides the largest NPV would be the optimum project to be developed. There may be constraints to the development of the optimum project, however the model would provide an indication of the best project for development.

**Designs of SKHDMP and SSDS**

- Carry out designs required for DPR and analysis of the projects for the following:

  1. Civil Works
     - Dams
     - Tunnels
     - Spillways
     - Diversion and Outlet Facilities
     - Powerhouses
     - Reregulating Facilities
     - Irrigation Canals
     - Diversions
     - Navigation Channel including structures like locks & others
     - Access Road
     - Temporary Facilities

  2. Electro-Mechanical Equipment
     - Generators and Turbines
     - Penstocks, Gates and Valves
     - Station and Service Equipment
     - Area Lighting and Services
     - Communication and Control Systems
     - Emergency Power Sources
     - Transmissions and Sub-stations
Environmental Impact Assessment Study

An Environmental Impact Assessment (EIA) will be performed in accordance with Environmental Protection Act, 2053 and Environmental Protection Regulation, 2054 of Nepal for both projects including latest amendments. For EIA studies of the components of the projects falling within Indian territory, relevant Indian Environmental Protection Acts and Regulations will be applicable.

Construction Planning for SKHDMP and SSDS

- Prepare contractor's plan of construction for both projects taking into account the quantities and the relationship of the various project components.

- The following should be included in the construction plans:
  - Mobilization & demobilization
  - Temporary roads, bridges and other infrastructures
  - Permanent roads
  - Logistics, Construction Power
  - Required equipment
  - Required manpower, Skills
  - Origin of needed resources (labour and materials)
  - Starting and completion of major project components
  - Manufacturing, delivery and installation of electro-mechanical equipment
  - Commissioning & testing of electro-mechanical equipment
  - Commercial operation and commencement of generation
  - River diversion
  - Environmental requirement

Cost Estimates

- Prepare preliminary capital and operating costs for both projects for the various alternatives to allow for project optimization.

- Prepare capital cost estimates for:
  - Dams and spillways
  - Powerhouse facilities
  - Transmission and substation facilities
  - Regulating facilities
  - Flood control facilities
  - Diversion structures, tunnels, penstocks, surge tank and irrigation canals
  - Navigation infrastructure and improvement works
Prepare operating cost estimates for:

- Dams and associated facilities
- Power houses, transmission and substation facilities
- Reregulating facilities
- Flood control facilities
- Diversion structures, tunnels, penstocks, surge tank and irrigation canals
- Navigation infrastructure and improvement works
- Tailrace structure
- Environmental requirements

Provide breakdown of costs by

- Needed resource (labour, material)
- Code of accounts (charged to appropriate benefit, recipient, power, irrigation, flood control, navigation, overall joint costs)
- Excluding duties and taxes
- Disbursement schedule
- Excluding IDC
- Environmental requirements

Project Evaluation for SKHDM and SSDS

A. Economic Analysis:

- Determine benefits resulting from the project based on methodology described in section IV.
  
  - Power benefits
  - Irrigation benefits
  - Flood control benefits
  - Navigation benefits.

- Determine all costs for the project
  
  - Construction costs
  - Operating and maintenance for various components
  - Interim replacements
  - Environmental costs
- Costs are to be broken up into local and foreign.

- Costs are to be free of duties and taxes, however, these figures should be calculated for the financial analysis.

- Prepare a cash flow for the project indicating the disbursements for the project.

- Determine
  - The Net Present Value for the optimum project, any feasible alternatives, and under the various sensitivities considered.
  - The Benefit/Cost ratio for the optimum project, any feasible alternatives, and under the various sensitivities considered.
  - Economical Internal Rate of Return.

B. Financial Analysis

- Carry out a financial analysis for the project to determine
  - The financial requirements for the project
  - A financing plan for the project
  - The charges and or contributions to be levied for the various benefits

- The financial analysis should also examine financing and revenue requirements and the impact of:
  - Export and import taxes
  - Royalties
  - Income taxes

- Determine NPV, B/C ratio and FIRR for the optimum project size under various sensitivities.
VI. BASIS FOR COST EVALUATION

Base Year Cost Estimates

All costs shall be based on the year of completion of Detail Project Report, price levels without inflation, duties, taxes and/or subsidies.

Inflation

All financial costs and prices will be adjusted for inflation up to the year of completion of Detail Project Report. All costs and prices over the project life will be evaluated in constant price levels.

Fiscal Parameters and Transfer Payments

Fiscal parameters including duties, taxes and subsidies shall not be included in the economic evaluation as they are direct transfer payments, which do not reflect changes in national income. Similarly interest during construction (IDC) shall not be included in the economic evaluation.

