CHAPTER 10 DAM OPERATION SYSTEM

10.1 General

In case of a multipurpose dam project, it is paramount to have the operation system established in advance of its implementation. The present portfolio of WAPDA covers operation and maintenance of (a) generation, transmission and distribution of power; (b) irrigation, water supply and drainage; (c) prevention of water logging and reclamation of waterlogged and saline land; (d) flood control; and (e) internal navigation in the country but future one seems intransparent subject to the next phase of the forthcoming organizational restructuring. On the other hand, as was mentioned in Section 5.5, the North-West Frontier Province Irrigation Drainage Authority was established in 1997 to take over all irrigation and drainage functions covered by the Irrigation Department of GONWFP. It is therefore necessary to clearly demarcate among the agencies concerned their responsible area before implementation of the Project, preferably before commencement of the detailed design.

10.2 Power Plant Operation and Flood Fighting

Power generation contributes the majority of benefit earnings in the Project. So far all the hydropower plants except a few which are for KESC were operated by WAPDA. There is no doubt at present that WAPDA will establish an operation team to operate the power plant. The power plant operation includes the operation and maintenance of the plant comprising powerhouse, switch gear, power waterway, spillway, river outlet, re-regulation weir, and other relevant structures to the Munda Dam Multipurpose Project. Flood fighting and maintenance flow operation also fall in the portfolio of the operation team. No separate formation for seasonal flood fighting can be considered as those facilities are incorporated in the power generation facilities. Depending on future restructuring, there may be a possibility to operate the power plant indirectly by employing or hiring a power operation company which may be constituted at the time of completion of the project. In such cases, flood fighting should be included as a scope of the works for the company.

10.3 Irrigation Water Supply

The established North-West Frontier Province Irrigation Drainage Authority (NWFPIDA) is an autonomous body for irrigation management, though the structure of the organization and process of implementation are yet to be formulated subject to recommendation by the Institutional Reform Consultants for which the procedure to appoint consultants was initiated in June 1999. This

is a part of institutional reforms in the irrigation sector under the National Drainage Program (NDP) assisted by World Bank and other donors.

According to the program, the Farmers Organization was supposed to be formed within one year after the establishment of NWFPIDA and Area Water Board, which is on pilot base, but it has not yet been implemented as of the end of 1999.

It is certain that NWFPIDA would be concerned with operation and maintenance of the irrigation component of the Munda Dam Multipurpose Project and the outcome of the deliberations on the Farmers Organization would be applicable to the new command area of the Munda Dam Multipurpose Project. Further activities of the Area Water Board on the Swat Canal Command would be influential to the new command area of the Munda Dam Multipurpose Project.

10.4 Possible Operation Organization

Until NWFPIDA is completely set-up and functioning well, WAPDA will be the only possible operating body of the Munda Dam Multipurpose Project.

As mentioned in Chapter 4, WAPDA (Power Wing) used to control vertically planning, design, construction and operation and maintenance of generation, transmission and distribution facilities, but they are in the process of dissolution for the purpose of attaining corporatization and privatization of the power sector. WAPDA (Water Wing) will be in charge of the hydroelectric generation of multipurpose and reservoir type projects covering all phases of planning, design, construction, and operation and maintenance. The current hydroelectric groups of the Power Wing will need to be included in this organization.

In this context, WAPDA will be the responsible body for implementation of the Munda Dam Multipurpose Project as well as operation and maintenance, but irrigation component of the project may be covered by NWFPIDA when it becomes operational.

CHAPTER 11 ENVIRONMENTAL ASSESSMENT

11.1 General

According to the GOP guidelines, a comprehensive EIA is required for all dams, reservoirs, and hydroelectric power projects with a maximum storage volume greater than 50 million m^3 or surface area greater than 8 km^2, and hydro projects above 50 MW of installed capacity. The EIA is planned and carried out following the detailed 1997 GOP, 'Guidelines for the Preparation and Review of Environmental Reports' and 'Policy and Procedures for Filing Review and Approval of Environmental Assessments'. In addition, donor agency guidelines, e.g. World Bank, ADB, and JBIC (OECF) also have to be followed.

The EIA has to comply with the, "Pakistan Environmental Protection Act, 1997" requirements, where the EIA has to be submitted by the executing agency to the Provincial Environmental Protection Agency in NWFP. For resettlement and compensation issues, most hydro projects have followed the ADB and World Bank requirements rigorously since Ghazi Barotha Hydropower Project.

Prior to the EIA, an IEE was carried out based on JICA Environmental Guidelines for Dam Construction Projects, JICA Environmental Guidelines for Infrastructure Projects (Water Supply), and the World Bank's New Policy on the Environmental Aspects of Dam and Reservoir Projects. All the details of IEE inclusive of the results are described in Appendix H.

11.2 Existing Environmental Conditions

The Swat River originates at an elevation of 4,850 m rising high amidst the western Karakorum and Himalaya mountains, and it moves to the west of the Indus River near Kalam. It is joined in the northern Swat by the Usho, and the Gabral rivers, then flowing southwards it passes through an elevation of 4,000 - 5,500 m to the west. At this location, the condition of water in the river is clean and cold. The Swat River near its source is pristine with virtually no pollution. There are 16 types of fish, found in the Swat River in the Munda reservoir area. The Mahseer, Swati fish (schizathorax), and Sher mahee are locally famous for their taste and are flagship species in this portion of the Swat River. The vegetation in the dam and reservoir area can be briefly described as dry subtropical broad-based forests, comprised mainly of kau (*Olea cuspidata*), phulai (*Acacia modesta*) and scrub.

The extensive irrigation system provides water for agriculture in Mardan and Peshawar Districts. Downstream of Munda Headworks, the Swat River gets divided into Abazai and Khiali Rivers, these branches join into Kabul River near the town of Charsadda. The Swat River in the south has become mostly degraded, due to agriculture run off and animal grazing activities. The ecological conditions of the surrounding area are also degraded due to excessive grazing and timber cutting. The dam and reservoir area, and command area are shown in Figures 11.2.1 and 11.2.2. The environmental impacts anticipated due to the construction of the Munda Dam Multipurpose Project are discussed below.

11.3 Potential Environmental Impacts

11.3.1 Fishery and Aquatic Biodiversity

The following fish were caught during the environment survey from the Munda Dam reservoir area.

Fish Collected for the Field Survey of Swat River at Munda Dam & Reservoir

Classification	Scientific Name	Local Name	English Name
Family: Cyprindae			
Sub Family: *Rasborinae*			
	1. *Baralius vagra*	Chilwa	Carp
	2. *Baralius bendelisis*	Patha Chilwa	Carp
Sub Family: *Barbinae*			
	3. *Labeo dero.*	Pehari Rohu	Carp
	4. *Labeo dyocheilus pakistanicus*	Torki	Carp
	5. *Tor putitora*	Mahseer	Carp
	6. *Puntius ticto*	Ticto popra	Carp
	7. *Puntius Sophore*	Sophore popra	Carp
Sub Family: *Garrinae*			
	8. *Gara gotyla*	Pather chat	Carp
Sub Family: *Schizothoracinae*			
	9. *Schizothorax plagiostomus*	Swati	Snow trout
	10. *Ptychobarbus conirostris*	Ladakhi snow carp	Ladakhi snow carp
	11. *Racoma labiata*	Chun mahi	Snow trout
	12. *Schizopyge esocinus*	Asala mahi	Snow trout
Sub Family: *Cyprininae*			
	13. *Carassius auratus*	Goldfish	Goldfish
Family: *Sisoridae*			
	14. *Glyptothorax cavia*	*Sulemani, Kan Kapr* (Pushto)	Cat fish
Family: *Schilbeidae*			
	15. *Clupisoma naziri*	Sher mahi	Cat fish
Family: *Chandidae*			
	16. *Channa punctata*	Daula	Snake-headed fish

The sections below provide the potential impacts on the fishes identified and how the people of the area are impacted by it.

(1) Impacts during Construction

1) Obtaining sand and gravel as construction material from the riverbed would have a negative impact on the aquatic biology of the river, and it should be avoided. The river deposits of sand and gravel are breeding and foraging grounds for many fish. Past instances of borrowing sand and gravel for construction purposes in upstream areas of the Swat River had already shown a decline of Mahseer and Swati fish populations in the river.
2) The earth material for the dam core zone will be procured from borrow pits a few kilometers downstream of the dam site or one located in the reservoir area. This will have no impact on aquatic biology if the construction is at a distance from the riverbank and care is taken to transport and unload the material at the construction site in a way that minimizes negative impacts.
3) The solid and liquid waste produced as a result of construction activity and the presence of a workforce may effect the water quality if not disposed of in a sanitary manner. Of special interest are the air-bound dust particles produced during blasting and earth-moving and sand at the construction site. Dust from excavation activities and dumping in water bodies will lead to a turbidity of water.
4) The impact of building two cofferdams and a water passage through the tunnels will lead to a complete drying out of the river between the two cofferdams. This will mean a short-term loss of fish and other aquatic biota in this area. The exact stretch between the two cofferdams is not known but it may be a minor loss.

