# 7. ENVIRONMENTAL AND SOCIO-ECONOMICAL ASPECTS

## 7.1 GENERAL

Hydropower development projects are closely linked to environmental and social factors in the process of project layout and design as well as evaluation. Today environmental considerations are already included from the first stage of work during identification. The number of specialists concerned with environment impacts working in hydropower development is steadily increasing. There are botanists, zoologists, water quality chemists, sociologists and many others evaluating the environmental issues.

The term environment is a broad term that includes physical, biological, and social impacts. Changes in productivity of downstream agricultural fields or fisheries are included, just as the question of population resettlement. Environmental effects may occur upstream, on-site, or downstream of the hydropower project. The following list presents a listing of environmental aspects of hydropower projects. Some impacts are positive, others negative. It should illustrate the complexity of the topic. The listing is taken from the World Bank Technical Paper No.10 entitled “Dams and the Environment”. It can be considered as a checklist of environmental aspects in hydropower development.

- Health
  some water related diseases can increase unless precautions are implemented (e.g. Vector control, prevention) schistosomiasis, onchocerciasis, encephalitis, malaria, etc. Remediation usually impossible; prevention is the only cost-effective approach.
- Resettlement
  of people is expensive and time-consuming when done acceptably. The people can (and should) be better off afterwards. Can hydropower projects become regional development projects, which integrate rural development for people, with watershed management and irrigation. Resettlement of vulnerable ethnic unacculturated minorities should be avoided; if unavoidable, special precautions are necessary.
- Wildlife
  extinction can be minimized by siting. Loss of wildlife can be mitigated by including a wildland management unit, equivalent to the inundated tract in the watershed. Biotic rescue can assist.
- Fish
  migrations (if any) will be impaired without passage facilities. Fish promotion in the reservoir can mitigate and produce more than before the project
- Biomass removal
  Related to whatever water quality is needed downstream, to fisheries and navigation. Valuable timbers and fuel should be salvaged; “opportunity costs” of lost timber and foregone use of inundated land should be internalized
- Water weeds
  Proliferation can increase disease vectors, and transpiration increases water loss and impairs fish and water quality (e.g. Water hyacinth (eichhornia), water lettuce (pistla)). Clogging impairs navigation, recreation and irrigation. Some potential to use weeds for compost, biogas, fodder
- Water quality
  Within reservoir and downstream, saline intrusions, water retention time (i.e. Flow/volume); decrease nutrients in estuary; pollution monitoring (agricultural leachates, industries).
- Erosion
  upstream leads to sedimentation which can impair storage; watershed management should be routine. Increased erosivity below a dam
- Drawdown strip
  Useful for recession agriculture (with disease and access precautions)

- Cultural property
  Archeological, historic, paleontologic, religious and esthetic or natural unique values or sites should be conserved or salvaged.
- Multiple use
  Can be optimized by tourism, irrigation, fisheries, recreation. Regulation improves seasonal rivers into perennial waterways; advantages for drinking and irrigation.
- Navigation
  may need special provisions such as locks, cleared shipping lanes, and access ramps if drawdown is large. Lake transport may become economically advantageous
- Induced seismicity
  Tectonic movements may increase or decrease; monitoring is becoming routine
- Intact rivers
  Hydropower and other developments are better concentrated on the same rivers in order to preserve representative rivers in their natural states.

There are several common points from the above mentioned aspects that are important: It is needed to re-emphasize that not all environmental effects are negative and entail costs only. They can also generate benefits. It is as important to identify the contributions of environmental factors to the project, as it is to identify the negative impacts and the constraints they may impose. Both environmental costs and benefits must be taken into account.
The second important aspect is that the effects and thereby also the environmental aspects of hydropower developments are strongly interconnected as the listing above shows.

## 7.2 DATA COLLECTION

The data collection concerning environment can be distinguished in three steps:
- Preliminary desk studies in the office
- Data collection in the field
- Establishment of environmental and socio-economic set up

Preliminary office work will gain only limited data, since high head hydropower development is usually in remote areas. In case of bigger projects in tributaries, some more information will be available. In recent years mapping of environmental and natural resources is carried out by multistage survey, where tools as satellite data, computer classification, aerial photography, ground sampling and land surface mapping is used.

Major information on the project area can be obtained during a site visit, which is carried out to observe and establish present environmental conditions. The range of possible impacts in the area of influence of the project can be assessed, on site as well as offsite which may extend into the catchment and even into the district.

A site inspection and village survey will be carried out. The purpose is to cover a large cross-section of the inhabitants of the project area and surrounding villages. Inhabitants of villages should be interviewed together with local people of the region and the proposed site should be inspected from weir to intake. Further information on the project area can be obtained from development programs and local authorities.

The fieldwork mainly includes the following information:
- Socio-economic conditions concerning the people and their basic necessities.
- Soil, land, vegetation, farming, irrigation, plantation, forestation and deforestation.
- Ecological conditions concerning fisheries and wild life.
- Climate of the catchment

The irrigation and water supply issue in connection with the determination of residual waters

can be considered as the main point of the environmental assessment of high head developments in rural areas. For this purpose it is useful to carry out discharge measurements in the small distribution canals and water supply canals during different seasons of the year. This will give some helpful additional information regarding the need for water together with other data taken in the field.

## 7.3 DATA PROCESSING AT GOLEN GOL, CHITRAL

The data collected during the field visit will be processed to establish a set-up of present different environmental and socio-economical data. This should describe the actual stage without any considerations of hydropower development. Later processed data are analyzed by applying it to the proposed hydropower scheme and to find their environmental impacts whether beneficial or harmful. The following example of the proposed hydropower project Golen Gol in Chitral Valley describes the set-up with collected data as basis.

### 7.3.1 PHYSICAL SETTINGS

#### 7.3.1.1 CLIMATOLOGY

Climate of the Chitral district in general is considered as a continental one. The summer season is hot while winter is chilly. Widespread snowfalls occur in winter. For Chitral town, the mean maximum temperature is 41$^{o}$C in July and extreme minimum temperature is -3.8$^{o}$C and -4.8$^{o}$C for the months of December and January respectively.

Chitral like other areas in North West of Pakistan, receives only 476 mm precipitation of which 75% occurs in winter and spring. The average monthly precipitation ranges from about 6 mm in June and July to more than 100 mm in March.

#### 7.3.1.2 GEOLOGY

In the project area, three important rock units i.e., Kaghozi Granite, Reshun Formation and Green schist Unit as well as different types of Quaternary deposits are present. The Kaghozi Granite is the main rock unit exposed in the project area. This is grey, fine to medium grained, foliated, non porphyritic and hard to very hard. Its lower contact with Reshun formation is faulted and is characterized by cataplastic texture. Rocks of Reshun formation are medium hard except at places where these have been affected by Ayun fault. Weir site is located where Golen Gol is wider in section and a spillway can be made on right bank. The foundation will be over the cobbles and gravel with little or no sand. The sand trap, the gravel spill and the headrace canal are to be constructed through terrace deposits. Headrace tunnel will be excavated through three rock formations Kaghozi granite, Reshun formation and Green schist unit. Six types of rocks are expected to be encountered during tunneling. The excavation of surge structure will take place in rocks of Reshun formation. The penstock has now been replaced by a completely embedded pressure shaft divided into a vertical section and a horizontal section. The power house is situated just downstream of Golen Gol mouth over a terrace consisting of the slope deposits. Appropriate drainage arrangement shall be needed for the terrace and slope deposits underneath the power house and the lower part of the pressure shaft.

