(3) Total Sediment Inflow

The total sediment yield can be estimated as the sum of suspended load and the bed load, namely, 373 ton/km^2.

The geological condition of the basin was reviewed in order to evaluate the estimated total sediment inflow. The geological condition of a catchment area is one of the influential factors on sedimentation together with other factors such as precipitation, vegetation, river gradient, and pitch of uplift. The catchment area of the Munda Dam has different geological conditions compared with neighboring dams of Tarbela and Warsak. In the area of Tarbela dam, unconsolidated sand of terrace deposits is widely distributed on the relatively higher portions of the catchment area. Due to the erodible nature of the sand, sedimentation problem has arisen in the Tarbela reservoir. The upstream area of the Warsak Dam lies in rocky desert containing a huge amount of loose sand, and sedimentation problem has occurred in the Warsak reservoir due to the erosion of the loose sand. In contrast with the geological condition of those two areas, the catchment area of the Munda Dam lies in rocky mountains covered with few erodible deposits. Although unconsolidated river deposits are distributed on a wide and gentle river plain in the middle reaches of the Swat River between Chakdara and Mingora, the river plain is relatively stable and looks like a trap of eroded materials from the upstream mountains without intense erosion. Considering these geological factors, the estimated annual total sediment of 373 ton/km^2 for the Munda Dam site is judged to be reliable.

(4) Fresh Sediment Density

The initial specific weight (fresh) of sediment density can be estimated based on the ratios of the clay, silt and sand contents in the sediment load using the following equation (ref. 12, eq. 12.8.2, pp. 12.38):

$$W_o = p_c W_c + p_m W_m + p_s W_s$$

Where W_o, W_c, W_m and W_s are the densities (kg/m^3) for initial, clay, silt, and sand respectively, and p_c, p_m and p_s are the percentages of the corresponding total sediment composition. Based on the mode of reservoir operation, the values of W_c, W_m and W_s can be estimated as 416, 1,120, 1,550 kg/m^3, respectively (ref. 12 pp. 12.39). According to the collected sediment data for the four stations, average percentages of clay, silt, and sand in the sediment load were estimated as 0.30, 0.53, and 0.17, respectively.

Using the above mentioned formula and percentage of clay, silt, and sand contents in the sediment load, the initial sediment density was estimated to be 982 kg/m^3.

(5) Compacted Sediment Density

Since the density of the deposited sediment will increase each year, the specific weight of sediment must be predicted in order to estimate the storage space in the reservoir which will be replaced by sediment in a given period of time.

In case of Munda Dam, the sediment is considered always submerged or nearly submerged. Using Miller's formula (ref. 12, eq. 12.8.3, pp. 12.39) the average density of sediment accumulation after 100 years is calculated as 1,257 kg/m^3.

(6) Bed Load Density

For bed load, accumulated permanently submerged specific weight can be considered as 1,760 kg/m^3 according to recommended range values by U.S. Soil Conservation Service for General Design Purposes. (ref. 13, Table 17-I-5, pp. 17-18)

(7) Trap Efficiency

Not all sediment passing through the dam section will be deposited in the reservoir because part of this amount of sediment will pass through spillway, waterways and river outlet.

The most commonly used relation for determining sediment trapping is the sediment trap efficiency curve developed by Gunner Brune and Dendy (ref. 12, Figure 12.8.2, pp. 12.38 and ref. 14, pp. F-2), where the trap efficiency is defined as the ratio between sediment trapped in the reservoir and the total sediment entering the reservoir.

$$E = 100 \times 0.97^{0.19^{\operatorname{Log}(C/I)}}$$

Where, E is the trap efficiency, C is the reservoir storage capacity and I is the flow inflow rate. As the storage capacity changes with the operation period, trap efficiency will be calculated for a 10-year interval as will be discussed later.

(8) Accumulation of Sediment in the Reservoir

In order to estimate the sediment accumulation in the reservoir, a 10-year calculation period was considered. For each period, cumulative sediment values were calculated based on trap efficiency suspended and bed sediment unit weight estimations. Four cases of the reservoir scales were examined as follows:

- Case 505: FSL 505 m and gross storage 690 million m^3
- Case 530: FSL 530 m and gross storage 1,070 million m^3
- Case 555: FSL 555 m and gross storage 1,590 million m^3
- Case 580: FSL 580 m and gross storage 2,340 million m^3

The results are summarized as follows:

Sediment Accumulation

Period	Sediment Accumulation million m^3			
	Case 505	Case 530	Case 555	Case 580
10	40.7	42.6	43.9	44.8
20	77.1	80.8	83.3	85.2
30	112.0	117.6	121.4	124.2
40	146.0	153.6	158.7	162.3
50	179.2	188.8	195.3	199.9
60	211.7	223.6	231.5	237.0
70	243.6	257.9	267.3	273.8
80	275.0	291.8	302.7	310.3
90	305.7	325.4	337.8	346.4
100	335.8 (0.25 mm/year equivalent)	358.5 (0.26 mm/year equivalent)	372.7 (0.27 mm/year equivalent)	382.3 (0.28 mm/year equivalent)

From this table, it can be seen that the reservoir would lose 49, 33, 23, and 16% of its capacity of 690, 1,070, 1,590, and 2,340 million m^3, respectively, after 100 years.

The plan formulation study was concluded with the optimum case of 555. The estimated sediment accumulation after 100-year is 373 million m^3 for the case 555. Figure 3.3.19 shows specific sediment discharges for some dam and hydropower projects in Pakistan as well as Munda Project. The Munda sediment accumulation of 0.94 ton/day/km^2 falls within a reasonable range in Figure 3.3.19. Therefore, the estimated 100-year sediment accumulation of 373 million is considered acceptable.

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CHAPTER 4 POWER DEVELOPMENT SURVEY

4.1 Power Sector Organization

4.1.1 Power Sector Organization of Pakistan

The energy sector organization of GOP is shown in Figure 4.1.1.

In the power sector, the Ministry of Water and Power controls the two power supply utilities, Water and Power Development Authority (WAPDA) in charge of the whole country except the Karachi area and Karachi Electricity Supply Corporation (KESC) for Karachi city and its surrounding area.

The Energy Wing of the Ministry of Planning and Development prepares the energy policy of the government.

4.1.2 Basic Functions of WAPDA and KESC

WAPDA was established in 1958 as an autonomous body to investigate, plan, design, construct, and operate (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. The overall organization of WAPDA in 1998 is shown in Figure 4.1.2. The Power Wing to be headed by Member (Power) (vacant at present and a Managing Director is at this position) had four Managing Directors, one each for Distribution, Generation, Transmission and Grid Substations, and WAPDA Power Privatization Organization (WPPO). 8 Distribution Companies in charge of power distribution in the country are under control of the General Manager (Operation). WAPDA (Power) vertically controlled planning, design, construction and operation and maintenance of generation, transmission and distribution facilities in the entire country except the Karachi area. The construction of hydroelectric projects and operation and maintenance of dams are managed by the Water Wing.

KESC is also a vertically integrated power utility that controls the generation, transmission, and distribution of electric power in and around Karachi city.

However, the current power supplying functions of WAPDA and KESC are in the process of dissolution to attain corporatization and privatization of the power sector as mentioned in Subsection 4.1.4.

4.1.3 HEPO, NWFP Government, and SHYDO

In coordination with the electric power policy of the government, the three public organizations of HEPO, NWF Provincial Government, and SHYDO are also executing activities related to the development of hydroelectric projects and power supply in remote areas in NWFP as mentioned in Appendix D1.

HEPO is a supporting organization of WAPDA Water and is in charge of preparing Feasibility Study and Detailed Design including preparation of Bidding Documents for hydroelectric projects. HEPO is carrying out their investigation and planning activities covering the whole country. In NWFP, HEPO is investigating and planning large projects (over around 1,000 MW, such as 2,400 MW Dassu and 2,270 MW Thakot).

NWFP Government: Under the 1998 Policy for New Private Independent Power Projects, one window supports to IPP activities at the Provincial level are to be provided by NWFP Private Power Cell (PPC). Various activities such as water use license, environmental assessment, bidding process, assistance to PPIB in issue of LOS, etc. are to be executed by NWFP PPC in cooperation with PPIB.

Provincial and AJK governments are to prepare rural electrification plans in own territories for execution under the public sector. In addition, the NWFP Government is extending power supply to remote FATA areas by constructing small hydropower plants and extending WAPDA's power network, under cooperation of its affiliated organization of SHYDO.

SHYDO is a public organization under the NWFP Government, and is in charge of carrying out feasibility studies for medium to large run-of-river hydroelectric projects for implementation under the private sector. In NWFP, SHYDO is in charge of projects smaller than those for HEPO, up to around 1,000 MW. Several hydroelectric projects studied by SHYDO are going to be implemented under the private sector participation as mentioned in Section 4.5.

Related to the hydroelectric power studies by HEPO and SHYDO, foreign technical assistance is available from experts of GTZ of Germany in Pakistan.

4.1.4 Structural Reform of the Power Sector

In accordance with a recommendation of the World Bank for corporatization and privatization of the power sector organizations, GOP is now corporatizing power supply organizations under the public sector as the first step toward future privatization. A gradual transition from the present integrated and state owned public utilities to future decentralized system with substantial private ownership and management is being envisaged.

The huge organization of WAPDA is going to be dissolved to WAPDA itself in charge of hydroelectric generation, Pakistan Electric Power Company (PEPCO), a managing company, and 12 companies under PEPCO's control, comprising 3 Thermal Generation Companies, 1 National Transmission and Dispatch Company (NTDC) and 8 Distribution Companies. As of October 1999, these organizations have already commenced their operation, but their offices are in the WAPDA head office in Lahore except for regional distribution companies. The distribution companies are based in the existing WAPDA regional offices.

The 12 companies will initially be operated as public limited companies, but GOP intends to privatize the Thermal Generation and Distribution Companies at an appropriate time. While, NTDC may remain in the public sector in the medium term. KESC is supposed to become a distribution company for the Karachi area after transferring its generation and transmission facilities to respective companies. The national power development plan is being studied including the Karachi area.