(2) Post-Construction or Operative Phase

1) Negative Impacts

Due to the construction of the dam, a 56 km long reservoir, with an inundated surface area of 24 km^2 will be created. The following changes and impacts are anticipated:

a) Fragmentation of Population

The first major impact in the area will be the creation of a reservoir which will impact on the fishes and other aquatic life. Lake fauna and flora have their own characteristics. Fish migrate upstream and downstream to spawn, to find better or alternative foraging grounds and to avoid seasonal rigors of

climate. The dam will halt the upward and downward migration of fish. This will lead to fragmentation of fish populations into two.

b) Migration for Spawning

Though there are no documented observations on the spawning behavior of most of the foraging fish in the project area; literature shows that in similar habitats elsewhere most of the breeds search for spawning areas in shallow water close to their foraging grounds. The Sher Mahi breeds in the gorges of the Swat River in Mohmand Agency. The fisheries officials of FATA have also observed breeding close to the Munda Headworks. The Sher Mahi could be considered a flagship or charismatic/ popular species that will suffer no negative effects by spawning upstream in the Panjkora River or in the Swat River where suitable spawning grounds will also be available.

The Swati (Schizothorax plagostomus) and other members of the Schizothoracinae family, are also plentiful and could be considered as flagship species. In the operative phase, the Swati and other related species will find new suitable spawning and breeding grounds after bearing the initial trauma of a changed habitat. Downstream from the proposed dam site the Swati may face the problem of changed water flow.

The spawning grounds and breeding behavior of the golden Mahseer of Malakand have been studied by Khan (Ref. 1) in the area where the Swat River drains into the Malakand Agency. In the past, the Swat River at Mingora was an ideal place for Mahseer breeding. The breeding grounds were lost due to many anthropogenic interventions, i.e., water diversion, extraction of gravel from riverbeds, and pollution. The Mahseer start their upstream migration to the streams and rivers of the Malakand division in March and remain there until September. The breeding season extends from April to September in the Swat and Panjkora Rivers. Three spawning periods during early June, late July, and late August were observed. According to Butt (Ref. 2) in his unpublished data, the Mahseer seems to be resident in the Mohmand Agency where it breeds throughout the year.

In summation, spawning and breeding of the Mahseer in the Swat River occurs from Chakdara, Totakan, Sallai Patti (all in the Mohmand Agency) down to the Khiali River. Although the Mahseer has extensive spawning and breeding areas, many of these areas will be lost due to inundation in the reservoir area related to the construction of the proposed dam. Areas like Salai Patti (in the reservoir area) and parts of the Swat River draining through Mohmand Agency (up to the dam site) and beyond will be affected

due to fluctuations in the water levels. This will be disturbing to the fish habitat and is a serious negative impact that will require mitigation measures.

c) Loss of Foraging Ground

The formation of a reservoir and related altered flow regimes in the project area and downstream will result in physico-chemical changes and will also have negative effects on the fish foraging grounds. The initial loss of foraging grounds and food due to the sudden and serious change in habitat and water flow will lead to a loss of food, and feeding or foraging grounds.

d) Sedimentation

Sedimentation or silting is another important consequence of damming and changed water flow. The accumulation of sediments in the reservoir and its method of disposal (if any) downstream from the dam may have a negative effect on aquatic biology. The annual sediment inflow into the Munda reservoir has been estimated at 373 ton/km^2. The volume requirement for storing sediments after 100 years, have been worked out to be 373 million m^3.

The area of concern regarding the accumulation of sediments is flooding. The flooding is due to natural or operative mechanisms.

e) Water Flow Regime

The current natural flow of the water will be changed due to the construction of the dam and storing water in the reservoir. Intermittent mechanisms of water release will have serious negative impacts on river ecology, particularly downstream from the dam. This will be mitigated to some extent by re-regulation dam. The water shortages from October to March will be an area of concern. Even no river flow downstream the Munda Headworks, has been reportedly experienced in this season. As is seen in Chapter 5, an additional water of 2.8m^3/s (100 cusecs) will be released. This could be an ecological maintenance flow based on the currently drawn volume and the future requirements. In addition, the reservoir study has concluded that enough water downstream will be available because of continuous power generation. The negative impact will be only during initial impounding.

f) Changes in Physio - Chemical Parameters and Water Quality

The dam will introduce changes in ambient temperature, the amount of dissolved oxygen in the water, PH value, and mineral and salt levels. The most critical change will be the amount of dissolved oxygen in the water as well as temperature changes and stratification (particularly in the reservoir).

According to Lone, "the water quality in an impoundment can often be better than that of the original stream due to the precipitation of solids; exposure of water to light and air for longer periods; thermal stratification resulting in a reduced heat budget for the system; and trapping of nutrients." (Ref. 5)

However, the quality of water may deteriorate due to turbidity and the depletion of oxygen because of pollution. Pollution has increased in the areas from Kalam to Totakan. There are no close settlements up to Patti Banda in the proposed project area and it is therefore almost free from anthropogenic pollutants.

Pollution problems may arise due to the establishment of post-construction new settlements and the decreased flow of water from the reservoir downstream. The gushing water released from turbines can cause a super saturation of gases in the water. This super saturation leads to gas bubble disease in fish, their symptoms include the blocking of capillaries in the fish's gill filaments.

g) Rooted Vegetation

There are no rooted trees on the bank up to the maximum water level of the river. It is generally recommended in similar projects to remove all decaying trees which otherwise will lead to the production of methane gas (a greenhouse gas) and snags for fishermen's lines.

2) Positive Impacts

a) Enhanced Fish Production

The construction of a 56 km long reservoir with an inundated surface area of 24 km^2 and 1,694 million m^3 capacity will create a new resource for capture and recreational fisheries. The increase in fish production will depend upon the type of stock and how it adapts to the new physical conditions and which new species of fish are introduced. The Tarbela and Mangla reservoirs, both with approximately the same climatic conditions, produce 150 and 1,000 metric tons of fish per annum, respectively.

b) Canal Fisheries

The two new irrigation canals proposed in this project along with the existing canals of Doaba and Swat (LSC) should be developed as an additional source of fisheries. The Department of Fisheries, Provincial Irrigation and Drainage Authority (PIDA) and WAPDA may undertake a

joint study to utilize this valuable water resource for further augmentation in fish production.

c) Improvement in Quality of Life

All the projected changes related to the proposed dam, including the construction of roads, supply of more consistent electricity, incoming tourists, recreational fishing, and better harvest of capture fisheries will bring positive impacts on the socioeconomic conditions of the area's inhabitants.

11.3.2 Agriculture and Water Usage

The irrigated area in the 12.9 km long Right Bank Canal (RBC) and the 14 km long Left Bank Canal (LBC) will measure approximately 2,043 ha and 4,066 ha, respectively, and totally 6,109 ha. The entire RBC command area lies in Mohmand Agency. The command area of LBC falls in Mohmand Agency, Tangi Tehsil of Charsadda District, and Malakand Agency.

(1) Land Ownership Systems

In the tribal territory of the Mohmand Agency, the land belongs to the tribes who form the community. Legend has it that the chief of the Mohmand tribes, Mohammad Baba, allocated lands in the present Mohmand Agency to different tribes based upon certain criterion, presumably in proportion to each tribe's population. Then, each tribe allocated land among its different households, again, presumably by criterion of household size. After this initial distribution, the household's land passed to the males of the next generation in equal proportion. There are no land records or cadastral maps but each household is aware of the ownership of all land in the area. Land is not sold to men outside the tribe or even outside the clan. If it is sold, then it is to men from one's own clan.

In the settled area lying in the command area, i.e., Tangi and Malakand, the land is generally individually owned. Cadastral maps and ownership records, maintained by the revenue department, are available.

(2) Agricultural Practice

The major agricultural practices followed in the command area are as follows:

1) More than 95 % farmers use tractors, only less than 5 % farmers use animal plow exclusively.
2) The use of chemical fertilizers is fairly extensive. Approximately 80 % of the farmers use nitrogenous fertilizers, and 60 % use phosphate fertilizer.

3) The survey has found that all the farmers have shown an interest in improved seed, but due to limited supply the incidence of use is not reflective of their interest. Only 56 % of the farmers use improved wheat seed, while corresponding figures for maize, onion, and tomato are 12 %, 8 %, and 44 %, respectively.
4) The use of insecticides, pesticides, and herbicides is low among farmers. Contributing factors may include high prices, low cropping intensity, and the farmers' inadequate knowledge.
5) Threshers are used by 36 % of the survey's sample farmers.
6) Around 23 % of the farmers use hired labor on a permanent basis, and another 13 % reported using casual labor on their farms. On an average, full-time hired labor was used for 23 days per farm per season. This was an unexpected finding, explained by the high representation of high value, skill intensive vegetable farming in the sample farms' cropping pattern.
7) The introduction of commercial scale cultivation of vegetables has been instrumental in spreading information about modern farming practices in the command area. The farmers are constantly improving their current practices, and it is expected that the process will accelerate with the coming of the proposed canal.

(3) Livestock

All but 4% of the sample farmers surveyed own livestock. Similarly, around 70% of the farmers keep poultry.