#### 7.3.1.3 SOILS

The soils found on the valley bottoms and old river terraces are derived from the alluvial deposits mainly brought by the hill torrents, avalanches and glaciers. These soils are the `drift soils'. Soils of various colours ranging from dark grey to brown and white are found in Golen-Gol area. This is due to ground water and back water conditions as well as to the development of thin layers of humus soils.

#### 7.3.1.4 EROSION

Loss of land through erosion by rivers, land slips or land slides and flash floods are common throughout the district because of which considerable areas go out of use every year. The problem of erosion is most serious in Drosh, Ayun, Belach, Booni, Yarkhun valley etc. and land slips and land slides are common in Mulkhow, parts of Torikhow and Lotkhuh areas. Flash floods are experienced in all parts of the district.

### 7.3.2 PRESENT LAND USE

The total geographic area of the district is 1,480,000 ha and the area of the Golen valley is 52,500 ha out of which 6-8% is snow bound. The area is rugged and mountainous. The cultivated lands are concentrated in alluvial fans near habitation. Total agriculture land is about 250 ha. Rest of the area is either under forests/pastures and the remaining is barren land belonging to the Government.

#### 7.3.2.1 AGRICULTURE

Most of the agricultural activities in the project area are carried out on the terraces prepared in the vicinity of the three main settlements. This includes: villages of Golen Payeen, Chashma and Babuka. Another larger area of agricultural land which belongs to village Bargozi is being irrigated by Golen Gol. Village Bargozi is located across the Mastuj river and irrigation water is taken through a 8” pipe by gravity flow. The total estimated agricultural land in the project area is about 157 ha. Normally wheat and maize are planted in the fields around the villages but potatoes are planted on the land owned up-hills during summer season. Wheat is sown during winter and maize in summer. It was observed that traditionally wheat is planted under rainfall conditions and no irrigation is applied during the growth period. Wheat is harvested in July and after that maize is planted on the same plot.

#### 7.3.2.2 FORESTS AND WOODLAND

The lower part of Golen Gol valley receives about 300 mm of rainfall which should facilitate the growth of some forest cover comprising Deodar, Spruce, Fir, Chir, Oak etc., however very little forests are found in lower Golen Gol valley. The vegetation of the area can be divided into following types:

1. dry temperate coniferous forests.
2. oak forests.
3. fraxinus xanthoxloides open scrub.
4. sub-alpine scrub.
5. alpine herbaceous vegetation
6. cultivated plants.

The work plan of Forest Department envisages management of the type 1 forests only.

The dry temperate coniferous forests can be divided further into two formations i.e., Silver Fir forests and Deodar forests. The Silver Fir forests are generally in the form of a belt above Deodar zone, at elevations ranging from 2500 meter to 3500 meter which varies in width considerably and is occasionally even absent. The crop is generally pure but scattered trees of high altitude kail, birch (Betula utilize) and juniper (Juniperus macropoda) are found growing in the stand in upper limits. The Deodar forests occupy about 75 percent of the total area under coniferous species. The altitude limits vary between 2000 and 3000 meter. These forests are confined to the side valleys. The trees are generally slow growing with long persistent branches, tampering bole and thick bark. The timber therefore, is of inferior quality and is liable to all sorts of defects like knots, shakes, cracks etc.

Below the Deodar belt are found the oak (Quercus ilex) forests. The type ranges from 1200 to 2000 meter and is generally found pure.

The area north of Chitral town is cold and arid and its flora resembles that of the steppes of Central Asia. The hill slopes are bare, almost devoid of soil except in the crevices. The only tree which is found in this area is the stunted Fraxinus xanthoxyloides. Further north, the type merges with alpine zone where due to height altitudes, sufficient moisture is available on account of melting snow.

The Sub-alpine scrub is found above silver fir forests between 3500 to 4000 meter elevations. The main species is birch (Betula utilis). Above about 4000 meter, only herbaceous plants grow. The density of the ground cover depends on the available moisture and soil depth.

In and around the villages various trees are grown for fruit, shade, timber and fuel wood. In northern parts of the state where there is great shortage of timber and fuel wood, these plantations are very cautiously guarded. More commonly grown plants are black poplar (Populus nigra), apricot (Prunus armenica, walnut (Juglans regia), mulberry (Morus spp), grape (Vitis vinifera), apple (Pyrus malus), pear (Pyrus communis), pomegranate (Punica granatum), sour cherry (Prunus cerasifera), sweet cherry (Prunus avium), peach (Prunus persica), Amlock (Diospyros lotus), fig (Ficus carica), almond (Prunus amygdalus) Chinar (Plantanus orientalis), willow (Salix spp), sinjul (eleagnus hortensis), Mirghiz (Hippophae rhamnoides), ash (Fraxinus excelsior) and black locust (Robinia pseud-acacia).

The harvesting of the forests is carried out by NWFP Forest Development Corporation (FDC).

#### 7.3.2.3 PASTURES

The natural pastures are found above tree limit from about 3800 m.a.s.l. Clover is most widely grown in the double-cropping villages, as winter crop. It is often sown under maize or rice a few weeks before these grains are harvested. Usually, it is fed green to the animals that remain in the village during the summer and sometimes these animals graze in the clover fields.

#### 7.3.2.4 FLORA

Natural flora of the area consist of (i) grasses extensively as Artemisia maritoma, (ii) herbs most commonly Astragalus spp, Polygonum spp, Saxifraga spp, Osytopis spp, Coorydalis spp., (iii) shrubs with common bushes as Biburnum continifolium, Lonicer spp, Spiraea Iindleyana, Daphne oleoides, Prunus eubernea (Chitrali-Kandu), Salix spp, Sophora mollis, (Chitrali-beshu), and Caragana decorticans (Chitali-Kagbeshu) Indigofera and (iv) trees; Important conifer spp: are spruce (Pilea smlhana), fire (Abies pendrow), Diar (Cedrus Deodawa), Kail (Pinus wallichiana) & Saruz (Juniperus spp).

#### 7.3.2.5 WILDLIFE

Golen Gol with very scattered settlement and meager population is almost a wilderness. Shooting, trapping of wild animals is not allowed except with a special permit. The number of animals or birds killed or captured is also restricted and specified in the permit. Markhor, and Ibex descends down to village Babuka during winter. Though Chitral lies on Indus fly way mass migration of birds during their passage to south has not been observed in the Golen Gol valley. Snow leopard is declared as endangered and other species of mammals are also scarce. Decline in wildlife has been witnessed over number of years.