At the present, the following structural changes are progressing as the first stage of reform:

a) As for hydropower generation, WAPDA Water will be in charge only for the hydroelectric generation of multipurpose and reservoir type projects covering all phases of planning, design, construction, and operation and maintenance. The run-of-river projects are to be implemented under the private sector. WAPDA is going to sell the generated power to NTDC.
b) The existing 11 thermal power stations will be managed by the three Thermal Generation Companies (Nos. 1, 2, and 3 companies located at Jamshoro, Guddu, and Multan). The Thermal Generation Companies will also sell the generated power to NTDC.
c) To attain the maximum extent of privatization, participation of private entrepreneurs (IPPs) is encouraged for construction and operation of generation projects in the forms of BOO (build, own, and operate) for thermal plants and BOOT (build, own, operate, and transfer) for hydroelectric plants.
The generated power of IPPs is also sold to NTDC. However, they are free to sell power directly to large consumers.
d) NTDC commenced its operation in 1999 as a public company for management of the 500/220 kV transmission system and dispatching control of the overall power system in the country. The company is responsible

also for the integrated operation of all the power system including power stations and transmission networks. The present National Power Plan (NPP) group is to belong to this company.

NTDC purchases power from WAPDA, three thermal generation companies and private producers and sell it to distribution companies and directly to large consumers as the wholesaler of electric power. The selling prices of power to eight regional Distribution Companies will be uniform for the time according to the government policy.

e) 8 regional Distribution Companies commenced their operation in the country as public corporations with the former WAPDA's Area Electricity Boards (AEB) as their cores. They are regionalized as given below:
   - Punjab : 5 (Lahore, Multan, Gujranwala, Faisalabad, and Islamabad)
   - NWFP : 1 (Peshawar)
   - Sindh : 1 (Hydelabad)
   - Balochistan : 1 (Quetta)

   These companies will also look after transmission lines up to 132 kV, grid substations and consumer power supply (distribution) facilities. These regional Distribution Companies commenced their operation in 1998.

f) The NEPRA Act was approved by the Parliament and signed into law in December 1997. The National Electric Power Regulatory Authority (NEPRA) is an autonomous, independent regulatory authority, solely responsible for the power sector. NEPRA is to oversee the power sector and to exercise control through its authority to license generation, transmission, and distribution activities, and to promote the establishment of a competitive and efficient power sector. Also it is responsible to carry out power cost studies to determine tariffs, rates, charges and other terms for power supply covering generation, transmission and distribution based on actual costs of services. However, according to a government request, the present tariff system is uniform to all distribution companies in the country. NEPRA is to prescribe and enforce performance standards of power supply business.

g) The Private Power and Infrastructure Board (PPIB) provides one-window supports at the Federal level to promote private sector power development. This organization includes one each representative from provinces and AJK. PPIB assists private sponsors in coordination with various governmental agencies to carry out negotiations on Implementation Agreement (IA), issue Letters of Support (LOS), monitor and follow up on progress of projects, etc.

The conceived relation of the power supply utilities at present is shown in Figure 4.1.3. The restructuring is now in the process of execution.

4.2 Power Tariff System

The current power tariff system effective from 1 April 1999 is presented in Table 4.2.1. The overall average tariff of WAPDA in 1997-98 was 2.96 Rupees per kWh including hydel surcharge, income tax, electricity duty, etc. The power tariff consists of the fixed charge per contract kW per month and energy charge per kWh consumed, and in addition the Fuel Adjustment Surcharge (FAS) and Additional Surcharge are charged to energy consumption. In the present tariff system, the additional surcharge occupies a very large portion as seen in the tariff table.

In October 1999, the next tariff rise effective in near future was announced.

Formerly, power tariffs were low to satisfy the basic human needs of poor people, and the financial balance of power supply utilities was in continual deficit, and power supply utilities were operated with subsidy from the government. With recommendations of international agencies such as the World Bank and ADB, the tariffs have been raised several times to improve self-financing capability of the power supply utilities including generation of development funds. Though the present tariffs are still not sufficient to cover all necessary costs and to make a reasonable profit in addition, it is recognized that the present tariffs are already high for the poor classes of the country.

Considerable degree of cross subsidy among consumption categories is observed in the tariff structure. Tariffs of the domestic category of small consumption are very low, while those of commercial category and large general consumers are higher than the others.

The time-of-day differential tariffs to charge high rates in the peak time and low in the off-peak time are applied only to large industrial consumers as seen in Table 4.2.1. This system is applied on an optional basis.

For industrial and bulk supply consumers, there is a penalty clause for low power factor consumption to impose penalty to consumers whose average power factor is below 90%.

All the consumer connection costs including line extension and meter installation and hiring charges are to be entirely borne by consumers. The feeder connection cost is high, and this system makes the consumer connection of poor people difficult.

At present, uniform tariffs are applied covering the whole country and tariffs of various categories are determined based on a pricing policy of the government without proper relevance to the actual costs of services to the different categories.

To attain privatization of the power supply business, the present pricing practices will need to be reviewed.

4.3 Historical Power Demand and Future Forecast

4.3.1 Historical Power Demand Records

The historical power generation and sales records of the country (WAPDA and KESC combined), WAPDA and KESC for the period of 1984 to 1998 are shown in Tables 4.3.1, 4.3.2, and 4.3.3. The annual growth rate of sold energy of the country was 6.2% on average in the last 10 years and 4.6% in five years, while GDP has grown during the same periods were 4.7% and 4.3% per annum. The growth of energy sales is stagnating in recent years presumably due to shortage in power supply capacities, both generation and transmission/ distribution. The energy audit, showing generated and sold energy, auxiliary power, energy loss, etc., of WAPDA and KESC are shown in Tables 4.3.4 and 4.3.5. Major particulars of the 1997-98 demand of the country are summarized below:

Major Particulars of 1997-98 Power Demand

Generated energy	60,018 GWh
Peak demand at generator terminal	10,081 MW
Sold energy	44,078 GWh
Per capita consumption	326 kWh
Annual load factor	68.0 %
T&D loss factor	24.0 %

The historical energy sales records of major sales categories of the WAPDA system are shown in Table 4.3.6. Since 1981, the sold energy to the domestic consumers has grown significantly and the domestic sector's share in the total has increased from 23.3% in 1981 to 41.8% in 1998. The industrial sales that formerly ranked first reduced its share from 39.4% to 27.5% in the same period, and the agricultural sales also reduced its share. The domestic sales surpassed the industrial sales in 1993. The transition of shares of energy of major categories for the period of 1983-84 to 1997-98 is as shown in Figure 4.3.1 below.

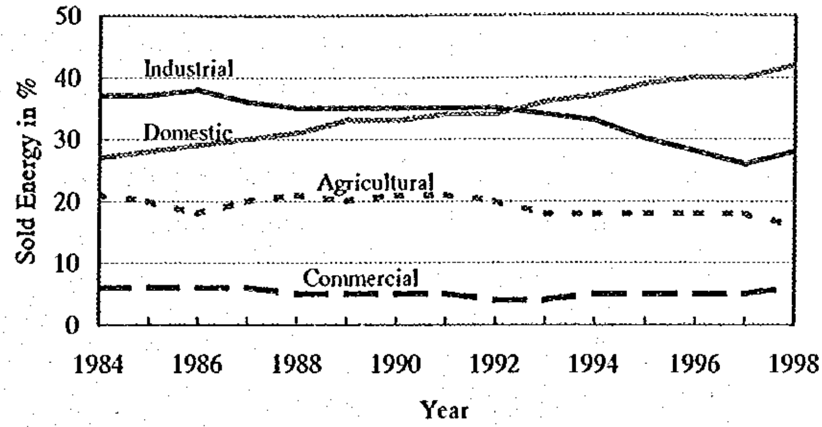

Figure 4.3.1 Transition of Category-Wise Energy

The transmission and distribution (T&D) loss factor of the WAPDA system was 24% in 1997-98. As noted in Table 4.3.4, the loss factor exceeded 30% in the latter half of the 1970s, but the factor gradually went down in the 1980s to a low of 20.3% in 1991, and has been increasing thereafter. This loss factor is high compared with other developing countries. To reduce the T&D loss, the LT distribution system including consumer service facilities need to be improved. Conceived loss reduction measures are stated in Appendix D2.

The LDC records for typical daily load curves of the WAPDA system are available for each month. The 1997-98 load curves of Summer (30 July), Winter (19 January) and Intermediate season (28 April) are compared in Figure 4.3.2.

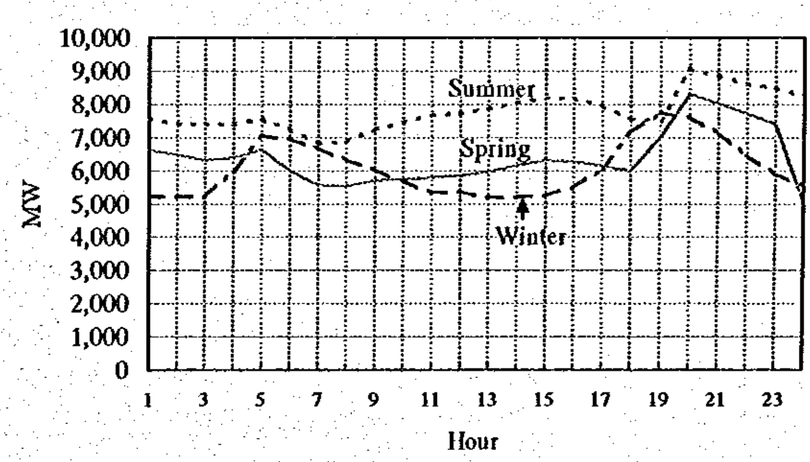

Figure 4.3.2 Daily Load Curves of Three Seasons

The following are observed from these load curves:

- The daily peak load appears in the evening, around 7 o'clock in winter and around 8 o'clock in summer, and the peak duration is around 4 hours throughout the year.
- Due to the increase in consumption for air-conditioning, both sold energy and peak demand are largest in summer, July. The daily load factor is also highest in this month.
- The shape of daily load curve is not much different between weekdays and Sunday in the same season. However, the peak load of Sunday is a few to 10% lower than that of weekdays.
- The daily load curve varies according to season; for instance the daytime demand is high in summer and morning peak is significant in winter.