Goats and cows are considered to be the most important livestock and account for 87 % of total livestock owned by the sample farmers. According to surveyed data, the average holding is 17 heads per livestock owners and 12 heads per sample farmer in general. The composition of livestock is as follows:

Composition of Livestock

No.	Livestock	Number owned:		
		Total	Average per household of:	
			Owners	Sample farmers in general
1.	Buffalo	13	0.14	0.13
2.	Cows	403	4.20	4.03
3.	Goats	738	7.70	7.38
4.	Sheep	87	0.90	0.87
5.	Draft Animals	70	0.73	0.70
	Total All Kinds	1,311	13.67	13.11
	Poultry	1,188	17.00	12.00

Sheep and goats are almost entirely dependent on grazing in the command area. Following the operation of the proposed canals, the bulk of the current grazing

land will be farmed for 2 crops a year, thereby reducing the land available for grazing. Hence, most farmers think that the sheep and goat population will either decrease or stay constant after the commissioning of the proposed canals.

In the case of buffaloes, cows, draft animals, and poultry the farmers' perception has been that the population will increase. Among the main contributing factors to this perception is an expected increase in fodder availability.

(4) Water Usage

The following use of water has been found to be common in the command area during the field surveys:

a) Drinking
b) Washing and bathing
c) Irrigation
d) Rafting upstream to the Munda Headwork on rafts made of truck tires in order to cross the river or to fish.
e) Boating at the Khiali Tributary for crossing the river or for fishing purposes, and collecting wood.

11.3.3 Archeological and Cultural Heritage

(1) Munda Dam Area

The shrine of Jud Baba, 3 km downstream from the proposed dam site on the left bank of the Swat River, is the most significant ancient Muslim religious structure in the project area. It will not be threatened by the Project. During the investigations, no reliable or authentic information was available regarding the antiquity of the shrine, its ancestry, or identity, although the local people revere Jud Baba. This area will be very close to the access road and maximum care will be taken to ensure the safety and integrity of this shrine during the construction period, and later during the operation period.

On the right side there is also a grave/shrine where there has been an enclosure under construction and local people place colored scarves. This is in the area where the access road will have to be constructed. Shrines are normally sensitive and delicate issues and would be dealt in a careful and cautious manner. The Political Agent of the Mohmand Agency will be asked to mediate with the relocation of this grave with help of local area's priest (*maulvi*).

A few kilometers downstream of the dam on the right bank, on top of a hill, where currently, the Frontier Constabulary (FC) picket is located, is a site locally known as Khazana Ghund. This site will not be affected by the project at all. However,

looking from this site one gets a most spectacular view of the dam and the river. It should be developed as a tourist attraction, consisting perhaps, of a museum where the project area related antiquities could be displayed and provide for a recreational attraction close to the Munda Dam.

(2) Reservoir Area

The survey found that the reservoir area has no significant archeological sites or remains of cultural heritage.

(3) Canals Command Area

Left Bank

There are 15 known archeological sites in the command areas of the proposed left bank canal. Of these, thirteen sites were new excavations. In the command area of the proposed left bank canal there are 11 archeological sites of great cultural importance.

In the command area of the proposed left bank only three sites (Maizero Dand, Ghatta Bakkara, Kotagai) will not be endangered or affected by the construction of the canal.

During the survey it was observed that all 11 of these archeological sites were subjected to illegal diggings and some of them have been badly vandalized. The sites are under threat from the local people who use stone blocks from the sites for construction purposes. The following are the major sites, some of which would be negatively impacted by the project:

a) Sulai Khat is in the command area and will be negatively impacted by the project.
b) Selay has been vandalized and will not be negatively impacted by the project.
c) Kajigal (Kandar) - Illegal excavations have been carried out here for the last 3 years. This site will be negatively impacted by the construction of the left bank canal.
d) Digir Raj - this site has had extensive illegal excavations and will also be negatively impacted
e) Salgaro site has a Gandhara period stupa and statues and relieves have been excavated by the farmer leasing this land. This site will be negatively impacted by the proposed left bank canal.
f) Kandarai, at this site the owner is removing stones from the exposed wall. The proposed canal will pass through and the site will be negatively impacted.

Right Bank

In the right bank canal area there are four archeological sites, of which two are new excavations. The site, Kanro Qala will also not be negatively impacted by the canal. However, illegal diggings have damaged this site substantially.

The sites Shin Ghundai and Zarif Koruna, will be negatively impacted by the Project. The Zarif Koruna site is also endangered because the tenant farmer working there, has determined to excavate all the Aryan era, 2nd century B.C., graves and remove the gravestones to make a passage, to obtain a better supply of water from an irrigation canal. Kanro Qila, and Zarif Koruna are both located in the Mohmand Agency.

Some of the archeological sites in the command areas of the proposed right and left bank irrigation canals are likely to be negatively impacted during construction and operation. The prospect of the availability of irrigated land is also a potential danger for the archeological sites. The increasing land reclamation for agriculture will ultimately lead to the leveling of archeological mounds.

Once the final alignment of the proposed canals and its command areas is determined, salvage or rescue excavations of the endangered sites would be essential.

11.3.4 Ecological Conditions

The project area is located in the southern part of the Swat valley, here the Swat River passes through a narrow gorge. The project area has 150 species of scrub vegetation. The scrub vegetation is suited for grazing cows and goats, which due to overgrazing has now become severely degraded. In the reservoir area, more than 6,000 goats, and 4,000 cows are owned by the local people for grazing in the rocky and craggy scrub vegetation terrain. The ecological conditions are being deteriorated due to overgrazing, deforestation, and hunting.

Information on the project area's vegetation was collected through random sampling in 110-square-meter quadrant's laid out in the dam, reservoir, and the command area of the proposed canals and along the reaches of the Swat River downstream of the dam. A total of 15 vegetation communities by habitat types were found in the project area. The floristic composition of all the habitat types were investigated at the Munda Dam site, reservoir area, and command area. The dam and reservoir area mainly possesses scrub vegetation type with some trees and wild palms. Most plant species found were common to areas impacted by heavy grazing and tree-felling.

In the flora of the project area, there are 24 species of *Pteridaceae*, 21 species in *Liliaceae*, 22 species of *Cyperaceae* family, 52 species of *Graminae* family, 19 species of *Papilionatae* family, 12 species of *Labiatae* family, while *Compositae* family has 36 species. *Graminae* family has the maximum species, which is followed by *Compositae* family. Only four threatened species were noted in the project area.

Natural plant communities include *Acacia nilotica, Dodonaea viscosa, Rhazya stricta, Zizyphus nummularia, Adhatoda vasica, Chrysopogon, Aerua pseudotomentosa, and Themeda anathera* as important plant communities. The project area has no endangered species as far as flora is concerned.

The project area's fauna includes 17 reptiles, 2 amphibians, 36 mammals, and 119 birds. Avian family Accipitridae had 13 species followed by Turdidae with 11 species. Amongst the Mammalia, family Muridae has 9 species.

During the wildlife survey interviews, it was found that some species like Urial and Kabuli Markhor were present in the project area in the past but now they are locally extinct. No rare or threatened animals were seen during field surveys. According to the locals, very few animal species are found in the area, since over the years, they have suffered from habitat degradation and uncontrolled hunting.

It is anticipated that the duck and waterfowl population will increase in the reservoir. The reservoir area due to the scrub vegetation is also very suitable habitat for Seesee, Black, Grey and Chakaur Partridges. The measures need to mitigate the adverse existing ecological impacts include wildlife conservation, erosion control, social forestry, range management, sustainable use of medicinal plants, and development of ecotourism in the area.

11.3.5 People Affected

(1) General

The following section provides information about the impacts on people affected in the dam, reservoir, and command areas of the project:

a) Socioeconomically the people in the Dam, Reservoir and Command Areas (CA) are backward and traditional. The main means of their livelihood are agriculture, mostly subsistence, and as day labor, mostly unskilled.
b) The social organization in the project area is tribal and ethnically *Pushtoon*, with the joint household being the primary unit. The settlements, villages and towns are collections of households of people belonging to the same ethnic group or subgroup. The people of this region reportedly aspire upward

mobility and not averse to movement and change for socioeconomic betterment. Because of the lack of economic opportunity in CA, considerable out-migration has been occurring, and continues.

c) By and large the area's population is skeptical about the government projects; the Munda Dam Project has been on the books for over thirty years now. The respondents of the field survey had heard about the project but were not concerned about its actual construction, as it had not been implemented for a long time.

d) The overwhelming response about the project was positive, considering that it would provide irrigation water, which will significantly improve the largely agriculture base economy of CA.

e) The negative environmental impacts of the proposed project in CA would be negligible. There are 118 people living in the reservoir and dam area, with 5,500 goats and 1,300 cows approximately in the reservoir area, most of these are seasonal, from October to April. Goat and cow herding is the main activity of these people. Near the dam site there will be resettlement of people who have dwellings and cleared agricultural plots. The WAPDA Compensation Survey Team has estimated that all of 118 people as above will be compensated for resettlement together with their hutments and low quality houses made of cobbles and tree leaves. The table below provides a breakdown of the land, houses, and people who will be compensated.