#### 7.3.2.6 FAUNA

There is no site specific information on avifauna. Chitral lies on Indus fly way No.4. Some migratory birds on their journey may stray to side valleys. Locals did not report sighting of mass migration through Golen valley.

The amphibian fauna of Chitral is not documented. The fish fauna has been reported. Amongst invertebrates aquatic insects have been found. Nine genera of Trichoptera (caddis flies) larvae have been reported from various streams having similar habitat as that of Golen Gol.

As the main Golen Gol stream is fast running and there are very few pools and puddles hence snails were not observed. Similar habitat also discourages the breeding of mosquitoes and black flies larvae. Field observations on insect pest problem did not show any serious attack on orchards.

### 7.3.3 LIVESTOCK

Resident livestock population in Golen Gol valley is 3332 which includes 657 cattle, 2650 goats or sheep, 25 horses/mules/donkeys, while seasonal nomadic livestock population is 4584 which includes 34 cattle, 4500 sheep and goats 50 horses/mules/donkeys. The cattle in general appearance are under-sized and weak. In spite of this, various types of diseases, lack of pastures, inadequate veterinary services, badly manages animal husbandry, danger of wild animals and danger of thieves from across the border, have been great obstacles in the development of flocks.

### 7.3.4 AIR

The air quality of the project area and its vicinity is generally fresh and clear under normal condition. There is no major source of air pollution as there are no major vehicular movement or industrial setup in its vicinity.
The vegetation cover in the area is very thin and the level of ambient (suspended) dust increases during windy conditions and major traffic movement which is an occasional occurrence.

### 7.3.5 NOISE

The noise level in the project area are fairly high and range between 50 to 65 dB without traffic, mainly due to the flowing water colliding against rocks and boulders. There is hardly any traffic on the jeepable track which runs through the Golen Gol valley. So traffic noise has negligible contribution to the noise level in the project area.

### 7.3.6 WATER

Water is the one of the most important natural resource of the project area. Most of the socio-economic activity of the project area are connected to the availability of adequate quantity and good quality of water. The conditions and use of water in the project area are discussed in this section.

#### 7.3.6.1 WATER QUALITY

In the vicinity of the project area, good quality water is available from Golen Gol and the water quality does not alter or deteriorate even during the rainy season.
Water quality of Golen Gol was tested at a different locations along the length of the stream mostly at intake points of different utility channel. Sampling shows that the water has very high Dissolved oxygen (D.O) contents (9mg/l) and surprisingly the Biochemical Oxygen Demand (BOD) was also fairly high (0.5-2.0 mg/l).

#### 7.3.6.2 ADJOINING TRIBUTARIES AND SPRINGS

The mean monthly discharge of Golen Gol is 18.71 $m^3$/s. The minimum monthly discharge of 6.28 $m^3$/s occurs during February and March and a maximum monthly discharge of 48.76 $m^3$/s during July. Downstream of the proposed weir small tributaries with occasional discharge join the Golen Gol. There are two major springs nearby Golen-Chashma village at an altitude of 1953 to 1958 m.a.s.l near the Golen Gol right bank. Besides these two springs with discharges 1200 l/s and 300 l/s respectively, diffuse springs seepage from lower river terrace at an altitude of 1948 m.a.s.l. The total discharge of all the springs is estimated to be about 3 $m^3$ at present and in winter is half of this. The origin of the spring water is still unknown although the temperature of the spring water is higher than Golen Gol water. The electricity conductivity is highly significant less than Golen Gol water and the total hardness is also less than Golen Gol

water. At the left bank there are two springs at about 2060 and 2120 m.a.s.l named Kano Gol. The water distributes to Golen Gol. It is also presently used for irrigation and domestic purposes.

#### 7.3.6.3 WATER QUANTITY AND USE

The water quantities required for all water uses, the hydrological data and plant operational requirements for water show that from the month of May to October there would be enough surplus water in the Golen Gol to fulfill all water requirements of the project area after fulfilling plant operation requirements. But in the months from November to April in order to make most economical use of the hydropower plant, most of the water in the Golen Gol will be used up in plant operation and residual water will flow in the Golen Gol for about 6-9 months. Golen Gol is very important utility channel for the people of the project area. Its water is mainly used for irrigation, domestic purposes, micro-hydel plant operations, fishing, running water mills and for carrying domestic waste water. The present water required for all these usages has been estimated along with the future requirements (25 years exponential projections). The estimates of water requirements when compared with hydrological data of Golen Gol show that presently there is enough water in the Golen Gol to meet all these water demands.

#### 7.3.6.4 IRRIGATION

Irrigation is essential for cultivation and no crops are grown without it. The rainfall in most of the valley bottom is too low to support more than semi-desert scrub, but higher on the mountains the precipitation is high especially in winter. For irrigation in lower lands, the water is diverted from the Golen Gol to irrigate the fields via open water channel. The distribution of water rights for irrigation purpose is proportional to the land holdings. Irrigation channels normally have enough water to serve all the irrigated land in the project area. Usually farmers irrigate their fields during day time only. In all, there are eleven irrigation channels which irrigate total agricultural land in the project area. Irrigation channels are man made and maintained commonly by all the farmers benefiting from the channel. Out of these 11 channels, nine irrigation channels are fed from Golen Gol.

Other than the above, there are two additional channels fed from springs in Chashma Village.

There is another irrigation channel being constructed by the community in collaboration with CADP. The intake of this channel is above the weir site and will reach Golen-Chashma village at a height of approximately 1990 m.a.s.l. This channel is expected to irrigate about 28 ha of land which currently is a barren land and consists of slopes which may be developed during the next 6-7 years.

#### 7.3.6.5 WASTE

The villages within the project area do not have any drainage, sewerage or treatment system for sewerage collection and disposal. According to a sample survey 30 per cent of the houses have improvised pour flush pit latrines. The reaming 70 per cent of the house holds use dry pits or defecate in the fields. Waste water (sullage) from kitchen, bathing and washing is discharged into small drains leading to the Golen Gol or directly to small fields outside the houses. The health and hygiene practices are very primitive but project like CADP, AKRSP are now coordinating with the health department to improve health and hygiene practices through training and information dissemination. There are no solid waste collection points or disposal practices in the area. People tend to throw their solid waste outside their houses or into the Golen Gol depending upon convenience. Animal waste specially cow dung is used as farm manure or rarely used for burning after drying.

### 7.3.7 FISHERIES AND AQUATIC LIFE

Chitral provides ideal water for the propagation of many varieties of local fish as well as trout. Trout fish is found in abundance in Golen Nullah although it is an exotic species which has

been introduced first in 1960 to this area.