The calculated daily load factors of the above 3 load curves are 78.5% in January, 76.7% in April, and 86.1% in July. The daily load factors are high due to suppression of peak demand caused by insufficiency in power supply capacities (transmission/distribution at present). These load factors will go down to a normal level of 70 to 75% when the supply capacities of power system become sufficient to meet the peak demand.

The Munda power station is planned as a peak power station, and for this Study the peak duration is assumed at 4 hours based on the present daily load curve from the reasons mentioned in Appendix D3.

4.3.2 Monthly Pattern of Future Power Demand

The monthly patterns of future peak demand and energy generation were estimated based on the past patterns of the WAPDA and KESC combined system in the recent 3 years, 1995-96, 1996-1997, and 1997-98. The computed peak demand, peak demand estimated if there is no peak suppression, is taken as real peak load. The power demand patterns of the 3 years are assumed to remain unchanged through the foreseeable future as explained in Appendix D3.

The behaviors of computed monthly peak demand and energy generation of the WAPDA and KESC systems combined for the recent three years are presented in Table 4.3.7 and analyzed in Table D3.1 in Appendix D3.

4.3.3 GOP's Load Forecast for Generation Programming

In the Revised 9th 5-Year Plan of May 1999, the government prepared power demand forecasts for the period of 1997 to 2018 in two scenarios. One forecast was based on a Normal Growth Assumption of Economy (6%), while the other scenario assumed a more realistic lower growth of economy (5%) referring to the recent situation of the economy. This low scenario forecast is quite similar to the forecast recommended by the World Bank.

The Normal Scenario and Low Scenario load forecasts are tabulated in Tables 4.3.8 and 4.3.9. The three forecasts, the above two of the government and WB's one, are compared in Figure 4.3.3.

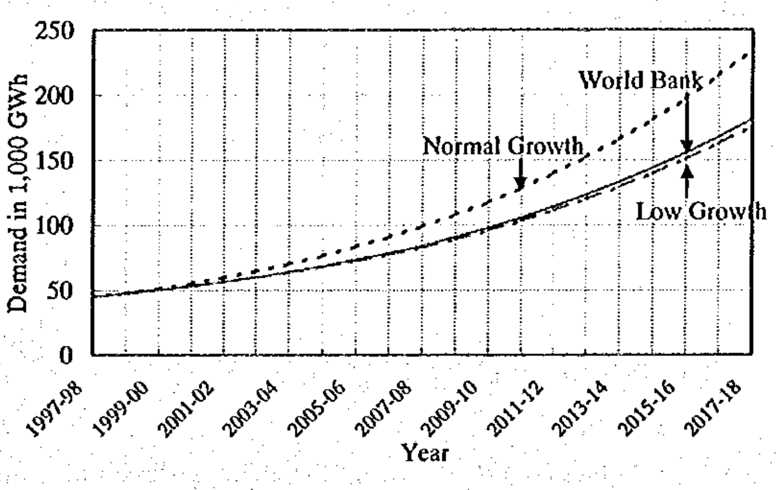

Figure 4.3.3 Comparison of Load Forecast

4.3.4 Review of Load Forecast by the JICA Team

The historical growth of sold energy was analyzed with reference to the growth of GDP for the period of 1982-83 to 1997-98. The past trends were analyzed on the following correlations at first. Then these trends were extended to the future for load forecasting taking into account prospects for changes in situation.

GDP of the Country vs Country energy sales
GDP of the Country vs Domestic energy sales
GDP of the Mining and Manufacturing sector vs Industrial energy sales
GDP of the Commercial sector vs Commercial energy sales
GDP of the Agricultural sector vs Agricultural energy sales

Good correlations are observed with some exceptions as detailed in Appendix D4. The correlation between GDP growth of the country and total growth of sold energy is in a declining trend. Though the ratio was over 1.6 for the past 15 years, this has become around 1.5 for the 10 years and further declined to 1.1 for the recent 5 years. Similar trends are observed also for other categories.

The JICA Study Team forecasted future demand for 2 cases of economic growths, i.e. GDP growth of 6% and 5%. The resultant growths are very similar to the GOP's forecast as compared between the forecast results in Table

D4.5 in Appendix D and the GOP's forecast in Tables 4.3.8 and 4.3.9. Thus, the revised load forecast of GOP is judged to be in a reasonable range. The detailed process for review of power demand forecast is included in Appendix D4.

However, considerable amount of investment will be required to achieve even the generation program based on the low scenario load growth.

4.4 Existing Power System

Information on the existing power system obtained mainly from WAPDA is included in Appendix D5, and items related to power system development are mentioned below.

4.4.1 Generation System

The generation system of Pakistan comprises hydroelectric and thermal power stations. Historical transition of the share of hydroelectric and thermal generation energy is shown in Table 4.4.1. The maximum hydro share of 78.7% was recorded in 1979, but the share has been declining thereafter due to delay in hydroelectric development caused by financial constraints, and is just over 40% recently. In 1997, the IPP generation was commenced and has exceeded 30% in energy in 1999.

As for the regional distribution of the generating capacity, the share of Punjab, the largest load center, is the largest, and followed by NWFP as shown below:

Installed Generation Capacity by Province

(Unit: MW)

Province	Hydro	Thermal	Total
Punjab	63	4,590	4,653
Sindh	-	2,909	2,909
N.W.F.P.	3,762	-	3,762
Balochistan	-	1,392	1,392
A.J.K.	1,000	-	1,000

The installed capacity of NWFP is large compared with its consumption, as the Tarbela power station is located in this province. In NWFP and AJK there are only hydroelectric plants, while the thermal plants are predominant in the other three provinces.

(1) Hydroelectric Power Generation

The total installed capacity of the existing hydroelectric power stations is 4,826 MW as tabulated in Table D6.1 in Appendix D, and the three major reservoir type power stations, Tarbela (3,478 MW), Mangla (1,000 MW) and Warsak (240 MW), occupies 98% of the total hydroelectric installation in the country. The largest Tarbela plant has 72% of the total capacity.

In Pakistan, the first priority of water use of multipurpose reservoir is the irrigation water supply. Therefore, the reservoir needs to be operated based on irrigation requirement. Sources of water flow to rivers in the area are snow melt and monsoon rain. The river flow is large from May to August, while the irrigation requirement is large from April to June and release from reservoir is closed in the winter. Under such situation, the peak power shortage appears in April, May, and June due to low reservoir level and the energy shortage in December and January is due to decrease in release from reservoirs.

In Pakistan, the repairing of hydroelectric equipment can be performed when the river flow is scarce in the dry months. Therefore, troubled equipment can be repaired before being heavily damaged and the chance of fault breakdown of equipment is generally little.

(2) Thermal Power Generation

The total installed capacity of existing thermal power plants in the WAPDA system consists of 4,281 MW of WAPDA plants and private facilities of 3,044 MW. That of the KESC system is 1,926 MW of KESC and 130 MW of private facilities as shown in Table D6.2 in Appendix D.

In the WAPDA system, 52% in installed capacity are steam plants and the remaining 48% are gas turbine and combined cycle plants. The recent gas turbine and combined cycle plants are operated with natural gas, while old gas turbine plants are with oil. The main steam turbine plants completed after the 1980s are furnace oil fired and provided with 210 to 250 MW units; only one unit is over 300 MW. The recent major gas turbine units are of 100 to 135 MW capacity. Many thermal units are very old, operation for more than 30 years. In Pakistan, the standard life of a thermal plant is 35 years for steam plant, 25 years for gas turbine plant, and 30 years for combined cycle plant.

All the KESC's stations, consisting of 76% steam, 11% gas turbine and 13% diesel, are based on the oil fuel and gas. The oil generation occupies 78.2 % of the total generation capacity and the remaining 21.8% by old gas turbines with gas. At present there is no plan to install a pipeline to reinforce the present gas supply. Development of oil-based thermal plants is not approved by the government, and KESC is obliged to rely on the transfer from WAPDA.

Regular maintenance of thermal generating facilities is being carried out mainly in the monsoon season when the river flow is abundant.

Hub Company commissioned the first large oil-fired power station of 1,292 MW (4 x 323 MW) capacity by IPP in 1996-97 at Hub on the Balochistan coast. The Kot Addu power station with new gas turbine and combined cycle units of 1,621 MW in total capacity was sold and management was handed over to KAPCO in June 1996. WAPDA is at present buying power from KAPCO.

4.4.2 Transmission System

The transmission network of Pakistan has the 500 kV transmission spine lines in two to three circuits from the Tarbela power station in the north to the Hub power station facing to the Arabian sea, 1,500 km in total length. The present configuration of the 500 kV transmission system is shown in Figure 4.4.1. These transmission lines interconnect seven 500/220 kV substations and 220/132 kV networks in the country. All major power stations and load centers scattered in the country are integrated through this 500 kV system. The total length of transmission lines of various voltage classes in each province is presented in Table 4.4.2.

In actual transmission system operation, the 500 kV and 220 kV systems are operated in loop formation to attain high system reliability, while the 132 kV and 66 kV systems are in radial formation to avoid misoperation of protective relays and to limit rupturing capacity of circuit breakers.

In NWFP, the 500 kV system was recently extended from Tarbela to Peshawar. Only two 220 kV transmission lines from Tarbela to Mardan and from Peshawar 500 kV to Daud Khel are in operation at present. In the province, there are two secondary systems of 132 kV and 66 kV. The 132 kV system is the major system to feed to grid substations for stepping down to the MV distribution voltage of 11 kV. Such transmission system covers only the southern part of the province, and most of the northern areas have not yet been electrified. The historical transition of substation capacity in NWFP is shown in Table 4.4.3. Many distribution system transformers (mostly 132/11 kV) are over-loaded covering all over the country including NWFP due to shortage in transformer capacity.

All 500 kV transmission lines are of single-circuit construction with four-bundled conductors. ACSR Drake (795 MCM) is the standard conductor. The standard conductors of 220 kV lines are ACSR RAIL (954 MCM). Twin-bundled conductors are going to be applied for heavily loaded 220 kV lines.