Population & Property in the Munda Dam Axis & Reservoir as of June 1999
(Village Survey Conducted by WAPDA)

Name of the Village	Approximate Location	Number of Houses/ Hutments	Number of Families/ Persons	Total Population	Land Area Possessed in '*Marla*'
Bara Adeera		3	3	3	23
Chak Mundi		6	8	8	9
Todobo Banda	3 km. U/S from Dam Axis, R/B of the river	8	21	21	68
Jorogh Banda	5 km. U/S from Dam Axis, R/B of the river	12	12	12	15
Munda Dam Axis	Huts on the dam site L/B of the river	11	11	11	38
Changal (Sandak Patti)		3	5	5	5
Palosai Banda	5 km. U/S from Dam Axis, R/B of the river	29	29	29	35
Bara Palosai Banda	5 km. U/S from Dam Axis, R/B of the river	6	6	6	8
Bara Gurkai Banda		9	6	6	10
Ziari Godar	4.5km.U/S from Dam Axis, R/B of the river	1	1	1	3
Gurkai Banda	7 km. U/S from Dam Axis, R/B of the river	6	9	9	12
Shamat Khan Banda	12km.U/S from Dam Axis, R/B of the river	2	2	2	6
Narai Banda	11km. U/S from Dam Axis, R/B of the river	2	1	1	4
Durood Banda	15km. U/S from Dam Axis, R/B of the river	1	1	1	4
Khajurai Khula	L/B of the river	3	3	3	5
Grand Total		102	118	118	245

Note: 1 Marla = 25 Yards^2

And, the tables below provides information about the land area requirements during the construction of the Munda Dam.

Required Land Area for Construction of Permanent Facilities

Facilities	Area (m^2)	Remarks
Access Road		
Right Bank; Length: 6 km, Width: 10 m	60,000	Permanent
Left Bank; Length: 5 km, Width: 10 m	60,000	Permanent
WAPDA Staff Colony	150,000	Permanent
Total	270,000	Permanent

Required Land Area for Construction of Temporary Facilities

Facilities	Area (m^2)	Remarks
Contractor – Civil Works	120,000	Temporary
Contractor – Metal Works	20,000	Temporary
Contractor – Hydromechanical Works	15,000	Temporary
Contractor – Hydroelectrical Works	15,000	Temporary
Total	170,000	Temporary

(2) Short Term Positive Impacts

a) The construction activities will provide a big employment opportunity to the locals. The level of positive impact of employment will be a function of the scale and duration of civil works. The provision of employment locally will have a positive impact in two ways. One through the increased consumption capacities of the workers, which will raise the demand for local goods and services. And second through the reduction in out-migration, which is a considerable existing problem.

b) Those who provide local materials and resources will be receiving cash compensation. This is likely to affect the consumption patterns of the beneficiaries, which in turn will have a positive spill-over effect on the demand of goods and services of daily life.

c) The building of access road on both sides of the Swat River downstream of the Munda Dam and to the borrow pit (8.5 km) for the movement of construction machinery and dump trucks etc. will facilitate the development of the local infrastructure.

(3) Long Term Positive Impacts

a) The most important positive impact will be a boost in the agricultural productivity of the command area through the provision of irrigation water. The people of the area are traditionally inclined to farming and agricultural activities. Even now wherever water is available for cropping, people have developed thriving farms and orchards. In many cases rugged land have been leveled and made cultivable. The major hurdle in the agricultural development of the area is lack of regular supply of water. Once water becomes available, there are indications that the people of the area will be capable of taking advantage of that in order to better their socioeconomic condition. The human resource will be there for a major improvement in agricultural productivity. The availability of water will provide the necessary natural resource.

b) The electricity generated in Munda Dam would give a significant boost to the local mining, and affiliated small industries, which are struggling at present.

c) There have been some reported (1929, 1995) floods in the Swat River which have caused some destruction. The construction of the dam will mitigate and will considerably eliminate, chances of flooding in the future.

d) The provision of irrigation water and electricity will contribute significantly in the overall economic development of the people and the area. This economic uplift will factor into social development and a qualitative positive shift in the availability of essential services like education, and health.

(4) Short Term Negative Impacts

a) There is a small human habitation with 102 hutments in the reservoir area, which will require relocation after the dam has been completed and the spillway comes into operation. Out of 102, there will be 11 hutments at the proposed dam axis.

b) The construction activities will necessarily mean the concentration of workers around the building site. This could have a negative impact on the nearby local communities. The closest villages to the dam site are quite small and the infusion of even a small number of outsiders is likely to have a big impact.

c) The use of roads for the movements of construction equipment would have a negative effect on the already stressed communications infrastructure.

d) The use of dynamite for blasting, for construction purposes will introduce negative elements into the local ecology. To a degree this is unavoidable but care should be exercised regarding the storage and use of such materials, and the timing of blasting activities.

e) The excavated earth from the project will amount to 10 million m^3, which can become a problem. Plans for the appropriate utilization and safe disposal of such materials should be undertaken.

(5) Long Term Negative Impacts

a) The key and complex problem will be of the rights over the use of irrigation waters, and the ownership and use of land. The provision of irrigation water will inevitably raise the value of the land and the possibility of land related disputes.

b) Currently in the command area about 50% of the locals are landless, and the land-owners also have small holdings. With the increase in the productive value of the land the traditional landlords, many from the proximal settled areas, are likely to acquire the land.

11.4 Environmental Management and Monitoring

A comprehensive and effective environmental management program will be required that establishes the environmental protection and rehabilitation during construction and operation phases of Munda dam. This program will incorporate an environmental monitoring program that will provide control and information of changes anticipated during the project implementation. It is assumed that many of these changes will have correctly been predicted by the EIA. However, flexibility will be provided to deal with some impacts that may have different outcomes and their corresponding mitigations.

11.4.1 Environmental Management Plan

The Environmental Management Plan (EMP), will be the main and comprehensive environmental protection plan to carry all the required environmental issues into the detailed design, construction and operation phases.

The EMP will be implemented by a senior professional from WAPDA's Environmental Cell, who will have the overall control for all aspects of the program.

The EMP will be developed as part of the requirements for detailed design of the Munda Dam. The EMP will build on the EIA report and will plan for the many different environmental conditions and requirements that will exist during the detailed design, construction and operation phases. Overall, the EMP will have two important components.

(1) An overall strategy together with a time based schedule for carrying out the EMP, and a detailed budget and areas of responsibilities for WAPDA and the people's participation.

(2) A Project Site Protection and Rehabilitation Program which will be prepared for the reinstatement of disturbed areas. This program will propose how disturbed construction sites are to be rehabilitated together with site stabilization and re-plantation of lost vegetation. Mitigation requirements for site clean up and stabilization of major waste disposal areas after construction is completed will be included.

In addition, a comprehensive watershed management program will be considered to initiate tree planting and afforestation during the detailed design stage of the project.

11.4.2 Environmental Monitoring Plan

Monitoring will involve the measurement and recording of environmental, social and economic variables associated with the Munda Dam Multipurpose Project. This plan should provide information on the characteristics and functioning of variables in time and space, and in particular on the occurrence and magnitude of the impact. Monitoring can improve environmental management of the project. It can also be used as an early warning system to identify harmful trends at the dam site and the entire project area before it is too late to take remedial measures. It will help in identifying unanticipated impacts. Monitoring will also provide an acceptable database, which will be used in mediation between interested parties. Monitoring is one of the most effective guarantees by WAPDA of its commitment to environmental quality. Monitoring of key activities will be required during detailed design, construction and operation. The following areas will be included in the monitoring plan.

(1) Water Quality Monitoring

Water quality monitoring will be required to (i) establish base line environmental conditions and (ii) evaluate effects of the Swat River's diversion during the construction period.

Water quality measurements will be needed from the Swat River before Panjkora River's confluence for basic parameters including nitrates and phosphates, and at 1 km before the existing Munda Headworks for human use parameters that will include biological oxygen demand (BOD), chemical oxygen demand (COD) and bacteriological contamination.

Additional water quality measurements will need to be made to evaluate the effect of the Swat River's diversion. The samples would be taken regularly over two years on a two-month basis.

(2) Fishery and Aquatic Biodiversity Monitoring

The EIA has assessed that the fish species composition is unlikely to be affected by the diversion, though productivity will most likely decline. The monitoring will be carried out to confirm the validity of this assessment. A monitoring program will recommend that the samples be collected for fish and plankton every two

months at four places of the Swat River, before the Panjkora River's confluence, reservoir area, near Pattai Banda, and the road bridge near Munda Headworks near canal inlet.

(3) Resettlement and Compensation Monitoring

The community acceptance of large dam projects is now being judged by the fairness of the resettlement and compensation procedures. Similarly, in the Munda dam's case it will not only be the amount that the affected people will receive but also whether this is handled by WAPDA in a speedy and acceptable manner to the people linked to the land around the reservoir and the dam site. Like in Ghazi Barotha, an NGO group would be able to act impartially with respect to mediation between WAPDA and locals. In addition a community awareness program will be beneficial to advise and reassure the local community.

11.5 Costs of Land Compensation and Environmental Mitigation

The cost for resettlement compensation and land acquisition was estimated at US$ 2.46 million equivalent (Rs. 123 million) by WAPDA compensation survey team. Major items surveyed comprise land acquisition, compensation and replacement/relocation cost of privately owned houses and structures, farm products and community infrastructures, cost of resettlement villages, contribution to integrated regional development program, cost of studies and others. Breakdown of the cost estimate is shown in Table 9.2 11 with the following summary:

Cost Estimate for Land Compensation

Description	Amount (Rs.1,000)	Amount (US$ 1,000Equiv.)
Land acquisition:	20,000	400
Compensation and replacement/relocation cost of privately owned houses and structures	2,500	50
Cost of resettlement villages	50,000	1,000
Contribution to integrated regional development program	5,000	100
Relocation of Community Infrastructure	12,000	240
Compensation for farm product & trees	1,000	20
Cost of studies	2,500	50
Others	30,000	600
Total	123,000	2,460

All the details are also provided in the Appendix H. The costs derived here could change during the negotiations for the purchase of the land, which may be protracted.