In Chitral region, the typical breeding season of trouts occur during November to February, when the eggs are collected from spawning areas of the streams. Eggs are also obtained in hatcheries from brood stock. The eggs are kept in the hatcheries for about one month, by that time the fries develop into 3-4" fingerlings, when they are released into low velocity riffles between boulders in selected streams. The typical period of releasing these fingerlings ranges from early April to July.
Major trout stocking points on the streams in Chitral include Golen Gol, Garam Chashma and in the Bumbhurat valley. Over 25000 fingerlings are released in Golen Gol every year by the Fishery Department. Fishing season commences from April and extends up to October.

The rooted vegetation on either banks of the stream is sparse and at a distance adding little to the biomass of the stream in the form of falling leaves and litter. Due to fast running nature of the stream filamentous algae and other macrophytes are not found except in some back water where pool-like situation exists.
The indigenous and exotic species of fishes found in district Chitral, stocking of Brown Trout and Kamloop and License issued for fishing in Golen Gol.

### 7.3.8 MICRO HYDEL STATIONS AND WATER MILLS

There are only two hydel power stations in the project area. The first is located immediately above the weir site with a capacity of 20 kW and intake discharge of 0.15 $m^3$/s. The second is located near the Golen Gol bridge in Chitral-Booni road with 40 kW capacity, and an intake discharge of 0.27 $m^3$/s. The length of these channels is between 350 to 500 m and they only effect the Golen Gol in these stretches before the water is returned to the stream.

In all, six water mills are in operation in the project area, out of which three operate on Golen Gol water. On average one mill require 0.125 $m^3$/s of water for operation. Length of water mills channel is about 60-80 m, after which water is returned to the stream. The upper mill is located in Babuka and the two lower mills (parallel) are located near the Golen Gol bridge. The water mills located in Chashma village operate on spring water. A fourth mill is under construction in Chashma village which will also be operated on spring water.

### 7.3.9 SOCIO-ECONOMIC SET-UP

#### 7.3.9.1 GENERAL

Chitral district is mainly a mountainous terrain. Area wise Chitral is the most extensive district of NWFP. Socio-economic indicators show that Chitral is backward with low quality of life. One of the most outstanding features is that it is cut off from rest of the country during winter months due to closure of Lowari top (the only land connection in Pakistan territory) due to snow. There is also a route through Afghanistan which presently is not considered due to safety measures. Hence the only means of communication after the closure is by air which is intermittent due to weather conditions.

#### 7.3.9.2 SOCIO-DEMOGRAPHIC CHARACTERISTICS

Golen Gol Project area is spread over three settlements namely Golen Payeen & Chashma, Babuka, and upper Mishkily which is a very small hamlet with only three households. There are one hundred and nine households in the project area, with 3 households in Mishkily, 40 in Golen Payeen, 38 in the adjacent Chashma village and 32 in Babuka village.

Total population of these three villages is approximately 978 with negligible difference in the proportion of male and female population. Golen Payeen had the highest population (323) followed by Chashma (304), Babuka (224) and Mishkily with only 27 individuals. Average

population per household is close to 9 individuals which is quite consistent with the findings of other studies (Statistics from EDC report attached in the Annexure).

There are two schools in the project area. One is a primary school and the other is middle school for boys. There is no separate school for girls. Both these schools are located in the Chashma village. Children from three settlements are enrolled in these schools.

Health care is provided by Basic Health Unit (BHU) located in Kaghozi as there is no BHU in the project area. In spite of low socio-economic indicators, the population look healthy.

Ethnic diversity is a characteristic feature of Chitral valley. People from different ethnic composition have distinct socio-cultural traditions, language and way of life. Major tribe in the area are Kho and their language is known as Khawar, which is commonly understood all over Chitral valley.

The inhabitants of the project area are from the majority Kho tribe and speak Khawar language which is an Indo-Arian language spoken in remote areas in valleys of Gilgit. Kho are descendants of Arians who three thousand five hundred years ago settled in Chitral area and now are spread all over Chitral valleys in small clusters.

The main vocation of the population is agriculture. The income is supplemented by keeping a few live stock. During winter male population moves to Chitral town or down country to seek employment.
Men in the area are responsible for all outdoor activities including agriculture and women are mainly confined to the household chores which include tending the livestock, carpet weaving and embroidery work. Household without presence of water may compel women to go out for washing the clothes and to fetch drinking water from nearby stream. Some women go out to collect fuel, wood and grasses to store for winter. Drying of apricot and mulberry is also carried out by female population. Female contribution to income is limited to raising and selling poultry products.

## 7.4 APPLICATION IN FORM OF IMPACT ASSESSMENT

In the second phase the impact of the planned hydropower development should be assessed to the environmental and social factors, which have been collected and analyzed in view of the existing circumstances. The impact assessment of hydropower projects can be distinguished to:

- construction caused impacts
- operation caused impacts

Since this discussion is better for understanding with actual site conditions, the example of the planned Golen Gol hydropower project will be discussed in detail in the following paragraphs:

### 7.4.1 CONSTRUCTION CAUSED IMPACTS

#### 7.4.1.1 GEOLOGY, GEOMORPHOLOGY AND SOILS

The rate of erosion will be increased slightly due to removal of spare vegetation cover on the slopes during construction stage. Construction activities like setup of the weir site, road extension, movement of trucks, clearing of land, setup of housing for the work force and storage for the machinery, excavation, tunneling will contribute to increased surface and fluvial erosion. It will increase the sediment load of Golen Gol river.

#### 7.4.1.2 WATER RELATED IMPACTS

There are no significant changes in the run off regime of Golen Gol caused by the construction

activities. The impacts caused by temporary diversion works at the weir site will be minor. During the construction stages at any riverside, movements of both construction equipment and river bed sediments within the flowing river water will increase the amount of suspended load in the river water. This impact is concerned to the construction of diversion structure and other inlet structures at the weir site. The increased sediment discharge will last for the time of active movements of construction materials and the bed material in the water body and will be observed downstream at the entire following river sections.

The diversion of water and increase in the temporary sediment is expected to affect the unprotected drinking water source of Golen Payeen and Bargozi water supply network. Babuka irrigation intake used for drinking water are located above the weir and will not be affected. Some mitigation measures will have to be provided to protect these water sources in order to maintain water quality. Additional water supply network may have to be established for construction labour in site installation camps.

No significant impact on ecology of Golen Gol stream and its tributaries is anticipated during construction phase. The excavated material produced during construction activity has to be disposed off in a way that it does not enter into the stream. Slight increase in sediment loads will have no major impact on the fish population of Golen Gol.

Any deterioration in water quality during construction stage would not have any impact on irrigation water quality requirements. However, some water channel intakes may have to be suitably relocated near the weir site where the diversion channel will be constructed. There may be slight increase in the quality of waste reaching Golen Gol during construction phase due to presence of large number of labourers. Some mitigation will have to be provided to control waste from site installation camps etc.

#### 7.4.1.3 LAND RELATED IMPACTS

During construction, site installation camps shall be maintained properly and after completion they shall be rehabilitated and returned to original owner. Proper compensation for leasing and resettlement should be worked out through mutual agreement with the concerned community to avoid any future conflict. The installation camp at the power house site would be later converted to the staff colony, so land for this site may be purchased instead of hiring.