International Costs

The costs of materials, supplies and equipment imported from outside both Nepal and India shall be based on quality adjusted international market prices at Calcutta plus transport costs to the project site.

Nepal/India Supplied Costs

The costs of materials, equipment and supplies from Nepal and India shall be based on local prices and non-traded items and labour, and on international prices on items for which imports are a practical and economic option.

Shadow prices for Unskilled Labour

Shadow prices for unskilled labour may vary between the dry and wet seasons. For project evaluation purposes the shadow price(s) for unskilled labour for Nepal and India will be obtained from the World Bank project evaluation report for Nepal and India respectively.

Standard Conversion Factors for Local Costs

To account for local economic discrepancies, local Nepalese and Indian costs for non-traded items will be adjusted by a standard conversion factor (SCF). The SCF for Nepal and India will be based on current practice by the World Bank for project evaluation in the two countries. The SCF will also be applied to benefits accruing from the project.
Foreign Exchange Rates

For evaluation purposes all economic costs and benefits will be estimated in US $ at the official exchange rates which exist at the start date of the project feasibility report.

Upon submission of the draft final report an analysis of the devaluation of the Nepalese and Indian currencies vis-à-vis the US dollar will be made to determine whether there are large discrepancies between the change in exchange rates and local cost inflation during the study period. If large discrepancies are noted, then the costs will be recalculated for the final report using the exchange rate that exist on the date of submission of the draft final report.

Construction Costs

Construction costs will be calculated in the currency of source. This includes Nepalese Rupees for all costs utilizing Nepalese inputs, Indian Rupees for all costs utilizing Indian inputs, and US dollars for input costs imported from outside both Nepal and India. All costs shall be calculated in economic terms using the proper conversion factors or shadow pricing ratios.

Once economic costs for all construction costs have been determined they will be converted to US$ estimates by applying the accepted exchange rate for conversion.

Operating and Maintenance Cost

Operation and maintenance costs (O & M costs) include routine O & M costs, interim replacement costs, insurance costs and owner's overhead.

Monitoring and Evaluation Cost

Monitoring and evaluation costs are assumed to be covered under owner's overhead in operation and maintenance costs. Hence, monitoring and evaluation costs shall be included under operation and maintenance costs for the project.

Environmental Mitigation Cost

Environmental mitigation cost will be the cost required to mitigate impacts due to construction and operation of the projects. These will be determined in accordance with the prevailing laws of Nepal and India for the project components in their respective territories.
VII. ECONOMIC CRITERIA

Time Value of Money

Costs and benefits of projects accrue over a period of years and include both capital investment and recurrent costs. Their monetary values cannot be used directly without taking into account the time value of money.

In this study the time value of money is equated to the opportunity of capital discount rate which is the minimum rate of return on capital which must be achieved by development projects based on the next best alternative use of the capital. All project cost and benefits will be discounted to the present value reference date using the opportunity cost of capital discount rate. The opportunity cost of capital to be used for analytic purpose will be equated to the discount rate currently used in World Bank Project Appraisals for the Indian Sub-continent and Nepal, which are currently 10%.

Project Life and Present Value Reference Date

For evaluation purposes the project life will be equated to the economic life of the project while recognizing that in fact the physical project lifetime will be longer. For purposes of standardization of feasibility studies for large-scale multipurpose projects, the economic life of the project will be set equal to that used for other similar projects. An economic life of 50 years is assumed for the project.

The present value reference date (PVRD) is the common date selected to discount all project benefits and costs to. For evaluation purposes the present value reference date is to be that year in which the feasibility study report is prepared. The B/C ratio is not affected by the present value reference date because both benefits and costs change by the same ratio. However, given the long lead times and construction period between project feasibility and commissioning the total discounted costs and benefits can be affected significantly by the choice of the PVRD. The selection of the commissioning date for the PVRD results in a calculated value of project costs, which is an acceptable approximation of actual in-service costs.

Criteria for Project Benefit Evaluation

The basic criteria for determining the optimum project size are to maximize the total discounted net benefits of the project. However, the development of the SKHDM and SSDS is contingent upon various criteria rather than straight project-specific optimization, the other criteria include:
Development strategy for the Kosi Basin

The project evaluation criteria to be used is not simply maximization of net benefits but rather should be based on assessment of the following economic performance indicators and their implications:

- **Benefit/Cost Ratio (B/C ratio)** which is equivalent to the sum of discounted benefits divided by the sum of discounted costs where the costs are discounted capital costs plus discounted costs of operation and maintenance. All project development options with a B/C ratio greater than 1 will be considered.