The cost for environmental mitigation is for minimizing or offsetting the adverse impact due to construction and operation and mitigating the costs of biological, socioeconomic and physical impacts of the project on the affected area. The total mitigation cost was assessed to be US$ 5 million equivalent (Rs. 250 million) as summarized below:

Cost Estimate for Environmental Mitigation

Description	Amount (Rs.1,000)	Amount (US$ 1,000Equiv.)
Fisheries	20,250	405
Archeology & Cultural Heritage	51,150	1,023
Ecological Conditions	92.900	1,858
Agricultural/Water Usage	9,000	180
Environmental Management and Monitoring Cost	76,700	1,534
Total	250,000	5,000

A line item detail of mitigation costs is shown in Table 9.2.12.

11.6 Conclusions

The conclusions drawn from the Environmental Impact Assessment for the feasibility study stage and the recommendations for their mitigation measures are summarized below. The objective of these recommendations is to maximize the benefits and to minimize the undesirable impacts of the Munda Dam Multipurpose Project on the environment and the surrounding local community.

1) In fishery and aquatic biodiversity, field studies and analysis found 16 species of fish in and around the Munda Dam reservoir area, although there will be a reduction in their population during the construction period. The EA devised mitigatory measures to make the fishery more productive, so there will be great opportunities for enhanced fish production in the reservoir being 56 km long and up to 190 m of water depth. Periodic stocking of fish will be carried out throughout the Project life from construction to operation period.
2) For the archeological and cultural heritage issues, attempt was made to evaluate all the sites in the Munda Dam area. Apart from one small grave/shrine downstream of the dam on the left side, no other cultural sites will be adversely affected by the Munda Dam and reservoir.
3) The ecological conditions will not be harmed, and there will be no significant loss of any rare or precious flora caused by the construction of the Munda Dam. This will be an opportunity to organize the grazing land in a scientific manner where areas are periodically rotated for replenishment. The sediment load will be 90% less passing the dam site. A 2.8 m^3/s compensation

discharge downstream of the Munda Headworks will maintain the biological minimum flow.

4) The reservoir is unlikely to exacerbate any landslides or falling rocks within the Munda Dam project area.
5) Excavation (underground & surface) will yield large amounts, some 10 million cubic meters of earth and dirt materials. These will be utilized and disposed off in an environmentally acceptable way.
6) The Project will displace in total 118 people. All of these people would be easily resettled as discussed in the WAPDA's Compensation Survey & Resettlement Action Plan in nearby areas in the Mohmand Agency.
7) The loss to any infrastructure will be five wire and rope bridges.
8) The procurement documents shall include such a provision that during construction the Contractor should give preference to hiring labor from within the above people so as to maintain good working relations between the Munda Dam Multipurpose Project and the local people who are economically not much above poverty level.
9) The cost of environmental mitigation has been estimated at US$ 5 million equivalent (Rs. 250 million).
10) The cost for resettlement compensation and land acquisition has been assessed by WAPDA to be US$ 2.5 million equivalent (Rs. 123 million). The compensation costs derived at here could change during the negotiations for the purchase of the land, which may be protracted.

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CHAPTER 12 ECONOMIC AND FINANCIAL EVALUATION

12.1 Approach to Evaluation

The economic viability of the Project is the fundamental requirement for the Munda Dam development to be feasible. The proposed Project is planned to be a multi-purpose dam providing power generation, irrigation, and flood control. The project's viability is assessed for the project as a whole firstly, and then for each respective purpose. The analysis of separate purpose needs the allocation of the dam development cost based on the conventional method called separable cost-remaining benefits.

Three types of power benefit can be considered. The first type compared project cost to the cost that would have been incurred should thermal units be used, thus deriving the benefits from avoided thermal. The second, an energy cost-benefit evaluation, used the Long Run Marginal Cost (LRMC) as benefits, to determine if the allocation of scarce resources for the hydropower development can compete with investment in other sectors of the Pakistan economy. The third followed the second cost-benefit model, except that the benefits are derived from consumer surplus.

As the current trend dictates and the GOP's policy encourages private sector participation in hydropower generation, financial analysis of a project is becoming more and more important. Even if the GOP/WAPDA is going to undertake this Project, an independent entity may be established to be responsible for its own profits and losses.

The critical question that the financial analysis should answer is whether the overall project is profitable, and whether the potential investors, private or public, or joint efforts, will see the incentives attractive enough for them to forgo the investment opportunities elsewhere to invest in the Munda project. Equally important, whether the project could bring reasonable level of income to the government, federal and provincial, through dividends distribution, taxes, water charges, and other charges and duties while maintaining an affordable tariff level, lower than the 1997-1998 average level of IPP's purchase price at busbar.

A detailed financial analysis was carried out on power generation alone (using the separable cost - remaining benefits). Three modalities of financing schemes were tested: 100% owned by private investors during the 25-year concession period (BOT), 100% owned by public sector during the same period, and joint ventures

between public and private sectors (BOT) with public equity financed by international soft loans.

12.2 Assumptions and Conditions

12.2.1 Parameters for Evaluation

(1) Discount Rate

A discount rate of 10% was used in the economic analysis to reflect the opportunity cost or scarcity value of capital in Pakistan. This value is derived from discussion with WAPDA economists and was used in other studies including Ghazi-Barotha Hydropower Project (GBHP). A discount rate of 12% was also tested. For financial analysis, a discount rate of 12% was used.

(2) Exchange Rate

An exchange rate of US$ 1 for Rs. 50 was used in the analyses.

(3) Standard Conversion Factor

The Standard Conversion Factor (SCF) represents the ratio of the price of all goods within the countries to their international prices. SCF is mainly determined by the foreign trade policies of the host government. It is derived by a weighted average of import and export tariffs (with any subsides excluded). The weights used are the shares of imports and exports in total trade (Average Imports+Average Exports) / (Average Imports+Average Exports+Average Tax on Imports). SCF in this Study is 0.89.

This value is close to those used by the World Bank in GBHP and other hydropower analyses in Pakistan. As the data are not available, the derivation of shadow factors for cement, steel, skilled and unskilled labor were taken from other studies or using SCF .

SCF Calculation

(Million Rs. at current prices)

	1995/6	1996/7	1997/8	Average of three years
Imports	397,575	465,001	436,338	432,971.33
Exports	294,741	325,313	337,160	319,071.33
Total Trade	692,316	790,314	773,498	752,042.67
Taxes on Imports (net)	88,916	86,094	74,497	83,169.00
Subsidies on Imports				
New Taxes on Imports				
Taxes on Exports				
Exports Rebate	9,367	12,288	11,744	11,133.00
SCF				0.89

Source: Central Bureau of Revenue, Pakistan

(4) Project Life

The project life depends on the endurability of its components. The service life of civil works was assumed at 50 years and the electrical and mechanical components are assumed to be replaced during the life of the project. Regular repair and maintenance will also be factored into the recurrent cost. However, for financial analysis, only the concession period, 25 years in this case, was considered.

(5) Price Escalation

The cost estimate and corresponding cash flows in the economic analysis reflect the mid-1999 constant price. Price escalation is taken into account up to the year 2009 when the dam construction is completed. The total construction cost of the project including price contingency is estimated in Chapter 9. However, estimation of price contingency would be needed for financial analysis of power only. The World Bank's Manufacturers Unit Value (MUV) is employed and the international inflation rate is assumed to be 2.4% per year.

(6) Others

In the financial analysis, a US¢ 0.23 per kWh water charge is levied to independent power producers (IPPs) as the policy of the Government of Pakistan. This water charge is applied to the three financial models (joint venture, 100% private, and 100% public) since an independent entity under whatever financing scheme is supposed to be responsible for its own profits and losses.

12.2.2 Valuation of Cost

(1) Cost for Project Evaluation

The total capital cost on the Munda project was estimated at US$ 1,148.9 million (including US$ 120.1 million in tax and duties.), of which US$ 611.8 million, or 53% is in foreign cost. Since the hydro generation capacity is estimated to be 740 MW, the unit cost is US$ 1,553/kW installed based on the total capital cost. The cost estimated is based on the detailed figures presented in Section 9.2.

The construction period was assumed to start from the year 2002, and last to the year 2009 and the disbursement schedule is shown in Table 12.2.1. The date of commissioning was assumed in the year 2010. Any cost, such as engineering and preparation fees, before the year 2002 was treated as the cost incurred in the year 2002.

(2) O&M and Replacement Costs

Annual operation and maintenance costs for the hydropower plant were estimated on the basis of the general experience of the Study Team for plants under similar conditions, and on specific information for other hydropower plants in the region. The average rate for O&M was assumed at 0.5% per annum of the total capital cost, and average auxiliary rate and line loss to delivery point were assumed to be 1.3% of the total generation.

The replacement of various equipment at intervals during the project lifetime has been included in the economic analysis as a lump-sum replacement cost of US$ 135.7 million that would incur in the 30th year of operation.