Some poles of electricity line along the jeepable track near weir site may have to be relocated due to lateral intake to headrace canal. Realignment of a small stretch of the track will also be required due to intake and related structures. Most of the area acquired for the weir and related structures is a waste land and no compensation may be required. The area required for realignment of existing jeepable road track would be around 280 $m^2$ and it may have to pass through cultivated fields. Some trees in the nullah bank behind the weir will be damaged due to accommodation of water. Trees should be removed and compensation is to be paid to the owners, details given in Table 7.1.

Proper care is required not to disturb the traffic on Chitral-Booni road during construction of power house. Proper drainage should be designed around the power house along with protection against falling of sacree.

Access roads to surge tank and weir sites have an impact on land use but it will also provide new access to the settlements. A total of 1.4 ha of land may have to be acquired for this purpose.

The location of site for staff colony will have limited environmental effect on the area during construction phase as it is expected that the same area used for site installation camps near power house will be developed into staff colony. Most of this area (1.0 ha) is agricultural land

with forest and fruit trees.

Leasing of at least 2 ha of land during construction period will be required for safe disposal of excavated material which may be developed and returned to local affectees. Total land required for the project is given in Table 7.2.

Borrow areas to suit the construction requirement will be required as close to the construction as possible. The adverse environmental impact anticipated due to borrowing can be averted if the contractors follow the Environmental Management Plan to be set up for this purpose.

A total of 0.12 ha of agricultural land may have to be acquired to accommodate intake channel.

During construction phase the blasting, collection of excavated waste and its disposal may scare the wildlife in immediate vicinity. However, the habitat of game animals is at much higher altitude at quite a distance from the project area. Therefore, there will not be any regular impact during construction activity. Minor effect on the scenic beauty of the area is also expected due to scenic beauty.

**Table 7.1**: **Compensation for trees and cost of afforestation**

| Name of Structure | Species | Dia (cm) | Unit Costs (Rs) | No Of Trees | Total Cost |
|---|---|---|---|---|---|
| A. Road widening | Walnut | 30-50 | 4000 | 8 | 32000 |
| | Mulberry | 30-50 | 2000 | 5 | 10000 |
| | **SUB-TOTAL** | | | **13** | **42000** |
| B. Weir site | Temaric | 10-20 | 300 | 5 | 1500 |
| | Thok | 10-20 | 500 | 6 | 3000 |
| | Apple | 20 | 700 | 1 | 700 |
| | **SUB-TOTAL** | | | **12** | **5200** |
| C. In take structure/power channel | Thok | 10-20 | 500 | 16 | 8000 |
| | | 20-30 | 800 | 10 | 8000 |
| | Sanjor | 10-20 | 500 | 19 | 9500 |

| | | | | | |
|---|---|---|---|---|---|
| | Apricot/Appl e/Peach | 10-20 | 700 | 23 | 16100 |
| | Terik | 30 | 500 | 1 | 500 |
| | Theli | 10-20 | 500 | 2 | 1000 |
| | **SUB-TOTAL** | | | **71** | **43100** |
| D. Power House-site. | Ailanthus | 10-20 | 500 | 31 | 15500 |
| | | 20-30 | 800 | 22 | 17600 |
| | Apricot | 1-20 | 700 | 27 | 18900 |
| | /Apple | 20-30 | 1000 | 16 | 16000 |
| | Theli | 10-20 | 500 | 23 | 11500 |
| | **SUB-TOTAL** | | | **119** | **79500** |
| | **GRAND-TOTAL** | | **0** | **215** | **169800** |

Therefore, compensation for trees works comes out to be Rs.169800 equivalent to US$ 4250.

**COST OF AFFORESTATION**

| Particulars | No. Of Plants | Unit of Cost Rs. | TOTAL |
|---|---|---|---|
| Planting of Robina, Poplar Apple and Apricot/Walnut | 15000 | 5 | 75000 |

Therefore cost of afforestation works comes out to be Rs.75000 equivalent to US$1875.

**Table 7.2**: **Total land required for the project**

| Item | Cultivated | | Uncultivated/ Waste | | Total | |
|---|---|---|---|---|---|---|
| | land (ha) | Unit Cost (Million Rs) | Land (ha) | Unit Cost (Million Rs) | Land (ha) | Cost (Million Rs) |
| Weir intake | | | 0.5 | 0.25 | 0.5 | 0.125 |
| Surge tank | | | 0.05 | 0.25 | 0.05 | 0.012 |
| Power house | 0.12 | 1.5 | 0.02 | 0.25 | 0.1 | 0.185 |
| Switch yard | 0.50 | 1.5 | | | 0.5 | 0.75 |
| Staff colony and related structure | 0.60 | 1.5 | 0.40 | 0.25 | 1.0 | 1.00 |
| Access road to surge tank | 0.30 | 1.5 | 1.10 | 0.25 | 1.4 | 0.725 |
| Realignment and widening of existing tract | 0.49 | 1.0 | 1.7 | 0.25 | 2.19 | 0.915 |
| Head race channel | 0.12 | 1.0 | | | 0.12 | 0.12 |
| **Total** | 2.13 | | 3.77 | | 6.00 | 3.775 |

**Table 7.3**: **Temporary Requirement of Land for Construction Period of 4 years**

| Item | Cultivated | Waste | Total land |
|---|---|---|---|
| 1. Site installation weir area | 0.5 ha | | 0.5 ha |
| 2. Site installation power house area | | | nil |
| 3. Deposition area | | 1.0 ha | 1.0 ha |
| **Total** | 5.0 ha | 1.0 ha | 1.5 ha |

#### 7.4.1.4 AIR RELATED IMPACTS

Dust will be the main source of health hazards during construction stage. Pulmonary Tuberculosis and silicosis may result from the dust generated by stone crushing, blasting and movements of equipment. Fumes and smoke from burning materials and vehicles exhaust can acute respiratory irritation and bronchitis. The area is already prone to high dust levels due to thin vegetation covers and limited annual precipitation. Although the problem will be temporary, special measures should be taken to reduce this impact.

Blasting activities and traffic will cause an increased noise level in the Golen Gol valley. The increase of noise and vibration levels would be site specific and short term. But also the average level will increase. High sound levels will also affect the villagers. Some special detrimental effects will be produced because sensitive receptors as two schools at Golen Chashma and two mosques exist in Golen Gol valley. As a precautionary measure, houses within 400 m radius of the weir should be relocated/resettled temporarily for construction period.

At powerhouse site, the existing noise level in the valley is already high due to the turbulence and resonance effect of Mastuj river. Noise shunting devices for dampening explosion noises during tunneling activity will be provided. Air pollution due to gaseous emissions from heavy machinery is also expected.