The lightning damage is not much in Pakistan, and only one overhead earthwire is installed on 220 kV or 132 kV double-circuit line. To avoid troubles of insulator contamination due to dust and salt in desert lands, fog insulator discs are sometimes installed. The standard number of insulator discs in one string is 15 for 220 kV lines for both suspension and tension strings.

For line protection including 500 kV lines, the distance protection combined with transfer tripping with the help of PLC channels is used as standard practice.

For a 220 kV switchyard with four generator circuits, planned for the Munda power station, the 1.5 circuit breaker double bus arrangement is the standard practice. However, the double bus system with a bustie circuit breaker will also be accepted.

4.4.3 Load Dispatching System

In the present Pakistan power system, there are four load dispatching centers in operation as mentioned below:

- National Power Control Center (NPCC) of WAPDA in Islamabad for generation system and 500/220 kV transmission system covering the whole country.
- Regional Control Center (RCC) (North) of WAPDA in Islamabad for the northern 132/66 kV transmission system, from Peshawar to Multan.
- Regional Control Center (RCC) (South) of WAPDA at Jamshoro for the southern 132/66 kV transmission system, south of Multan.
- Load Dispatching Center of the KESC system at Karachi.

The daily generation plan covering the whole country is prepared by NPCC and operating instructions for the next day are sent to WAPDA's power stations and to IPP stations. Annual generation plan and generating equipment maintenance schedule of the whole power stations covering the hydro and thermal plants are prepared in NPCC.

The power system frequency is controlled using four generators each of the Tarbela and Mangla power stations.

The power system operation records including fault data are compiled and databased in NPCC. NPCC has off-line computers for power system analysis to review and determine system operating conditions.

The KESC Load Dispatching Center controls the KESC system. This center is operated with good coordination with the WAPDA's dispatching center. The record of energy interchange between WAPDA and KESC is shown below.

Power Interchange between WAPDA and KESC

Fiscal Year to June 30	Export to KESC (GWh)	Import from KESC (GWh)
1983-84	6.00	37.00
1984-85	0.97	674.00
1985-86	0.55	470.03
1986-87	6.00	191.00
1987-88	86.22	116.00
1988-89	82.00	32.00
1989-90	171.16	264.46
1990-91	193.55	41.50
1991-92	292.21	463.02
1992-93	93.90	517.27
1993-94	367.74	350.71
1994-95	884.04	207.58
1995-96	794.61	298.47
1996-97	1,232.80	90.56

For a long time, WAPDA was receiving power from KESC, but recently from 1993-94 WAPDA is exporting power to KESC every year and the exporting energy has been increasing rapidly.

4.4.4 Communication System

The power line carrier (PLC) system is the main communication means of the transmission network and provided on all the existing transmission lines of up to 500 kV. Only 1-channel sets are used in Pakistan with formation of, 1+1+1....

For standby and maintenance communication, both VHF simplex and UHF duplex radio links are in use. In addition, the public telephone is also utilized for voice communication. However, the data communication and protection signal exchange are being performed using only PLC channels.

The power system administrative telephone system consists of the central exchange (PABX) at NPCC in Islamabad and about 100 local exchanges.

In Pakistan, there is only one microwave link of 2 GHz, 60 CH between Islamabad and Jamshoro in the south to meet increased communication needs in recent years. Multi-channel UHF links are also in use in heavy traffic sections, for instance between Tarbela and Peshawar.

At present, optical communication is not used for power system operation. OPGWs were once installed on a 500 kV line, however this system was damaged and is being recommissioned after repairing.

4.5 Power System Development Plan

4.5.1 Generation Development Plan

The government wishes to utilize indigenous sources of energy as much as possible for power generation and reduce reliance on imported oil. Based on this policy, the first priority of power development is to accelerate development of hydroelectric projects. The utilization of fuels of indigenous sources, with emphasis on coal and natural gas, is aimed in thermal power development. Oil thermal plants based on imported fuel are not planned after the 9th Plan.

The ongoing generation developments during the 9th 5-Year Plan period are shown in Table 4.5.1. The total capacity addition of 4,733 MW comprises public sector addition of 1,959 MW (hydroelectric and nuclear plants) and private sector addition of 2,774 MW (thermal plants). The largest addition of the public sector is the 1,450 MW Ghazi Barotha hydroelectric plant, a run-of-river project on the Indus main stream just downstream of the Tarbela power station. The private sector development consists of a number of relatively small thermal power plants based on fuel oil and gas.

At present, the government intends to solicit IPP proposals only for hydroelectric and indigenous coal-fired projects that already have feasibility studies. The total capacity of the existing generating facilities is sufficient to meet the present demand. As seen in the power development program of NPP in Table D7.1 of Appendix D for the Normal Scenario forecast and Table D7.2 for the Low Scenario case, GOP is now seeking projects that need long lead time with priority to the hydroelectric development.

In 1995, GOP announced the Policy Framework and Package of Incentives for Private Sector Hydel Power Generation Projects for private sector hydroelectric development either of run-of-river type or with nominal pondage for absorption of daily flow fluctuation. Tax exemption and other financial incentive measures were prescribed. Proposed projects must be technically and economically feasible and executed under the BOOT scheme. The minimum annual plant factor must be not less than 50% and the minimum of 40% energy be generated during low flow period of January to June. Fixed tariffs were adopted for the output levels of 20 to 300 MW and "cost plus" approach for projects less than 20 MW in output. However, bulk purchase tariffs for hydroelectric plants above 300 MW, and all those plants with (seasonal) reservoirs, are to be determined on a case by case basis. The operation period of IPP hydroelectric projects before transfer to the government was set at 25 years.

But in the 1998 Policy for New Private Independent Power Projects, a competition process was introduced in setting power tariffs to move towards the creation of a competitive power market in Pakistan. At present, IPPs are selected by reviewing proposals from applicants with emphasis on the energy generation price by a committee organized by the government. The power tariff for IPP comprises an Energy Purchase price and a Capacity Purchase price with adequate provisions for price escalation.

4.5.2 Hydroelectric Power Development Plans

According to data obtained from WAPDA, the identified hydroelectric potential of Pakistan in 1997 was 33,572 MW as shown in detail in Tables D8.1, D8.2 and D8.3 in Appendix D as summarized below:

Pakistan Hydroelectric Energy Resources

1. Hydel stations in operation:	4,826 MW
2. Implementation stage:	
A. Under implementation	1,658 MW
B. Ready for implementation	5,118 MW
3. Feasibility/ Pre-feasibility stage with WAPDA:	
A. Feasibility study	2,202 MW
B. Pre-Feasibility study	5,836 MW
4. Identified projects with WAPDA:	9,640 MW
5. SHYDO projects:	4,292 MW
Total	33,572 MW

In the 9th 5-Year Plan, the available hydroelectric potential was estimated at 38,000 MW. The present hydroelectric installation amounts to 14.4% of the identified potential or 12.7% of the available potential. Thus, Pakistan has huge remaining hydroelectric potential for future development, which is expected to increase further with progress of investigation.

Based on the government policy, carrying out of hydroelectric power studies is basically free to any parties notwithstanding existence of water right, etc. Any party can carry out study any type of project, whatever the place and capacity.

Generally, large projects, 100 MW and above, are planned taking into account the national balance of demand and supply, and small projects, up to several MW, are planned based on the regional demand.

4.5.3 Development of Indus Main Stream

The Kalabagh Multi-Purpose Dam Project (first stage of 2,400 MW, 3,600 MW finally) is at present recognized as the most important project for early development.

This project is on the main stream of the Indus river located 192 km downstream from the existing Tarbela power station. Feasibility of this project was already studied in the 1980s confirming economic superiority of the project, and detailed design and preparation of all bidding documents have already been completed. Thus, implementation of this project can be commenced any time if the environmental problems are settled and construction fund is secured. GOP gives the first priority to this project for implementation at an earliest possible time.

However, benefits and ill affects to regional governments and inhabitants at the power station site, upstream and downstream areas are complicated together with environmental concerns. At present GOP is trying to reach a compromise among the parties concerned.

The Basha Hydroelectric Project (3,360 MW) is another very important project on the Indus main stream, located upstream of the Tarbela power station. The energy generation cost of the power station is also estimated to be very low.

International technical assistance to feasibility studies of this project has not been concluded, and at present investigation and design of this project is waiting for sanction of foreign assistance.

4.5.4 Other Hydroelectric Development Sites

For hydroelectric development succeeding to the 9th Plan period, 41 proposals were received from private investors in the world by 1997. Through project selection and joint review on the basis of the 1995 Policy including negotiation with investors on candidate projects by members of WAPDA (Planning) Power, WPPO and HEPO, the following four projects were selected in 1998 as IPP projects for approval by the government:

IPP Projects Selected for Approval

Name of Project	Output	Location	Studied by
Malakand III	81 MW	Malakand on Upper Swat canal	WAPDA/ SWAB/ SCARP
Jinnah	96 MW	Jinnah Barrage on Indus river	WAPDA/ GTZ
Matiltan	84 MW	Ushu on Swat river	SHYDO
New Bong Escape	45 MW	Mangla on Jhelum river	WAPDA/ HARZA

Detailed design is to be commenced soon for these projects for commissioning in the 10th 5-Year Plan period.

As the next step, the following six projects have been selected in 1999 on the basis of the 1998 Policy as IPP projects for implementation:

IPP Projects Selected for Implementation

Name of Project	Capacity	Location	Studied by
Neelum Jhelum	963 MW	Muzaffarabad on Jhelum river	WAPDA/ Norconsult
Khan Khwar	72 MW	Khan Khwar on Swat river	SHYDO
Golen Gol	106 MW	Chitral/ Mastuj on Golen river	HEPO/ WAPDA
Daral Khwar	36 MW	Panjkura on Swat river	SHYDO
Allai Khwar	163 MW	Allai on Indus river	SHYDO
Summer Gah	28 MW	Summer on Swat river	SHYDO

The Kohala project (590 MW) in AJK is also recognized as a very prospective project, but a proposal for this project was not submitted in time.