12.3 Valuation of Benefits

12.3.1 Power Benefits

(1) Avoided Cost

Thermal plants contemplated in the recent generation program (up to 2018) includes 9,000 MW of coal fired units and 10,080 MW of combined cycle units for base load supply. So the avoided thermal units assumed with the Munda Dam is a mix of gas turbine and combined cycle generators. Only the capacity cost of gas turbine is considered for peak power generation. Capacity cost of gas turbine, at 100-200 MW unit class, is assumed to be US$ 480 per kW, based on the unit cost in other studies by HEPO and updated to 1999 price. The off-peak energy does not contribute any avoided thermal capacity, but does avoided fuel and O&M cost of the thermal power plant.

The details of the Munda avoided cost assumption is shown in Table 12.3.1.

Long Run Marginal Cost (LRMC)

Long Run Marginal Cost (LRMC) is used assuming that the power will be sold to WAPDA grid. LRMC was calculated in a study conducted by HEPO in 1994/95 as shown below:

Long Run Marginal Cost at 1994/95

Level	Marginal Capacity		Marginal Energy Cost US¢/kWh	
	US$/kW	US$/kW-a	Peak	Off-peak
Generation	461	54	3.70	3.16
500 kV	559	66	3.76	3.21
220 kV	597	70	3.80	3.27
132 kV	689	81	3.89	3.36
66 kV	725	85	4.04	3.46
33 kV	725	85	4.34	3.65

Note: kW-a means annualized cost of capacity cost
Source: Hydro Electric Planning Office

For the Munda project, use of transmission line of 220 kV up to Shahibagh substation was optimized but in this study, LRMC at 500 kV level which gives a conservative value is applied and updated to a level of September 1999 as below:

LRMC at September 1999

	Capacity US$/kW	Capacity US$/kW-a	Peak US¢/kWh	Off-peak US¢/kWh
500 kV Level	583	70.29	3.92	3.36

The LRMCs at peak and off-peak are estimated to be US$ 0.061/kWh and US$ 0.056/kWh, respectively.

Energy generation of the Munda hydropower is as follows:

Total Energy Generated

	Peak	Off-peak	Total
Energy at power plant (GWh)	847	1,560	2,407
Energy at grid (GWh)	835	1,540	2,375
Installed capacity (MW)	740		

The multiplication of the LRMC with energy generation gives the primary energy benefit (US$ 51.06 million) and secondary benefit (US$ 85.47 million).

(3) Consumer Surplus

WAPDA's average tariff as of April 1999 was calculated to be about Rs 3.76/kWh or equivalent to US¢ 7.52/kWh. The tariff was considered, however, to underestimate the real value of electric energy to consumers in a power shortage

situation. A more appropriate measure of this value is the consumer's willingness to pay (WTP) for electricity.

Consumer surplus is the method usually used in estimating consumer's WTP. It may be derived by observing how much consumers of various categories are willing to pay for electricity from alternative sources. The consumer surplus was estimated at 81% over the prevailing tariff in both studies of the Matiltan and Ghazi-Barotha Hydropower Projects. In this Study, consumer surplus is assumed to be conservative, around 50% over the prevailing tariff.

The tariffs with consumer surplus at peak and off-peak are estimated to be US$ 0.1094/kWh and US$ 0.0547/kWh. The multiplication of these tariffs with energy to be generated gives the consumer surplus-based benefits consisting of US$ 91.4 million for primary and US$ 84.3 million for secondary energy.

12.3.2 Agricultural/Irrigation Benefits

The evaluation of the agricultural and irrigation costs and benefits is based on with and without scenarios and development concept discussed in Chapter 5. The incremental net benefits were calculated and converted into economic price for economic analysis. Three irrigation benefits, that is, for new command area, for additional water supply for LSC system, and for stable and sufficient water supply to civil canals, were considered here.

An import parity price of major crops such as wheat, maize, and soybean is estimated as economic value of them based on the World Bank's World Commodity Price, April 1999.

(1) Benefit for New Irrigation Command

Net annual irrigation benefit for new irrigation command of the Project is estimated at Rs.152,100,000 (with project: Rs.163,900,000. without project: Rs.11,800,000). The unit benefit is Rs. 24,900 in terms of specific benefit of unit agricultural land, per hectare.

(2) Supplemental Irrigation Water Supply to LSC System When Water Shortage Happens.

All reduction of productions of crops caused by water shortage can be regarded as the project benefit, and calculated at Rs. 96,625,000 annually as shown as follows:

Annual Benefit of Supplemental Irrigation Water Supply to LSC System

Crops	Cropping Intensity	Cropping Area (Acres)	Shortage of water	Specific Benefit (Rs./Acre)	Damaged efficiency	Recovered Benefit (1,000 Rs.)
Wheat	40%	53,800	23.6%	4,789	100%	60,805
Sugar Cane	25%	33,625	23.6%	8,958	25%	17,772
Sugar Beet	5%	6,725	23.6%	8,671	50%	6,881
Oil Seed	3%	4,035	23.6%	2,152	50%	1,215
Rabi Fodder	6%	8,070	23.6%	5,804	50%	5,527
Vegetables	2%	2,690	23.6%	14,027	50%	4,452
Total						96,625

Total command area of LSC is 134,500 acres

(3) Stable and Sufficient Water Supply to Civil Canals Located Downstream of Munda Headworks

Civil canals have supplied irrigation water and municipal water to the concerned command areas. During Rabi (dry season), it is not possible to supply sufficient water to the civil canals under the present condition because of lack of runoff in the Swat River.

Benefit due to enhancement of irrigation by providing sufficient water to the civil canals may be considered to be produced by making the present rainfed cultivation to irrigated cultivation of wheat during Rabi. Since the command area of concerned civil canals under the Project is 5,300 ha (13,000 acres), it will bring about Rs. 41,000,000 annually as the irrigation benefit.

In the present benefit analysis, only 5.7 m^3/sec (200 cusecs) for the existing civil canal were taken into account. 2.85 m^3/sec (100 cusecs) as maintenance flow as referred to Subsection 5.4.3 were not evaluated as its use at downstream stretches can not be proven on sound base though the same would be utilized for some purposes somewhere while it flows down to the ocean.

(4) Total Irrigation Benefits

The total irrigation benefits due to the Munda Project are summarized as follows:

New irrigation	Rs 152,100,000
Supplemental water	Rs 96,625,000
Sufficient water	Rs 41,000,000
	Rs 289,725,000

The benefits total Rs 289.7 million or US$ 5.79 million. In financial analysis, only the irrigation benefits for the new command area, Rs 186.4 million or US$ 3.73 million are used.

12.3.3 Flood Mitigation Benefits

The flood mitigation benefits were calculated based on the historical flood damage data. The probability of different average annual flood damages was calculated and the incremental benefits extracted for financial analysis and converted to economic benefits. Economic and financial benefits were calculated as US$ 0.92 million and US$ 1.03million, respectively.

12.3.4 Summary of Benefits

The following table shows a summary of benefits:

Summary of Benefits

(Million US$)

	Total	Power Generation	Irrigation	Flood Control
Economic Benefits in First Year of Operation	143.25	136.53	5.79	0.92
Financial Benefits in First Year of Operation (Simple Cash Flow)	208.79	204.02	3.73	1.03

12.3.5 Environmental Benefits

Environmental benefits of avoided thermals units in Pakistan are substantial. Although they were not considered in the base models, they were tested, using the internalized environmental cost of thermal units. Based on a World Bank study, Incorporating Environmental Concerns into Power Sector Decision-making, 1994, the environmental cost for coal-fired generation was estimated at about US¢ 1.73 per kWh, gas turbine about US¢ 1.32 per kWh, and combined cycle US¢ 0.86 per kWh with note that the latter two were adjusted so as to suit for fuel being gas instead of diesel oil which was the base for the World Bank study. In the present feasibility study, the environmental cost for gas turbine is assumed for peak power generation at US¢ 1.32 per kWh and for combined cycle for off-peak generation, at US¢ 0.86 per kWh.

12.4 Cost Allocation

The Munda dam is a multi-purpose project and the dam construction costs estimated are allocated into power generation, irrigation, and flood control. The method called Separable Cost Remaining Benefits is used for cost allocation, and results are tabulated below:

Cost Allocation

(million US$)

	Remaining Benefits Method	Power	Irrigation	Flood Control	Total
a	Total Multi-purpose project cost, 12% NPV				641.0
b	Benefits	1,825.3	31.0	8.6	1864.9
c	*Alternative Single Purpose Project Cost	1,883.0	32.0	8.7	1,923.7
d	Justified Expenditure (lesser of b or c)	1,825.3	31.0	8.6	1,864.9
e	Separable Multi Purpose Project Cost	268.8	39.8	0.0	308.6
f	Remaining Justified Expenditure (d-e)	1,556.5	0.0	8.6	1,565.1
g	Percent Distribution of f	99.45%	0.0%	0.55%	100.00%
h	Inseparable M-Purpose Project Costs Allocation((a-e)*g	330.6	0.0	1.8	332.4
i	Total Allocated Cost (e + h)	599.4	39.8	1.8	641.0
j	Percent Distribution of i	93.51%	6.21%	0.28%	100.00%

Cost Allocation

Million US$

	Economic Cost	Financial Cost
Economic cost ((LC-tax)*0.89+FC)	735.6	1,148.9
Economic cost ((LC-tax)*0.89+FC)-Power	687.9	1,074.5
Economic cost ((LC-tax)*0.89+FC)-Irrigation	45.7	71.3
Economic cost ((LC-tax)*0.89+FC)-Flood	2.0	3.1

12.5 Viability of Project

12.5.1 Economic Viability

The economic viability of the Project was assessed by the economic internal rate of return (EIRR). Economic construction cost is estimated to be US$ 735.6 million. Benefits consist of power generation, irrigation, and flood control, out of which power benefits are separately estimated by i) avoided cost, ii) LRMC, and iii) consumer surplus.