#### 7.4.1.5 SOCIO-ECONOMIC IMPACTS

During the construction phase of the hydropower project, a mass inflow of outside workers and heavy machinery will disturb the local socio-political and socio-cultural life. As a result the women folk in particular, could be restricted by a more strict application of purdah and sense of insecurity amongst the locals may increase. The project, during the construction stage will have a major effect on the life style of the people. It is anticipated that new hotels and accommodation facilities will be developed and the local people will be exposed to new income generation opportunities. New markets will also be established. People from other cities and countries are expected to visit the project site and participate in the construction activity which will lead to cultural transformation and learning from each other.

The project will have major affects on local economy, employment and income. The local market will provide food, clothing and other consumable items for the work force on the project. The requirements of gasoline, fuels, hotelling and commodities will bring more business in the project area boosting its economy. The prices of local products will slightly increase or will be stabilized at a certain level.

Employment opportunities will increase as well, not only in the construction field but also on development of new workshops and services. Moreover, as new jobs become available in the area, the out migration of the labour force will reduce, enabling the men to stay at home and find work. Both semi-skilled and unskilled workers can benefit by getting employed on the project. The demand for labourer will increase.

During the construction stage of head works, no resettlement is required. Due to major losses of agriculture land at the headwork site, an indirect migration may also be caused. This effect can hardly be estimated.

The project sponsors would develop facilities for clean drinking water for local community. This will reduce the incidence of water born diseases in the area. Due to presence of large number of working force (about 200 people), the contractor would maintain a dispensary at site and the local community could benefit from this facility.

### 7.4.2 OPERATION CAUSED IMPACTS

#### 7.4.2.1 GEOLOGY, GEOMORPHOLOGY AND SOILS

No impacts on subsoil are expected.

#### 7.4.2.2 WATER RELATED IMPACTS

During the operation phase, only residual flow will be released in the Golen Gol for major parts of the year (9 months). As most of the solid/liquid waste of population of the project area is carried by Golen Gol, reduced flow will also decrease the waste digestion/dilution capacity of Golen Gol which in turn will affect its quality. In general reduced flows may make the Golen Gol water unsafe for drinking purposes. Mitigation measures may have to be provided to ensure adequate safe drinking water provision for the local population. This slight water quality deterioration will have no effect on other uses of Golen Gol water.

The upstream portion of the stream above the weir will remain undisturbed except the section in immediate vicinity of the weir where water is collected for diversion in the connecting channel

leading to tunnel. As no reservoir is being provided, nature of stream will remain running and will not acquire a lacustrine (lake like) situation. However, the negative impact will be that the fish population will be fragmented into a population above weir and one below the weir due to weir acting as a barrier to migration. For protection of fisheries and other aquatic life, 10% of average daily flow is required. Based on the available data the minimum flow to be ensured is 1.87 $m^3/s$.

During the operation stage reduced flows downstream of the weir may affect the water requirements of many irrigation channels for downstream areas. The project sponsors should ensure availability of adequate quantity of water for these channels.

The release of sediment free water from the plant tailrace is also expected to result in some downstream erosion of nullah banks and bed. This effect can be considerably reduced by bank and bed protection measures near the tailrace. The speed of the discharging water can also be controlled by an appropriate design to cause minimum erosion.

As the population of the affected villages of the project area is limited, so the complete cost of sanitation intervention is not expected to be very high. There should be an option to provide this facility along with provision of good quality of domestic water. Similarly, waste generated at the operator colony will also have to be properly controlled/treated before it is released into any water body, otherwise it will have additional impacts.

#### 7.4.2.3 LAND RELATED IMPACTS

While loss of land is minor in nature but considering the limited availability of useful land in this area it is reasonably significant. Similarly due to limited land resources, resettlement may not be very easy and will require community dialogue and proper pre-planning assistance and monitoring.

Arable land downstream of weir site can be affected due to decreased flow in Golen Gol. In addition, staff colony will be a permanent addition to the settlements of the project area. Access and mobility in the area will improve with the provision of new roads and land use practices (agricultural extension) are also expected to improve. New roads constructed will improve access and mobility in the project area. There is a possibility of reclaiming about 1 ha of land along the Golen Gol near upper Mishkily by developing the deposition area. This may be achieved by properly managing the muck disposal activity.

The power transmission lines do not pose any negative impact other than the scenic beauty of the area. Aesthetic degradation by transmission lines would not be significant because major section of the lines would pass through in remote hilly area.

During operational phase increase in population, better means of communication and more flow of tourists is anticipated. This may also encroach the wildlife habitat unless wildlife official and local community cooperate to protect the wildlife.

The aesthetic values of the weir intake can be exploited to provide recreational spot for the area. The small pondage upstream of weir can be managed and developed for sports fishing. Similarly landscaping and afforestation of the adjoining areas can further add to the scenic beauty of the project area and enhance its value as a recreational spot.

#### 7.4.2.4 AIR RELATED IMPACTS

All the operational and moving parts of the project equipment are confined. No increase in dust levels are expected during operation.

During the operation stage, the only possible noise can be that of generators and turbines.

These machines in any case have a level below the limit which already exists in the area. But as a precautionary measure it should be ensured that noise of the turbines and generators does not rise above the present noise level in this area. The basic noise level of flowing water will decrease rapidly according to reduction of discharge. Compared with other energy resources, the production of hydel energy from Golen Gol Project will decrease the emission of $CO_2$ in air.

#### 7.4.2.5 SOCIO-ECONOMIC IMPACTS

At present Golen Gol valley is an isolated area with very little population density, limited agricultural resources and limited employment avenues. The road network will enhance geographic and social mobility. The possibility of tourism will open up due to better roads and development activities on tourism sector.

The income of the inhabitants could increase substantially by adjusting to new demands. Also with these new demands and activities land prices will increase. The recipients of compensation whose land is affected by the project may invest their money in new business activities. The project could provide steady employment to some residents which could release funds for making innovative changes in their agriculture. The income from employment and increased agriculture production will improve their standard of living. The regular electric supply may activate the existing cottage industry. The demand for these goods may sharply increase with the advent of tourism in the area.

Like other sectors of development, health facilities will also improve due to increase in tourism and business markets. In addition to this, a permanent medical dispensary will be provided for the operators village. Local people will also benefit from medical facility.

## 7.5 ENVIRONMENTAL MEASURES

### 7.5.1 MITIGATION PROGRAMME

The purpose of a mitigation programme is to manage the environmental effects in a manner that minimizes adverse impacts and maximizes secondary benefits. As mitigation is a process of making a project more compatible with its environment, two approaches present themselves: (i) refine the project to reduce its effects on the resources, or (ii) alter its environment to achieve the same end. In general, planners prefer to keep the project in its optimum state and make compensatory changes in the environment, but, in fact, many acts of mitigation take place before the first project component reaches its ultimate configuration.