- **Net Present Value (NPV)** which is equivalent to total discounted benefits minus total discounted costs. From an optimization perspective the maximum NPV is the optimum scheme. However, for evaluation purposes any project with NPV greater than zero is economic and should be considered.

- The discount rate at which the NPV with-project equals the NPV without project will also be calculated. Up to this discount rate the with-project scenario is the least cost scheme.

**Basis of Comparison of Alternative Development Scenarios**

Alternative development scenarios will be compared at a range of discount rates to be agreed upon. Costs and benefits will be in constant terms. The major basis of comparison will be the B/C ratio and incremental B/C ratios for the alternative development scenarios across the selected range of discount rates, however, the other economic indicators described above will also be analyzed.

**Base Case Scenario**

The base case scenario will be selected on the basis of the selection of the best dam-sites and type of dams determined by comprehensive engineering study incorporating additional seismic, hydrologic, geologic and site investigation and comparative design and cost studies. The resulting recommended project configuration will be used as the basis for the second stage optimization studies to establish reservoir-operating levels and installed capacity. Power, irrigation, flood control, sedimentation and navigation benefits will be included in the base case scenario.
Sensitivity Analysis Scenarios

The following sensitivity scenarios will be analyzed:

a. **Total costs** – Two scenarios will be analyzed; a most probable scenario in consideration of the environment of uncertainty and a high cost scenario representing the worst case scenario;

b. **Low Growth of Electrical Energy Demand** - The low growth scenario will be low load growth projections for both the Nepal and Northern and Eastern Indian power systems.

c. **Delay Commissioning** – Under this scenario the impact of delaying project commissioning should be evaluated.

d. **Export All Power to India** – Under this scenario all power produced by the project will be exported to India.

e. **Standard Conversion Factor = 1.0** – Under this scenario the standard conversion factor is set equal to 1.0. This assumes that there are no economic distortions in the region vis-à-vis world prices for the goods and services.
VIII. MODALITIES FOR THE STUDY

The understanding reached between the Prime Ministers of the two countries have identified the need for the formation of Joint Team of Experts (JTE) to finalize the modalities of the investigations and the method of assessment of benefits. The role of JTE is to identify mutually acceptable modalities for the conduct of investigations and the methodology for assessment of benefits.

Institutional Arrangements

The development of SKHDM and SSDS demands sincere and concerted effort of both Nepal and India for the smooth execution of study as well as to establish appropriate linkage mechanism between decision-making bodies and technical teams. This can be achieved through the establishment of an institutional mechanism, which needs to be identified.

A Project Team (PT) consisting of a team of Nepalese and Indian experts for field investigations and preparation of Detailed Project Report (DPR) shall be constituted. Each side will nominate their respective Team leader. The Team leaders, after site inspection, shall jointly workout the composition of the project team and the cost estimate shall be put up in the next JTE meeting for finalization and approval.

The team members will comprise of surveyors, geologists, project economists, system planners, hydrologists, sedimentologists, water resources engineers, civil engineers, irrigation engineers, electrical engineers, mechanical engineers, environmentalists, transportation planners, cost-estimators, specialists on inland waterways and others as appropriate.

PT will be responsible to carry out engineering, costs and benefits analysis, environmental and other relevant studies. Part or full components for the study can be contracted to the consulting firms. PT will be fully responsible and accountable for quality and content of the project study.

The JTE shall supervise and monitor the execution of the study. Meeting of the JTE shall be held frequently during investigation and studies.

Financing of the Studies

The Team Leaders, after site inspection, shall jointly workout composition of the Project Team and also the cost estimate for investigation and studies in accordance with the scope of works. The cost of the investigation and studies for the preparation of DPR including cost of JTE meetings shall be borne by GOI in the form of grant assistance.
Work Schedule

Target dates for different activities included in the scope of works will be shown in a work schedule.

Reporting Schedule

The following reporting is to be done on the project:

- Monthly Reports
- Field Investigation Reports
- Interim Report
- Draft Final Report
- Final Report

The Monthly Reports are to review work activities, report on progress and schedule and identify concerns on the study progress as well as expected study outcomes.

Field Investigation Reports will report on the activities and describe the findings from the field investigations. These Field Investigation Reports will be used for the project studies.

The Interim Report will be produced midway through the study and will summarize the field investigations reports, report on the preliminary findings and present the preliminary project layouts.

The Draft Final Report will be produced at the end of the study period and report on all aspects of design, costs, economic and financial analysis etc. The Final Report will be produced after incorporating comments from JTE and other relevant agencies in both Nepal and India.
Reports:

Ten copies of draft final report will be produced. The draft final report from the field investigations and project studies will include the following:

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