The list of hydroelectric projects studied by SHYDO is tabulated in Table 4.5.2, and of these feasibility studies have been completed on seven projects. Among these listed projects, the six IPP proposals listed above including the Malakand III project have been accepted by the government. For future development, hydroelectric projects amounting to 2,400 MW in total are planned on three river systems (Kohistan, Swat and Mansehra).

4.5.5 Thermal Power Development Plans

Based on the power sector privatization policy, there are no public sector thermal power projects to be undertaken in the near future. All thermal developments, ongoing under the 9th Plan and planned for future implementation, are to be implemented in the private sector with the BOO scheme. By 1999, a total of 1,715 MW power plants will be completed under the 9th Plan as listed in Table 4.5.1. They are a number of medium size plants mostly based on fuel oil and gas including a small coal plant, and these are located in the central to southern regions of the country.

According to the Generation Program of NPP in Tables D7.1 and D7.2 of Appendix D, thermal plants using indigenous coal and natural gas are required after 2005 based on the normal growth scenario or after 2007 based on the low growth scenario. In the Program, the total development scale of coal thermal plants is comparable to that of natural gas combined cycle plants. Availability of indigenous natural gas in Pakistan is uncertain in the long run, and importation from either Turkmenistan or Iran may be considered if available quantity is not sufficient.

4.5.6 Transmission System Extension

Transmission system extension plans are being prepared by WAPDA based on results of their power flow studies. The WAPDA's extension plans of 500 kV and 220 kV transmission systems in the northern area up to 2003 are shown in Table 4.5.3 and Figure 4.4.1.

In the NWFP areas also, the 220 kV and 132 kV transmission system need to be extended with development of hydro power sites such as Munda, Swat B1, Malakand III, Matiltan, and other hydro power projects and for promotion of electrification of remote communities. The 220 kV system extension is planned for large stations and the 132 kV extension for medium to small stations. The Munda power station is located 40 km north of the large power consumption center of Peshawar.

Considering the available capacity of the existing substation facilities, it is not possible to handle all the Munda power at one existing substation. In the surrounding area of the Munda power station, there are two large 220 kV system extension plans as given below:

1) Construction of a 220 kV line with two-bundled Rail conductors between the Ghazi Barotha power station and Peshawar 500 kV substation with two intermediate substations of Nowshera Industries and Shahibagh. The Shahibagh substation is located in the northern suburb of Peshawar, and is nearest to the Munda power station.
2) Construction of the Charsadda 500/220 kV substation to receive 500 kV power from Mansehra and deliver to Peshawar. The 220 kV side of this substation will be connected to the Shahibagh substation through a 220 kV line with 2-bundled Rail conductors. However, the construction plan of this substation has not yet been finalized.

The planned sites of both Shahibagh and Charsadda substations are 25 to 30 km from the Munda power station and these substations are planned for large power and can be designed taking into account transfer of all the power from the Munda power station.

4.5.7 Load Dispatching and Communication System

In future, all important hydropower stations need to be connected with respective load dispatching centers for necessary supervision and remote control by means of stout and reliable communication paths for data transmission.

WAPDA has a plan to use the optical communication on the 500 kV system and important and heavy traffic sections of the 220 kV system, and installation of OPGW is now progressing on several lines for commissioning in the near future.

The frequency allocation for the PLC system in the Peshawar area is congested and there will be a lot of difficulties in allocating frequencies including the Munda system. For the 220 kV lines in the section of Ghazi Barotha–Nowshera–Shahibagh-Peshawar 500 kV, there is a proposal to provide an optical communication system to meet expected large communication needs. However, this plan has not yet been finalized. There is also possibility to extend the optical system to the Munda power station from the 500 kV Charsadda substation.

4.6 Institutional Issues Relevant to Hydropower Development

The federal and provincial government and local relationships in FATA, are involved in hydropower development in Pakistan. The Article 161 (2) of the constitution of Pakistan states that the net profits earned by the Federal Government, or any undertaking established or administered by it, from the bulk generation of power at a hydroelectric station shall be paid to the Province in which the hydroelectric station is situated. In 1991 a formula had been worked out to pay NWFP the profits from Tarbela and Warsak hydropower projects.

It is expected that the issue of profits from generation of power from Munda Dam will also be dealt within the same manner as Warsak hydropower project whenever the decision is to be made by the Government of Pakistan.

CHAPTER 5 WATER SUPPLY DEVELOPMENT STUDY

5.1 Concept for Irrigation Water Supply

Water supply purposes on the Munda Dam Multipurpose Project were studied considering hydropower generation, irrigation water supply for barani area, supplemental irrigation water supply for existing systems, and water supply for domestic and industrial uses based on those optimized in the Pre-Feasibility Study. Water supply established in the beginning was examined repeatedly and practicably as the data and information were collected.

Basic concept of planning irrigation and other water supply of the Munda Project is to formulate the most effective economic scale and formation on condition that hydropower generation is the principle component of the Project. The surface irrigation method which is traditionally and widely spread in the Study Area is applied as it is easy for the farmer to adopt. Native farmers are considered as bases for the planning in the Project without resettlement of new farmers from other areas. And no drastic change on the present agricultural structure will be brought about by the Project.

5.2 New Irrigation Scheme

5.2.1 Study Area

Study Area of the new irrigation scheme of the Project conforms to the new command area proposed in the Pre Feasibility Study which extends in the left bank area of 8,207 ha (20,280 acres) and right bank of 3,683 ha (9,100 acres) in Cultivable Command Area (CCA). (Ref. Figures 5.2.1, 5.2.2) Land use of the new command area of the Project was set in the Pre Feasibility Study as follows:

Land Use of the Study Area

(Unit in ha (acres))

Classification	Right Bank Area	Left Bank Area	Total
Cultivated Area			
Current Fallow	1,593 (3,940)	3,876 (9,580)	5,469 (13,520)
Net Sown	1,490 (3,680)	3,623 (8,950)	5,113 (12,630)
Subtotal	3,083 (7,620)	7,499 (18,530)	10,582 (26,150)
Cultivable Waste	600 (1,480)	708 (1,750)	1,308 (3,230)
Forest	0	0	0
Cultivated Area (CCA)	3,683 (9,100)	8,207 (20,280)	11,890 (29,380)
Uncultivated Area	409 (1,010)	912 (2,250)	1,321 (3,260)
Total Area (GCA)	4,092 (10,110)	9,119 (22,530)	13,211 (32,640)

The Study Area of new irrigation scheme of the Project conforms to the new command area proposed in the Pre Feasibility Study.

The Study Area covers the three administrative divisions of Charsadda District, Malakand Agency and Mohmand Agency, as shown in Figure 5.2.3. Area in each administrative division is as follows:

Areas of the Study Area by Administrative Divisions

(GCA in ha (Acres))

District/Agency	Right Bank Area		Left Bank Area		Total	
Charsadda	4,010 (9,910)	98.0%	6,475 (16,000)	71.0%	10,485 (25,910)	79.5%
Malakand	0	0.0%	1,094 (2,700)	12.0%	1,094 (2,700)	8.2%
Mohmand	82 (200)	2.0%	1,550 (3,830)	17.0%	1,632 (4,030)	12.3%
	4,092 (10,110)	100.0%	9,119 (22,530)	100.0%	13,211 (32,640)	100.0%

5.2.2 Land Classification of the Study Area

Referring to the result of land capability classes of the New command area in Pre Feasibility Study, the Study Area was classified into four land classes from I to IV.

Land Classified Areas in New Command Area

(Unit in ha (acres))

Land Capability Classes	Right Bank Area		Left Bank Area		Total	
	(GCA)	(CCA)	(GCA)	(CCA)	(GCA)	(CCA)
I	2,013 (4,970)	1,777 (4,390)	1,686 (4,160)	1,640 (4,050)	3,699 (9,130)	3,417 (8,440)
IIr	0	0	1,387 (3,430)	1,350 (3,340)	1,387 (3,430)	1,350 (3,340)
IIsr	0	0	267 (660)	260 (640)	267 (660)	260 (640)
IIIs	1,352 (3,340)	1,193 (2,950)	1,429 (3,530)	1,393 (3,440)	2,789 (6,870)	2,586 (6,390)
IIIsr	127 (320)	113 (280)	1,167 (2,880)	1,136 (2,810)	1,295 (3,200)	1,248 (3,090)
IVsr	0	0	2,475 (6,120)	1,721 (4,250)	2,475 (6,120)	1,721 (4,250)
Other	600 (1,480)	600 (1,480)	708 (1,750)	708 (1,750)	1,308 (3,230)	1,308 (3,230)
Total	4,092 (10,110)	3,683 (9,100)	9,119 (22,530)	8,207 (20,280)	13,211 (32,640)	11,890 (29,380)

I : Arable without any limitations
IIr : Arable with little limitation on irregular topography
IIsr : Arable with little limitation on irregular topography and gravely nature (20 - 30% gravels on surface)
IIIs : Arable with some limitation on gravely nature (50% gravels at 35 cm and below)
IIIsr : Arable with some limitation on irregular topography and gravely nature (50% gravels at 35 cm and below)
IVsr : Special use land with excessive limitation on irregular topography and gravely nature (80 to 90% gravels on surface)
Other : Uncultivable

The soils of the Study Area, posses no serious ailment except gravely irregular topography in some parts and shallowness. The Study Area has 3,699 ha (9,130 acres) in GCA of land available with no limitation to any crops. Similarly 1,387 ha (3,430 acres) are available with no limitation to crops except topography and may require local land leveling or terracing, the other 267 ha (660 acres) of class II lands, are also deep loamy soils with 20-30% gravel and stones on the surface may require scrapping and land leveling, while being also suitable for all types of crops and orchards. The other 4,075 ha (10,070 acres: class III lands) are permanently problematic and are not suited to deep rooted crops like orchards, sugarcane and maize etc. However, shallow rooted crops can be grown successfully with somewhat reduced yield. Furthermore, the other 2,475 ha (6,120 acres: class IV lands) consists of excessively gravely and stony alluvial ridges containing 80 to 90% gravels by volume. Due to very high topography and extremely gravely and stony nature, this classed land is not fit for irrigated agriculture. It is recommended to use it as range land or for forestry.