### 7.5.2 CONSTRUCTION STAGE MITIGATION PROGRAMME

#### 7.5.2.1 WATER RELATED MITIGATION

The following measures should be adopted in order to mitigate the impact on environment due to water pollution caused by construction activity:

(1) The quality of Golen Gol water may be affected during the construction activity. This requires protection of the water supply intakes and basic treatment of the water before it goes into the network or extension of network to safe water source. By the time the construction will start on the Golen Gol Hydropower project, the water demand of Babuka Village will be fulfilled by the under construction scheme of PHED, hence no mitigation measure is required for Babuka water supply during construction. The Golen Payeen village already has a network. The intake of this network is below the weir and it needs to be connected to a suitable point above the weir and suitably protected to ensure supply of good quality water to Golen Payeen before construction work at intake starts. The intake of Bargozi water supply might not be affected during construction as it is quite far away from the construction activity.

(2) The irrigation water quality would not be affected by construction activity but some

intakes near the weir and diversion tunnel may be affected in terms of water quantity and location. These intakes should be suitably extended or relocated.

(3) Proper collection and disposal of process water used in construction activity.

(4) Septic tanks should be provided to treat the wastewater from site installation camps and sanitary appliances.

(5) Drainage channels should be built around or at the downstream ends of all construction areas and these channels should lead the water to the treatment and settlement ponds.

(6) Sludge collected from septic tanks and solid waste shall be disposed off properly through landfill methods.

(7) Diesel, oil and lubricants shall be properly stored in accordance with the petroleum regulations.

#### 7.5.2.2 LAND RELATED MITIGATION

Many land use changes are expected in the project area during construction. About 2.07 ha of cultivated land will be acquired in total for construction of access roads, to powerhouse and surge tank and to construct different project infrastructures. In addition about 1.5 ha area would be leased for construction period for installing site camp and deposition area. This will exert pressure on already limited land resources available in the area. Land should be acquired at an early stage and proper compensation should be ensured to all affectees.

Control of contractor's activities, proper management, planning, route selection are required to avoid the problem of traffic hindrance. Widening of existing track in the section where the road passes through densely populated areas are required in order to avoid lot of inconvenience caused due to movement of construction machinery and vehicles, causing increase in suspended dust in domestic area.

Vegetation and forestation the most effective and economical methods for erosion control. Both sides of affected area should be planted with grass cover, tiny bushes and trees. Also, construction slope for road, powerhouse, other structures should be kept as flat as is reasonably possible.

Environmentally safe disposal of the surplus (about 50,000 $m^3$) muck generated during the construction of the project is essential to protect the natural resource of the area. The reclamation of barren land selected for muck disposal along the Golen Gol is considered as a better option for developing additional land resource of the area. Muck disposal area can be improved by topographic modification. This can be done by terracing, providing stone rubble retaining walls and levelling these terraces by graders. Consideration should also be given to store the useable muck for future use by local communities in land levelling, nullah management or other purposes.

#### 7.5.2.3 AIR RELATED MITIGATION

The following preventive measures should be adopted for effective mitigation caused by the increase in suspended dust and exhaust emission during the construction phase:

- constant sprinkling of water on the service roads and access track
- controlling the vehicle speed within the limit
- appropriate selection of stockpile sitting in order to minimize dust blowing.
- planting rapid growing trees in the project area.
- control of exhaust gases of vehicles used for construction.

To mitigate the effects of high noise level during construction, all vehicles shall be equipped with effective mufflers. Noise level of machines used during construction shall be controlled as far as possible and workers shall be provided with earmuffs where necessary. The portals should be provided with noise shunting devices to diffuse blasting noise.

#### 7.5.2.4 SOCIO-ECONOMIC MITIGATION

The construction of the proposed power plant will create job opportunities for the people living in the surrounding area. It is expected that large number of people will be employed, particularly in the category of labourers and semi skilled workers. Commodity markets and medical clinic etc. will be established with the construction of the project which will result in opportunities for the local people to establish their small business in the form of shops and craftsmanship in the adjoining areas of the power plant and also use project medical and education facilities to their own benefit. Some houses may have to be relocated during the construction stage. This will depend upon the extent of the construction activity and exact location, so the number of houses to be relocated cannot be ascertained but funds would be allocated for the purpose. The owners will have to be adequately compensated financially and the resettlement process will be properly assisted and monitored.

### 7.5.3 OPERATION STAGE MITIGATION PROGRAMME

#### 7.5.3.1 WATER RELATED MITIGATION

Water supply of various villages in the vicinity of the project area also needs to be mitigated. For Babuka village a network is under construction by PHED. This network will need to be extended by the project sponsors for house to house connections. Cost of extending the network is given in Table 6.3. The project sponsor should accommodate extension of existing network of Golen Payeen to all houses and to upper Chashma, in their budget (Table 6.3). The existing water intake should be extended to safe point upstream of the weir with proper intake protection measures. People of Chashma village prefer using spring water, so no further project support is required. As a precautionary measure cost of tapping the spring for water supply network in Chashma may be included in the project budget (Table 6.3). The water intake of Bargozi is presently located in Upper Mishkily. This intake should be extended and connected to the springs in Chashma and its intake suitably protected. The same water will fulfil the domestic water demand of the three houses located in Upper Mishkily.

For the irrigation water demand, the Upper Channel of Babuka with its intake above the weir should be suitably lined (500m) and realigned (1000 m) to supply water to smaller channels with their intakes below the weir to cover the whole village. The Golen Payeen intake should also be lined in some portion to conserve water (1000m) and connected through a pipe (1500m) and outfall pond to a point above the weir. No additional irrigation water supply is required for Chashma Village. The Bargozi irrigation intakes (0.112 $m^3$/s capacity), the proposed Moori lasht intake (0.112 $m^3$/s capacity) and the Mishkily hydel/irrigation intake (0.224 $m^3$/s capacity) are located below the discharge points of Chashma Village Springs which have a capacity of 1.47 $m^3$/s of additional discharge. So the requirements of all the above schemes can be adequately met from this additional flow without affecting the residual water flow required for fisheries in the Golen Gol.

**Table 7.4**: **Environmental impact mitigation cost**

| Particulars | Total Units | Unit Cost (USD) | Total Cost (USD) |
|---|---|---|---|
| **1. Rural Water Supply** | | | |
| A· Water Supply | | | |
| 1- Babuka Secondary Network | lump sum | 7,000 | 7,000 |
| 2- Chashma Primary/Secondary Network (Spring Fed) | lump sum | 16,000 | 16,000 |
| 3- Golen Payeen Intake & network extension & protection | lump sum | 15,000 | 15,000 |