(1) EIRR of the Project

Avoided cost

The cash flow is shown in Table 12.5.1, where avoided costs of gas turbine account for capacity, O&M, and fuel expenses for peak generation while that of combined cycle does fuel expenses only. The EIRR of avoided cost is estimated to be 13.65%.

LRMC

The power benefits comprise primary and secondary ones. Since the Munda Project contribute to generation of environmental benefit as explained in 12.3.4, the EIRRs of the Project estimated based on LRMC is further classified into those with and without environmental benefit.

EIRR with environmental benefit	14.9 %
EIRR without environmental benefit	13.3 %

The cash flow of LRMC is shown in Table 12.5.2 and 12.5.3.

Consumer surplus

Both peak and off-peak energy tariff are assumed to be 50 % over the prevailing energy tariff. The cash flow is shown in Table 12.5.4 and EIRR is estimated to be 15.8 %.

(2) EIRR by Purpose

The estimation of power benefit is represented by LRMC. The results of EIRRs by purposes are summarized as follows:

EIRR by Purpose

Description	EIRR	Table as reference
Power	13.4 %	Table 12.5.5
Irrigation	9.7 %	Table 12.5.8
Flood control	24.2 %	Table 12.5.10

12.5.2 Financial Viability

The financial viability of the Project was assessed by financial internal rate of return (FIRR). Financial construction cost is estimated to be US$ 1148.9 million. The results of FIRRs are summarized as follows:

FIRR by Purpose

Description	FIRR	Table as reference
The project as a whole	12.7 %	Table 12.5.6
Power	13.2 %	Table 12.5.7
Irrigation	4.1 %	Table 12.5.9
Flood control	19.7 %	Table 12.5.11

12.6 Financial Analysis

12.6.1 General Description

The financial analysis of the Munda Project was based on the assumption that the scheme (Power Only) will be owned and operated by an independent company (Private, or Public, or Joint Venture) that will supply all the energy generated to the national grid. The grid was assumed to be operated by WAPDA or the future transmission company, which will purchase all the energy at a technically and economically acceptable point (at 500 kV level). The tariff, as well as other relevant parameters for financial analyses, was determined based on two principles: a) the Project must be profitable, and b) the tariff level should be lower than Rs 3.9/kWh which was paid to IPP in 1997/98.

Three scenarios are envisioned; 100 % publicly-owned, 100 % privately-owed, and Public-Private joint ventures. Prices used in the analyses are market prices. The analyses were carried out in fixed prices, at the mid-1999 level. A 25 year life after commissioning of the Munda Project was assumed, as stipulated in the Policy Framework document for IPP project. At the end of the 25 years, the Project will be transferred to the Government free of charge.

(1) Tariff: Peak and Off-peak price

Off-peak tariff is usually calculated as 80% of the peak tariff in other studies. In the Long Run Marginal Cost table, the difference is between 81 and 85%. The load factor of WAPDA system is 69.8% in 1998, implying a larger difference in peak requirement and average consumption. However, in order to maintain consistency between economic and financial analyses, 80% of peak tariff was assumed for the secondary energy in the financial analysis.

(2) Parameters for Financial Analysis

The basic assumptions for financial analyses are summarized as follows:

Parameters for Financial Analysis

Description	Unit	Financial Parameters		
		Public-Private	100% Privately-owned	100% Publicly-owned
Total Capacity (Base Model)	MW	740	740	740
Plant Utilization Factor (Firm Energy)	%	37.14 (13.06)	37.14 (13.06)	37.14 (13.06)
Total Cost (exclude Interest during construction and Price contingency)	Mil. US$	916.33	916.33	916.33
Debt-equity Ratio		70-30	70-30	70-30
Years of the Project Considered	Years	25	25	25
Weighted Average Interest Rate		9.8	12.5	1.8
O&M	%	1	1	1
Annual Escalation of O&M	%	1.24	1.24	1.24
Water Charge	USc	0.023	0.023	0.023
Depreciation	25 Years	Flat Rate	Flat Rate	Flat Rate
Tax	%	0	0	0
*Insurance and Development fee as % of total cost	%	1	1	1

Note:* Insurance on the loan during the construction period is required by lenders and Development Fee is assumed before and during the construction period.

12.6.2 Cost Assumed for Financial Analysis (Power Only)

Total investment cost is US$ 1,092.7 million at the mid-1999 price level, including customs duties and tax of (10.7%) on imported equipment and other procurement items and price and physical contingencies; the cost of transmission equipment was included in this total. Replacement cost was considered to maintain the plant in proper working conditions for the concession period.

Cost Estimate (Power Only)
(Based on Public-Privately Owned Model)

Unit: Million US$

Total in 1999 US$	2002	2003	2004	2005	2006	2007	2008	2009	Total
Disbursement Schedule	3.9%	5.9%	8.1%	10.3%	18.0%	20.9%	22.1%	10.8%	100.0%
Total in 1999 US$ excluding IDC	35.97	52.96	74.02	94.84	165.11	191.35	202.76	99.31	918.33
Nominal Price	38.63	58.23	83.34	109.34	194.93	231.33	251.00	125.89	1,092.7
Total to Date	38.63	96.86	180.20	289.54	484.47	715.80	966.81	1,092.69	3865.0
IDC	1.33	4.77	10.00	17.35	29.07	45.84	65.71	83.34	257.4
Insurance and fee	0.28	0.44	0.65	0.89	1.57	1.94	2.22	1.46	9.5
Total	40.23	63.44	93.99	127.58	225.57	279.11	318.93	210.69	1,359.60
Total to Date	40.23	103.68	197.67	325.25	550.82	829.93	1,148.86	1,359.55	
Total Loan	28.16	44.41	65.79	89.31	157.90	195.38	223.25	147.48	951.7
Total Equity	12.07	19.03	28.20	38.28	67.67	83.73	95.68	63.21	407.87

The difference in financing models will have impact on interest during construction (IDC), loan interest rate, and taxes (although not assumed here), etc. According to the usual practice on IPPs, 1% of the total cost was added during the

initial phase of the Project to cover the development cost and insurance fee on loans during the construction.

12.6.3 Benefits for Financial Analysis

(1) Revenues:

The energy generated and supplied, net of line loss and auxiliary use, was taken to be 835 GWh for peak energy and 1,540 GWh for off-peak energy. The tariff was set at 1999 price, and will be escalated at 2.4% per annum (international inflation rate) before Commercial Operation Date (COD) and 1% after COD. The weighted average price of peak and off-peak tariffs in mid-1999 was assumed to be US$ 0.0662 and escalated to US$ 0.0860 in the year 2010, the date of commissioning. Annual revenue was assumed to start at US$ 204 million. The net cash received also includes a small amount of interest received on the deposit in the bank.

The plant factor was set at 37.14%, but only 13.06% is used here as firm energy, considering the hydrology risk. Therefore a high peak power tariff, US$ 0.0987/kWh in 2010 price, was assumed for the Project. The tariff for the secondary energy is 80% of the primary tariff. Table 12.6.1 explains the processes taken for this calculation. Based on the rules setup by the government policy, the following three- step tariff structure was assumed:

Peak Energy Tariff at Current Price

Years	Tariff (US¢/kWh) in 1999
01-12	7.6
13-22	7.4
23-25	7.6

During the first 12 years the tariff will be slightly high to cover the loan repayment and insure a reasonable level of profit to the investors. In the next ten years, the tariff will be brought down after the loan repayment requirement is eased. The tariff will return to its initial level just before the Project is supposed to be reverted to the government.

The WAPDA's purchase price from IPPs can be used here as a reference to the tariff calculation.

Estimated IPP Price to Consumers

US$ = Rs. 43.1958 in 1997-98

Generation	Average T&D	Average T&D*	Rs./kWh	US$/kWh
Rs./kWh	Rs./kWh	Required	Average Price	
3.91	0.62	0.13	4.66	0.108

Note: * Since power transmission operation is becoming a separate entity, the current and future Transmissions & Distributions (T&D) cost is used to estimate transmission cost.

Source: WAPDA

For the use of water by the power company, a water charge of US¢ 0.23/kWh is to be levied. This charge is deducted from the bulk tariff paid to the company by WAPDA.

In view of the long term power demand, the full energy supply, peak and off-peak, from the Munda Project was applied in the analysis.

(2) Cost

The cost per kWh, levelised to the year 1999 is US$ 0.0687, assuming a 16% rate of return on equity investment, based on Public-Private Investment Model (Table 12.6.2).

12.6.4 Public-Private Investment Model

Assumptions:

The public-private model assumes a joint venture between GOP and a consortium of private sector. An independent power development company under BOT schedule was assumed in this model and the debt-equity ratio of 70-30 was used. GOP would be responsible for 25% of equity investment, and the GOP equity was assumed to come from an international soft loan, with an interest rate of 1.8%, a 30 year repayment including a grace period of ten years.