The infiltration of soils, varies widely from 0.31 to 6.60 cm/hr of basic intake rate. Surface irrigation method such as level border irrigation method is best suited to soils that have moderate to low intake rate as being in the 5.0 intake family or less. So, soils in the Study Area are applicable for surface irrigation method, this method is allowable even for soils with rapid intake characteristic of 6.60 cm/hr by considering this in the design of the irrigation facility.

5.2.3 Agricultural Status of the Study Area

(1) Farms and Land Tenure

Farm-size and owned status for the Study Area were estimated by data obtained from the Agricultural Census (1990) and revenue records of concerned *tehsils* (subdistrict). The result is summarized below.

Farm-size and Owned Status for the Study Area

Farm-size	Farm number	Owned area (ha(acres))	% of Total
Private Farm Total	5,903	11,890 (29,380)	100.0%
under 1.0 acre	160	48 (119)	0.4%
1.0 to 2.5	1,017	590 (1,457)	5.0%
2.5 to 5.0	2,630	3,656 (9,035)	30.8%
5.0 to 7.5	799	1,836 (4,536)	15.4%
7.5 to 12.5	881	2,950 (7,290)	24.8%
12.5 to 25.0	356	2,341 (5,784)	19.7%
25.0 to 50.0	54	265 (656)	2.2%
50.0 to 150.0	5	113 (280)	0.9%
150.0 above	1	89 (221)	0.8%

Source: Agricultural Census (1990)

The farms in the Study Area fall under three categories, small (up to 12.5 acres), medium (12.5 to 25.0 acres), and large (above 25.0 acres). Corresponding percentages of number of farms in each category come to 93.0%, 6.0%, and

1.0%, respectively. On area basis, percentages of the owned areas are 76.4%, 19.7%, and 3.9%, respectively. An overall average per farm for the Study Area is 4.9 acres, which is the smallest in comparison with province-wise averages of NWFP (7.8 acres), Punjab (11.8 acres), Sindh (11.6 acres), and Balochistan (19.2 acres).

According to the data for concerned districts in the Agriculture Census (1990), prevalent land tenure system are registered as owner operators, owner-cum-tenants, and tenants. On the basis of the Census data, the tenure distribution estimated for the Study Area is 66.0%, 8.5%, and 25.5% of the total Study Area for owner, owner-cum-tenant and tenant operated, respectively.

(2) Existing Research and Extension Facilities

In the Study Area, the following agricultural offices and organization are available.

a) Research:
- Soil fertility laboratory at Charsadda
- 10 Acres Portion for research at sugarcane farm, Harichand, Charsadda
- Agriculture Research institute, Tarnab, Peshawar
- Cereal Research Station, Pirsabak, Mardan
- Sugarcane Research Institute, Mardan

b) Extension
- Sugarcane seed multiplication farm at Harichand
- Farm services center at Dhakki covering 3 union councils (pilot project)
- EADA (Extra Assistant Director Agriculture) office at Charsadda 1-2 officers for Agricultural offices at Shrikabad Mohammad, Deri and Dhakki

c) Input Supply Centers

The Agricultural Development Authority has three sale points located at Charsadda, Tangi, and Shabqadar areas. Storekeepers are offices in charge of the sale-points and controlled by District Agricultural Supply Officer, Peshawar. There is no District Agriculture Supply Officer/Office at Charsadda District. Agriculture Development Authority is responsible to supply seeds and fertilizers whereas insecticides/pesticides sale and distribution are under private control. Seeds of the some varieties of wheat and maize are only supplied by these centers.

(3) Marketing

There is no proper market in the area for specific crops. The major marketing areas are Charsadda Shabqadar, Tangi, and Sardheri but no proper market is available. There are no regular/controlled markets, and storage facilities fall short. Proper market and cold storage facilities are required at the places. Majority of farmers' income is likely being exploited by middlemen. Most farmers borrow money from the dealers, who in return purchase their commodities at the own rates. Therefore, proper loaning facilities should be encouraged so that the farmers may be able to sell and get the optimum price for their products.

Mardan and Peshawar are the other markets available to the Study Area. There is a large sugar mill at Mardan that has a capacity to absorb the cane crops of the additional area. Vegetables, fruits and cereals are needed at the Peshawar and Mardan market.

(4) Present Cropping Pattern and Intensity

Present cropping pattern and intensity in the Study Area were investigated based on recent series of Agricultural Statistics of NWFP and revenue records of concerned tehsils in the Study Area. Through an investigation on agricultural data in barani areas of concerned tehsils in the Agricultural Statistics of NWFP, the present cropping intensity in concerned tehsils was estimated at 63.7%.

With use of the latest three years revenue records of concerned tehsils covering 46.6% in the area of Study Area, another estimate of present cropping pattern and intensity of the Study Area was made. Obtained present cropping intensity was 56.4%.

Taking reliability of data into consideration, present cropping pattern and intensity in the Study Area were determined as follows:

Present Cropping Intensity

Crops	Intensity obtained by Agri. Statistics	Intensity obtained by Revenue records	Applied Intensity of the Study Area
Maize	1.67%	0.07%	1.7%
Wheat	51.02%	52.70%	51.0%
Barley	4.12%	3.30%	4.1%
Oil-seed	1.05%	0.05%	1.0%
Sugarcane	4.78%	0.03%	- *
Total			57.8%

* Sugarcane is cultivated in Tangi lift irrigation schemes area within Study Area.

Present yields under the unirrigated condition were estimated by recent series of Agricultural Statistics of NWFP. Their results are summarized below.

Present Crop Yields of the Study Area

Crops	Yield (Kgs/Acre)	Remarks
Maize	461	400 Kgs/Acre in 1990
Wheat	481	435 Kgs/Acre in 1990
Barley	373	425 Kgs/Acre in 1990
Oil-seed	190	
Sugarcane	11,616	

Data source: Agricultural Statistics of NWFP and interviewed information in agricultural extension offices

5.2.4 Existing Irrigation Systems within Study Area

The following functioning irrigation schemes exist within the Study Area:

- Tangi Lift Irrigation Scheme (Left Bank Area)
- Palai Dam Irrigation Schemes (Left Bank Area)
- Warsak Left Irrigation Canal (Right Bank Area)
- Private pump schemes (Left Bank Area, Right Bank Area)

(1) Tangi Lift Irrigation Scheme

Tangi Lift Irrigation Scheme was constructed in the 1950s for the area in two major mozus, namely, Maira Abazai and Maira Tangi Barazai. Salient features of the scheme are as follows:

Salient Feature of Tangi Lift Irrigation Scheme

Items	Data	Remarks
Command Area (CCA)	1,766 Acres	714.7 ha
Crops	(Kharif) Sugarcane, Vegetable, Orchards (Rabi) Sugarcane, Vegetable, Wheat	
Cropping Intensity	145.7% - 196.6%	Agriculture Statistics 1997-98
Water Source(Swat River)	Turbine Pump (3 nos.) Centrifugal Pump (3 nos.)	6 cusecs(0.17 cu.ms) 6 cusecs(0.17 cu.ms)
Lift Head	60 feet	18.3 m
Canal	22,300 feet length (6.8 km)	Canal water is used for daily use(washing cloths, bathing etc) without any treatment.

(2) Palai Dam Irrigation Scheme

Palai Dam is located in Jindai Nullah, about 16 km (10 miles) north of Tangi Village and about 40 km (25 miles) north of Charsadda district. Since the feasibility study was completed in January 1994, the construction works of main dam, spillway and outlet/inlet structures were started on December 24, 1995 with construction period of 24 months. Though the construction works were interrupted in November 1996 for some financial problems, it will be started within certain years. Salient features of the Palai Dam Irrigation Scheme is as follows:

Salient Features of Palai Dam Irrigation Scheme

Items	Data	Remarks
Dam:		
Dam type	Concrete faced rockfill dam	
Height	104 feet	31.7 m
Length at crest	1,203 feet	366.7 m
Live storage capacity	3,650 AF	4,500,000 cum
Normal pool elevation	1,447 feet	
Design discharge	21,293 cusec	603 m^3/s
Canal:		
Feeder channel	30.0 cusec, 3,755 feet length	0.849 m^3/s, 1,145 m
Left Bank Canal	23.5 cusec, 38,450 feet length	0.665 m^3/s, 11,720 m
Right Bank Canal	6.5 cusec, 11,500 feet length	0.184 m^3/s, 3,505 m
Irrigation:		
Command Area	1,862 ha (4,600 acres in CCA)	3,600(Left),1,000 acres(Right)
Cropping Intensity	130%	
Crops	(Kharif) Sugarcane, Orchard, Maize, Pulses, Oil-seeds, Fodder, Vegetables (Rabi) Sugarcane, Orchard, Wheat, Pulses, Oil-seeds, Fodder, Vegetables, Tobacco	

Water Use Plan of Palai Dam

Water Requirement	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Irrigation W.R.												
in Ac.ft	768.9	175.1	716.6	514.3	562.5	1747.7	789.4	786.0	1300.5	1362.4	1460.7	890.3
in mm	50.9	11.6	47.5	34.1	37.3	115.8	52.3	52.1	86.2	90.3	96.8	59.0
River runoff												
in Ac.ft	1301.1	3191.4	2908.8	2908.8	542.3	794.4	4251.3	9056.6	1649.8	422.1	713.2	1091.6
Deficit in Ac.ft					20.2	953.3				940.3	747.5	

This irrigation scheme will be regarded as an existing irrigation system because the scheme was once officially approved for the implementation by the Government of NWFP though construction work has been interrupted at present. Under the conditions of the Study Area where the Palai Irrigation Scheme exists, the left canal plan proposed in the Pre-Feasibility Study report is not recommendable as it overlaps with canals of the Palai Irrigation Scheme.

(3) Warsak Left Irrigation Canal

Warsak Left Irrigation Canal, of which off-take is located downstream of the Warsak hydropower plant, runs in the left bank of the Kabul river. The canal aims at irrigating about 4,452 ha (11,000 acres) in Mohmand and Shabquadar areas. It has a discharge of 1.274 m^3/s (45 cusecs) with the total canal length of 29.6 km (18.4 miles). According to the review, a portion of right bank of the Study Area was found overlapping with the command area of the existing Warsak Left Irrigation Canal.

The review identified that the existing canal has been clogged at a distance of RD.60,000 (18.2 km from off-take) due to blockade of distracted canal structure and has not been functioning beyond that point for a long time. Thereby, the canal command of the Warsak scheme is being limited within the right bank of Subhan Khwar at present. According to the office of Warsak Left Irrigation Canal, no plan has been established to restore this structure, and no budget has been allocated. Based on the fact that the water from the Munda reservoir is available even when the Kabul river flow is low and subject to the office of Warsak Left Irrigation Canal, the left bank command area of the Warsak left canal should be transformed as the command area for the Project.

(4) Private Pump Schemes

According to the revenue records of concerned tehsils in the Study Area, about 745 ha (1,840 acres) are irrigated by tube-wells and wells in the Study Area, i.e. 599 ha (1,480 acres) at the left bank (7.3% of the Left Bank Area) and 146 ha (360 acres) at the right bank (3.6% of the Right Bank Area). These tube-wells and wells are privately operated at the owner's expense. After implementation of new irrigation system of the Project, the area under tube-well irrigation operation will be shifted to canal irrigation through the new irrigation system because it is economically advantageous.

5.2.5 Agricultural Development Plan

Cropping pattern and intensity of a command area used for agricultural development plan are generally governed by a number of factors, which are dependent basically on characteristics of water, soil, and climate. The other factors for determining the cropping pattern are local and adjacent areas' demands, profitability and marketability, etc. The prevailing cropping pattern nearby the command area is also a good indicator for the future demands.

Keeping in view of the existing conditions and recorded performance in Tangi Lift Irrigation Scheme (data collected from Irrigation Department) and averages of Charsadda district and other related districts, an intensity of 177 % /1 proposed in the Pre-F/S report was considered achievable. This, however, needs further adjustment with the verification of availability of water so that optimum benefit be achieved.

Note /1 177 % of cropping intensity was proposed in the Pre-F/S report but was found to be double-counted the intensity of sugarcane and orchards in Kharif (40 %) and Rabi (40 %).

Target yield in the irrigation development plan should be realistic and achievable. Proposed yield of Pre-F/S in some cases seems to be higher side. However, farmers of the area are well acquainted to all the crops suggested in the pattern as they are growing these crops on their irrigated lands commanded by Upper Swat Canal (USC) and on the right side under Doaba Canal System. The target period may be increased from 5 to 8 years in case of intensity and from 10 to 15 years in case of yields as the command area may require some local leveling and time.

The cropping pattern and intensity, yields and fertilizer recommendation are given below: (Refer to Figure 5.2.4)

Proposed Cropping Pattern and Intensity

Crops	Intensity(%)	Crops	Intensity(%)
Kharif		Rabi	
Maize	27	Wheat	30
Vegetables	8	Oilseeds	2
Pulses	4	Onion	6
Fodder	3	Vegetables	7
Tobacco	6	Fodder	3
Sugarcane	30	Sugarcane	(30)
Orchards	8	Orchards	(8)
Subtotal	86	Subtotal	48
		Total	134

The following table compares quantities of required water and profits between the proposed plan and actual records in adjacent areas of the project area. Details are given in Appendix E. It shows that the proposed cropping pattern holds sound profitability and practicability.

Comparison with Other Cropping Patterns

(%)

Crops	Munda Project		Records in adjacent area			
	Pre-Feasibility Study	Feasibility Study	Charsadda	Malakand	Peshawar	Mohmand
Maize	29.0	27.0	27.3	16.0	26.2	28.4
Vegetables	6.0	8.0	0.9	1.3	1.3	1.5
Pulses	0.0	4.0	0.2	0.2	0.1	0.4
Fodder	3.0	3.0	0.9	7.7	10.7	0.7
Tobacco	6.0	6.0	10.3	2.8	0.0	0.0
Sugarcane	35.0	30.0	42.9	14.3	28.8	31.4
Orchards	5.0	8.0	2.0	1.6	1.3	1.3
Rice	0	0.0	0.2	20.1	0.6	0.0
R.Wheat	35.0	30.0	36.2	28.0	46.6	53.5
R.Barley	0.0	0.0	0.5	0.1	2.3	0.6
R.Oil seeds	2.0	2.0	0.1	0.3	0.1	0.4
R.Onion	1.0	6.0	0.1	0.7	0.2	6.6
R.Vegetables	4.0	7.0	1.3	3.2	2.2	1.6
R.Fodder	3.0	3.0	8.6	4.1	11.7	1.1
R.Sugarbeet	8.0	0.0	0.5	0.0	2.9	0.0
Water Rq. (mm)	794.8	780.1	785.6	662.1	649.3	615.4
Yield (10^3Rs./ha)	3,185.6	3,539.0	3,016.2	1,582.0	2,172.8	2,321.9

Crops Yields and Fertilizers

(kg/acre)

Crops	Yields	Fertilizers		
		N	P_2O_5	K_2O
Maize	1,000	50	25	0
K.Vegetables	4,788	52	25	18
K.Pulses	314	16	14	0
K.Fodder	9,000	40	0	0
Wheat	1,150	50	25	0
Barley	800	16	14	0
R.Vegetables	7,500	52	25	18
Oil seeds	404	25	20	0
Tobacco	1,025	25	35	30
Onion	4,500	52	25	18
Sugarbeet	12,756	45	30	20
R.Fodder	16,000	18	27	0
Sugarcane	22,000	60	40	25
Orchards	6,002	64	40	25

Source: Department of Agriculture, NWFP

5.2.6 New Irrigation Development Plan

It was unveiled that some portions of the new command area might be eliminated because farm lands are not fully arable and some overlap with the other existing irrigation plan and system. The command area overlapped with the Palai Dam Irrigation Scheme should be adjusted to avoid double development, respecting the fact that the Palai Dam Irrigation Project is a preceded scheme within the new command area of the Project. In due consideration of the fact that the implementation of the Palai Dam scheme is being suspended, it was proposed that the right bank of Jindai Khwar be covered by the Project while the irrigation area of the Palai Dam scheme be extended westward. By this adjustment, the planned right canal of the Palai Dam scheme will be added to the end of the left canal. This was accepted by GONWFP.

At the right bank, it was found that the Study Area overlaps with the command area of the existing Warsak Left Irrigation Canal and the canal beyond 18.2 km from the off-take has not been functioning for a long time due to blockade of distracted canal structure as mentioned before. With due consideration of present situation of the Warsak Left irrigation scheme, it was proposed that the left bank command area of the Subhan Khwar be transformed as the command area for the Project, in which case a new canal will be aligned at the higher elevations than the existing left bank canal of the Warsak scheme, beyond the Subhan Khwar. This was accepted by GONWFP.

Target area of new irrigation scheme of the Project is major rainfed farmlands extending in both banks of the Swat river. Adjusted new command area is summarized as follows:

Area of New Irrigation Scheme

Unit: ha (acre)

	(GCA)	(CCA)
Left Bank Area	4,539 (11,220)	4,066 (10,050)
Right Bank Area	2,314 (5,720)	2,043 (5,050)
Total	6,853 (16,940)	6,109 (15,100)

As shown in Figure 5.2.5, the left bank area of the new irrigation scheme extends up to the Jindai Khwar and includes arable lands located in the west side of the Jindai Khwar and the existing Tangi irrigation scheme area. The right bank area stretches it out over the Subhan Khwar embodying a part of the Warsak Canal command area. Breakdown of the new irrigation scheme area is shown as follows:

Breakdown of New Irrigation Scheme

Category	Hectare	Acre	Remarks
Left Bank Area	(4,066)	(10,050)	
Rainfed area	2,946	7,280	
Tangi scheme	715	1,770	
Palai scheme right	405	1,000	rainfed at present
Right Bank Area	(2,043)	(5,050)	
Rainfed area	1,023	2,530	
Warsak canal	1,020	2,520	not supplied water at present
Total	(6,109)	(15,100)	

5.3 Supplemental Irrigation Water Supply Scheme

5.3.1 LSC

The Lower Swat Canal (LSC) takes off from the Swat River at Munda Head works. This canal realized perennial irrigation in the area of districts of Charsadda, Nowshera, Peshawar and major portion of Mardan District. The British government had faced many difficulties in constructing this irrigation system and finally completed its construction in 1885.

For the original plan of LSC, it irrigated 54,432 ha (134,500 acres in CCA) with 23.50 m^3/s (830 cusecs) for the LSC System and 4.98 m^3/s (176 cusecs) for the Sholgara Canal. The design was based on providing 5 to 6 cusecs of a water allowance (discharge at the distributary head gate for each 1,000 acres of service area). The cropping intensity used in the original design is 100% (40% in Kharif and 60% in Rabi season). By 1978, the cropping intensity had, however, substantially exceeded the design intensity, averaging about 175% (145% after adjustment of double-count of crop intensity for sugarcane).

In order to regain and improve the improper conditions of the service areas effected by the constraints of inadequate irrigation supplies, the menace of waterlogging and salinity, frequent flooding from the natural drains, and lack of quality inputs and modern agricultural techniques, Mardan SCARP Project was launched in February 1981, and completed in March 1993. The peak period headgate capacity at full development was found to be 54.90 m^3/s (1,940 cusecs), based on a new crop consumptive use of 11.3 cusecs of a water allowance at a cropping intensity of 180% (150% after adjustment of double-count of crop intensity for sugarcane). Canal system of LSC was remodeled within the Mardan SCARP Project so as to meet these requirements.

5.3.2 USC

The Upper Swat Canal (USC) takes off from the Swat River at the Amandara Headworks. This canal realized perennial irrigation in the area of districts of Swabi, Mardan and Charsadda. Its construction was started in 1907 and was finally put into operation in 1918. Though Benton tunnel as an essential feeder facility was designed having full supply design discharge of 62.77 m^3/s (2,218 cusecs), it never discharged more than 50.94 m^3/s (1,800 cusecs) due to the inadequate design.