The weighted average interest rate of the loan for the whole project (70% of the total cost) was assumed at 9.8%. The prevalent interest rate of commercial loans in Pakistan was assumed at about 12.5% while the international soft loan of 1.8% was assumed as mentioned above. The international soft loan, in this model, was assumed to cover 25% of the total loan to correspond to the proportion of the government ownership of the project. However, OECF loan can actually cover up to 75% of the total project cost.

Annual O&M and insurance cost was assumed to be 1.0% of the total project cost and escalated at 1.24% per annum. Annual insurance and fee during the

construction period was assumed to be 1% of the loan portion (70%) of the total annual investment.

Plant self-use and line loss was assumed to be 1.3% as in the economic analysis. US¢ 0.23/kWh was used for water charge according to recent government policy. IPPs under the 1994 government policy were exempted from corporate income tax, therefore, the corporate income tax was not assumed here.

A flat, 25 year depreciation rate was assumed. The concession period is 25 years and after 25 years, the project will be reverted to GOP. The analysis is presented in Tables 12.6.3 and 12.6.4.

The results for the Public-Private Investment Model:

Equity	30%				
		Government	25%		
		Developers	75%		
Loan	70%				
		Commercial loan	75%	Government equity loan	25%
		Interest	12.5%	Interest	1.8%
		Repayment	25 yrs	Repayment	30 yrs
		Grace	-	Grace	10 yrs

FIRR and NPV for Public-Private Investment Model

	Public-Private Investment Model	FIRR (%)
1.	FIRR on project	12.8%
2.	FIRR on equity	15.2%
3.	FIRR on GOP receipts, including Dividends, Water Charge and others	17.4%
4.	FIRR on GOP (Dividends only)	15.2%
5.	NPV at 12%, Million US$ of Total GOP Receipts	86.7

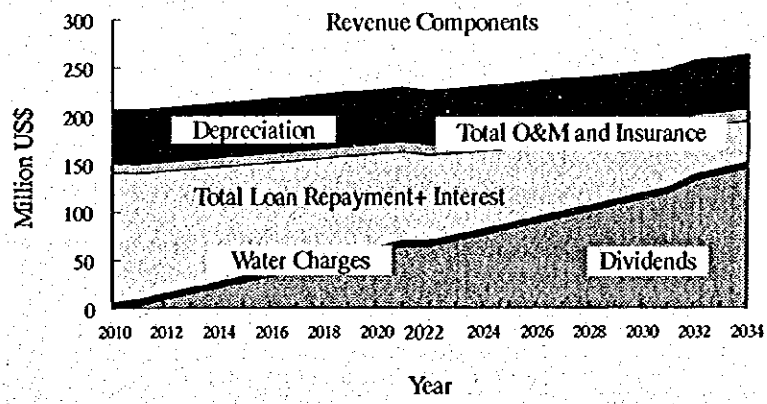

Figure 12.6.1 Public-Private Investment Model: Million US$

12.6.5 Private Investment Model

This model assumes 100% private investment in the Project. The debt-equity will still be 70-30%, yet the loans will all come from commercial loans with higher

interest rate, at 12.5% in weighted average, and short repayment period, in most cases, without grace period.

In the 100% Privately-owned Model, the government's income will come from water charge only. The analysis is presented in Table 12.6.5.

FIRR for 100% Private Investment Model

	100% Private Investment Model	FIRR (%)
1.	FIRR on project	12.8%
2.	FIRR on equity	11.1%

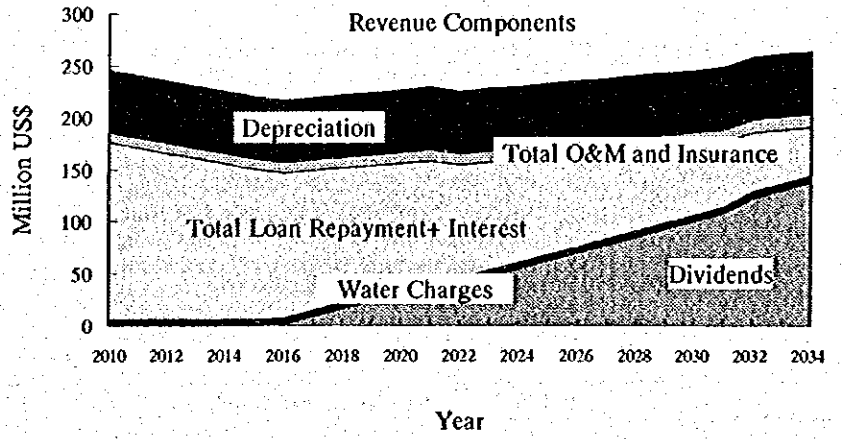

Figure 12.6.2 Private Investment Model: Million US$

To achieve a Financial Rate of Return above 12% on equity, the Project will need a higher tariff to cover its development cost and high interest rate, which will exceed the average current price paid to IPPs.

12.6.6 Public Investment Model

In Publicly owned Model, the power company will pay no tax and the project cost will be covered by an assumed international soft loan at an interest rate of 1.8% per annum, 30 years repayment period and 10 years grace.

FIRR and NPV for 100% Public Investment Model

	100% Public Investment Model	FIRR (%)
1.	FIRR on project	12.8%
2.	FIRR on equity	26.2%
3.	NPV at 12 %, Million US$ in water charge and dividends	562.7

This model will bring more favorable returns to the government. The only risk is if WAPDA/GOP can maintain a tariff level on a par with that of IPPs so that the

Project will be commercially viable. The analysis is presented in Tables 12.6.6 and 12.6.7.

12.6.7 Sensitivity Analysis of FIRR

Risks in investing in hydropower projects in Pakistan, from a developer's point of view, include external and project risks. External risks are foreign exchange risks (convertibility and devaluation) and inflation. Project risks are the possibility that the sales price agreed in the power purchase agreement fails to be honored with unexpected tax increase. Other risks include cost and time overrun, power production short of projection for hydro and other reasons, O&M cost increased by 20% of the total project cost, commissioning date delay by one year, and unexpected increase of water charge and corporate income tax.

Sensitivity analysis of FIRR was carried out on the 100% publicly owned model to test the risks involved in the project. The results are favorable as shown in Tables 12.6.8 to 12.6.12, except the return on project is somewhat sensitive to the delay and investment cost increase, implying a lengthy duration of project construction.

Sensitive Analysis

	Risk Analysis	FIRR on Project	FIRR on Equity
1.	GOP Investment Base Case	12.8 %	26.2 %
2.	O&M Cost Increased by 20%	12.8 %	26.1 %
3.	Water Charge Up by 20%	12.7 %	26.1 %
4.	10% Increase in Investment Cost	10.9 %	23.1 %
5.	10% Decrease in Total Energy Sales	11.6 %	24.1 %
6.	Project Delay by One Year	11.7 %	22.9 %

12.6.8 Loan Repayability

At this stage, no sponsor for this Project has been identified, and the allocation of fund resources was roughly estimated based on experience. However, Debt Service Current Ratio (DSCR) was tested for the three financial models with various weighted average interest rates: 12.5% for 100% private, 9.8% for public-private joint efforts, with a long repayment period of 25 years (no grace period assumed). The minimum DSCR is 1.4 times for the joint venture, 1.1 times for 100% privately-owned, which are below the usually required 1.5 times by international development agencies. The loan terms assumed for the 100% publicly owned model are 1.8%, 30 years, with 10 years' grace period. The minimum DSCR for this model is 5.0 times, showing a very strong loan repayment ability, because of the low interest rate and the long grace period.

Note: DSCR means (Net after tax profit excluding depreciation, interest and repayments) / (Principal and interest payments).

12.7 Summary of the Economic and Financial Analyses

The analysis was carried out on the basis of the proposed project plan and cost estimate done by the Study Team. The financial cost was converted into economic cost by netting out price escalation, duties, and taxes. Shadow pricing to foreign exchange is usually derived from the difference between the Open Market Rate and the Government Rate, but is not used here, since Rupee was generally free to float on the international currency markets when the feasibility study was conducted. Adjustment was also made using standard conversion factor.

Since the Munda Project is multipurpose, the estimated cost was allocated into three different portions, power generation, irrigation, and flood control, using Remaining Benefits Method. Both economic and financial analyses, simple methods, were tested on total project, (1) power generation only, (2) irrigation only, and (3) flood control only. The results are shown as follows.

Comparative Analysis
(Simple Cash Flow)

Unit: Million US$

	Total Project*	Power Only*	Irrigation Only	Flood Control
EIRR in 50 years	13.2 %	13.4 %	9.7 %	24.2 %
Total Project Cost (Economic) in Mil US$	735.6	687.9	45.7	2.0
NPV of Benefit at 10% Discount rate (Economic)	194.17	193.2	(1.0)	3.05
* Using LRMC cost at 500 kV				
FIRR in 50 years	12.7 %	13.2 %	4.1 %	19.7 %
Total Project Cost (Financial) in Mil US$	1,148.9	1,074.5	71.3	3.1
NPV of Benefit at 12% Discount rate (Financial)	55.1	83.0	(27.2)	1.75

EIRR of irrigation is below 10%, which shows low economic viability while the FIRR is as low as 4.1% and hence irrigation would not be objective of investment. FIRR of the total project is 12.7%, slightly higher than the opportunity cost of capital (12%).