For the original plan of USC having the constraint of Benton tunnel which draws maximum discharge of 50.94 m^3/s (1,800 cusecs), it irrigated 113,720 ha

(281,000 acres in CCA) with 48.39 m^3/s (1,710 cusecs) for the Machini Branch and 11.18 m^3/s (395 cusecs) for Abezai Branch. The design was based on providing 5 cusecs of a water allowance (discharge at the distributary headgate for each 1,000 acres of service area). The cropping intensity used in the original design is 100% (40% in Kharif and 60% in Rabi season). By 1997, the cropping intensity had, however, substantially exceeded the design intensity, averaging about 119%.

In order to better the improper conditions of the service areas effected by the constraints same as LSC construction of Swabi SCARP Project was started in July 1993, and was implemented subsequently. The peak period headgate capacity at full development was found to be 87.73 m^3/s (3,100 cusecs), based on a new crop consumptive use of 9 cusecs of a water allowance at a cropping intensity of 175% (145% after adjustment of double-count of crop intensity for sugarcane). Canal system of USC was remodeled within the Swabi SCARP Project including remodeling work of the Benton tunnel so as to meet this requirement.

Besides this implementation of the Swabi SCARP Project, Pehur High Level Canal Project (PHLC) was promoted so as to enable conjunctive operation of USC-PHLC system to resolve water-shortage problem through optimizing water use in consideration of the Swat River surface water supplies. By implementing the Swabi SCARP Project and the PHLC, USC will be completed without any water-shortage for proposed agriculture with 175% cropping intensity (145% after adjustment of double-count of crop intensity for sugarcane).

5.3.3 Water Supply for LSC

USC will be a complete irrigation system with its shortage of facilities' capacity improved by remodeling of the Swabi SCARP Project, and enhanced capability of water source by execution of PHLC. On the contrary to the USC, LSC is not always in full water supply circumstance especially in Rabi season, because additional water source development was not attained while remodeling of facilities was done within the Mardan SCARP Project. Some deficits of irrigation water supply in LSC were found as shown in table below.

Shortage of Irrigation Water Supply in LSC

(Unit: m³/sec (cusecs))

In PC-I of Swabi SCARP			
Month	Diversion Requirement	Swat River Flows	Deficits
January	5.38 (190)	14.72 (520)	
February	12.45 (440)	14.72 (520)	
March	26.32 (930)	58.02 (2,050)	
April	48.39 (1,710)	116.03 (4,100)	
May	64.81 (2,290)	41.04 (1,450)	-23.77 (-840)
June	64.81 (2,290)	308.47 (10,900)	
July	36.79 (1,300)	226.40 (8,000)	
August	47.54 (1,680)	182.82 (6,460)	
September	51.51 (1,820)	99.90 (3,530)	
October	42.17 (1,490)	35.09 (1,240)	-7.08 (-250)
November	32.00 (1,130)	24.62 (870)	-7.36 (-260)
December	16.13 (570)	24.90 (880)	

Source: PC-I Proforma, Swabi SCARP (Revised), April 1997, Table-7

Deficits in this table should be supplemented from a new water source. Proposed Munda Project could be an option to supply water to meet the water demand.

5.4 Other Water Supply

5.4.1 Present Water Use

Civil canals located along the Khiali and Abazai Rivers, Swat River downstream from the Munda Headworks have functioned as other water supply systems concerning the Study Area. The civil canal is an earth canal that directly introduce water from the Swat River having flow capacity not exceeding 0.85 m^3/s (30 cusecs) without permanent intake structure. These civil canals were constructed in the 1800s, and then maintained and operated by farmers themselves. Due to meandering of the Swat River flowing down on alluvial fan, a number of civil canals were abandoned. For these reasons it is difficult to identify exact number of civil canals steadily functioning. At present fourteen civil canals have been working having total discharge of about 5.70 m^3/s (200 cusecs). While no problem in water quantity is reported for the present civil canals' water use during Kharif, it is difficult to feed water at all during Rabi due to no river flow in the Swat River.

A water shortage in a sugar mill in Mardan was reported during Rabi. The sugar mill is not taking water from its own water supply system but being supplied water from the LSC system. If water shortage problem in LSC is solved, the shortage in the sugar mill is settled correspondingly.

5.4.2 Other Water Use in Future

Irrigation canals are devised so as to utilize canal water for domestic water use such as washing, drawing water by means of equipped steps at certain distances. Domestic water supply is satisfied by not only private wells and public water schemes conducted by Public Health Department but also from the water supply through irrigation canals. High potential for increase of domestic water use to be allotted by the Swat River water is not recognized at the moment.

5.4.3 Possibility for Further Water Needs

Another water need for the Project is to supply water to civil canals during Rabi. River discharge downstream of Munda Headworks in Rabi is to be increased. In the Pre-Feasibility Study report, it was proposed to improve civil canal water feeding at 8.49 m^3/s (300 cusecs) by adding 2.85 m^3/s (100 cusecs) to the present water requirements for civil canals, i.e., 5.70 m^3/s (200 cusecs). Considering quantity of water to meet requirements and extra release as standing water in river for convenient water taking, it was considered reasonable.

5.5 Institutional Reforms of Irrigation Sector

In terms of implementation of the National Drainage Programme (NDP) assisted from the World Bank and other foreign donors, institutional reforms in the irrigation sector has been progressed. An autonomous body of the NWFP Government for irrigation management, the North-West Frontier Province Irrigation Drainage Authority (NWFPIDA), was established with the North-West Frontier Province Irrigation Drainage Act 1997 promulgated on July 17, 1997, in which it is further expedient to transform the Provincial Irrigation Department into an autonomous authority.

The basic framework of board of the NWFPIDA was set up as shown in Figure 5.5.1, but structure of the organization and process of implementation will be formulated as recommended by the Institutional Reform Consultants for which procedure of appointment of consultants was initiated since June 1999.

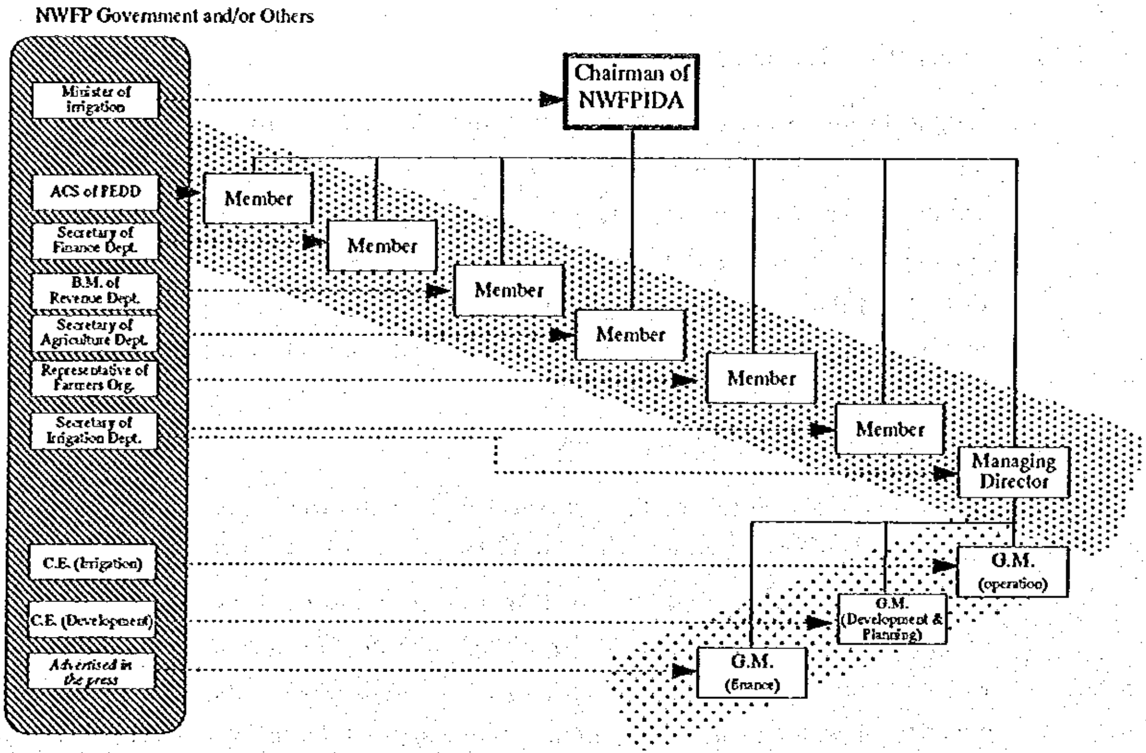

Figure 5.5.1 **Basic Framework of the North-West Frontier Province Irrigation Drainage Authority (NWFPIDA)**

On May 11, 1999, the NWFPIDA held its first meeting and disposed of the pending agenda as follows:

- The establishment of the NWFPIDA fund as well as opening of the NWFPIDA account was approved.
- The NWFPIDA constituted a Redundancy Committee to review the structure of the existing Provincial Irrigation Department and identify the positions which would not be needed by the NWFPIDA and propose their disposal.
- The NWFPIDA approved the remittance of Abiana into NWFPIDA account.
- The NWFPIDA agreed to look after the Civil/Private Channels, however, the funds would be arranged by the Provincial Government without any liability to the NWFPIDA.
- The Secretary Irrigation was designated as the Managing Director of the NWFPIDA. General Manager Finance is going to be appointed. With the appointment of the General Manager Finance the Board of Management (BOM) will be fully installed and would become functional as envisaged.
- The NWFPIDA has designated an existing block on the Warsal Road as "PIDA House".

- As far as the enhancement of Abiana to meet the O&M charges is concerned the same is being increased by 25% every year.
- The Area Water Board was notified on the Swat Canal Command on pilot basis and Superintendent Engineer (SE) of North Irrigation Circle Mardan was designated as its Chairman.
- The requirement of forming the Farmers Organization within one year of the establishment of the Authority and Area Water Board could not be fulfilled immediately due to circumstances beyond its control.

Recent progress in the NWFPIDA was concerned with operation and maintenance of the irrigation component of the Munda Dam Multipurpose Project.