| | | | | |
|---|---|---|---|---|
| | 4- Bargozi Intake extension and providing roughly filters | lump sum | 24,000 | 24,000 |
| B. | Water Pollution/ (optional) providing pour flush double pit latrines to all house holds below weir | 255 | 200 | 51000 |
| **2.** | **Irrigation Works** | | | |
| A. | Lining/realignment of existing irrigation channels | 2,500 m | 10 | 25,000 |
| B. | Lining/realignment of existing channels for water mills | 160 m | 13 | 2,080 |
| **3.** | **Infrastructure Maintenance (during construction)** | lump sum | 22,000 | 22,000 |
| **4.** | **Area Development** | lump sum | 17,000 | 17,000 |
| **5.** | **Forest Service Value Restoration** | 15,000 | 0.125 | 1875 |
| **6.** | **Compensation for Tree Removed** | | | 4250 |
| **7.** | **Relocation cost of Water Mills** | 3 | 2,000 | 6,000 |
| **8.** | **Land Acquisition Cost** | | | |
| | Land Acquisition Cost (Private) | 2.13 ha | | 872250 |
| | Land Acquisition Cost (waste land) | 3.77 ha | | 22125 |
| **9.** | **Land Leasing Cost** | | | |
| | Installation Camp (Private) | 0.5 ha | | |
| | Deposition Area (State Owned) | 1.0 ha | | |
| **10.** | **Relocation cost of Babuka/Kaghozi Micro-hydel (20 kw)** | 2 | 12,000 | 24,000 |
| **11.** | **Fisheries Development Cost** | | | |
| | Fisheries management plan research | | | 13,889 |
| | Additional stocking of fish (recurring) | lump sum | 3000/anm | O&M |
| **12.** | **Temporary Relocation Costs** | lump sum | 40,000 | 40,000 |
| **13.** | **Treatment Domestic waste water from operator's village** | | | construction cost |
| **14.** | **Solid waste disposal from operators' village** | | | included in O&M cost |
| **15.** | **Fire protection** | lump sum | | included in O&M cost |
| **16.** | **Settlement of process water** | lump sum | | construction cost |
| **17.** | **Noise buffing/shunting devices** | lump sum | | construction cost |
| | **TOTAL MITIGATION COST** | | | 1,163,470 |

Note: The Institutional and Monitoring costs are included in O&M costs. Also details regarding the compensation of trees and cost of afforestation are given in Table 7-2.

No mitigation is being suggested for the fragmentation of fish population above the weir and beyond the weir. As the fish is not reported to migrate upstream, no fish ladder or fish way is being recommended. Mitigation for low flow of water during lean months is to provide 10% of mean annual flow (average daily flow) and based on the currently available data it has been calculated as 1.87$m^3$/s. This water shall be released during low flow conditions of Golen Gol for sanitation purposes, downstream fisheries sustenance, agriculture, and to meet any other miscellaneous uses. Sedimentation load discharged beyond weir may lead to fish mortality as trout is known to be sensitive to suspended matter. This may be compensated by stocking more fish annually.

Water channels for grinding mills should be properly lined. No additional water is required for running these mills as their impact is negligible and additional water quantity added below Chashma springs offsets this impact.

Water pollution likely to occur during the operation stage can be avoided by the following mitigation measures:

- septic tanks and soakage pits shall be provided for sanitary drainage of operator village.
- oil, grease and lubricants shall be properly stored and disposed.
- quality of Golen Gol water shall be monitored. Monitoring costs should be part of mitigation costing plan (Table 7.4).
- optional funds should be allocated for complete sanitary intervention in the project area.

#### 7.5.3.2 LAND RELATED MITIGATION

There are no additional land related impacts during the operation phase. The land leased for construction period (0.5 ha) should be properly developed for agricultural use before it is returned to the original owners to compensate for the cultivable land used up permanently by project infrastructure.

There is possibility of reclaiming and developing 1 ha of additional land along Golen Gol on the deposition area by properly planning the dumping activity and covering it with top soil removed and stored during contraction of other project structure and from homes material drudged out of the river bed. The land should be returned to the families whose land was acquired for different project infrastructure during the construction phase.

#### 7.5.3.3 AIR RELATED MITIGATION

The provision of electricity is expected to reduce the trend of burning wood and kerosene oil, hence it is anticipated that the air quality of the project area will further improve.

Golen Gol hydropower project will in fact contribute towards improvement of air quality at the national and international level. According to an estimate, oil-fired steam units produce 0.75 tones of $CO_2$ for every MWh of energy generated whereas hydropower plants have zero emission levels. The mean annual energy output of Golen Gol Hydropower project is 436 GWh and when it is connected to the national grid, it will reduce $CO_2$ emission in air by 232,500 tones annually.

The plant shall be designed in a way that noise levels do not exceed the following levels:

- at a distance of 5 m from noise source 90 dB
- at boundary of power house 55 dB
  (or present noise level)
  (35 dB nighttime level)

#### 7.5.3.4 SOCIO-ECONOMIC MITIGATION

The provision of social sector services will likely improve with regular supply of electricity in the area. Small scale industries like furniture making, agricultural, light engineering and tailoring are likely to creep up. The value of land will automatically increase.
During the construction of the project, direct on job training will be provided to the workers. After gaining experience, the unskilled workers are likely to become semi-skilled.

Since the effect of the project on the socio-economics of the area is generally positive, no special socio-economic mitigation measures are required.

### 7.5.4 ENVIRONMENTAL MONITORING PROGRAMME

Some environmental effects are difficult to identify and evaluate prior to project construction and operation. Even effects that have been mitigated may be misjudged or success of mitigation measures may not come upto expectations. Thus, a general environmental monitoring programme should always be considered as back up to environmental assessment and mitigation. It will be the responsibility of the Environmental Task Force to follow the monitoring plan.

#### 7.5.4.1 CONSTRUCTION STAGE MONITORING PROGRAMME

In order to avoid any environmental hazards and inconvenience to local people, WAPDA should depute some staff for strict environmental monitoring of different construction activities. The following parameters shall be specially monitored:

(1) Proper medical, sanitary and residential facilities should be provided by the contractor to its workers. Also, proper safety measures should be provided and maintained by the contractor.
(2) Resettlement plan should be carefully monitored.
(3) Traffic hazard and hindrance should not occur at the Chitral-Booni road and the Golen Gol track passing through the village area.
(4) Process water from tunnelling activity should be carefully monitored.
(5) During tunnelling, excavation and equipment movement, dust and noise should not increase to undesirable limits.
(6) The contractor will be monitored to ensure that he is operating according to the land use plan and observes strict housekeeping measures.

#### 7.5.4.2 OPERATION STAGE MONITORING PROGRAMME

Following parameters should be monitored at operation stage:
(1) Noise of the power house.
(2) Sanitation of settlements downstream of weir intake and residential colony.
(3) Water quality of Golen Gol downstream of weir intake.
(4) Socio-economic and resettlement monitoring.
(5) Fire protection system.

### 7.5.5 ENVIRONMENTAL COST

Environmental costs are based on the expenditures required to neutralize the impact of pollution, due to the construction and operation of the power station, on the environmental and ecology of the surrounding area. The overall environmental cost comprise the mitigation cost, institutional costs and monitoring cost which are discussed in the following sections:

#### 7.5.5.1 ENVIRONMENTAL IMPACT MITIGATION COST

Major basis of the mitigation cost are for the measures to be taken at the pre-construction, and construction stages. Most of these costs therefore shall be included as a part of the main power project contract costs. Table 6.3 gives the estimated costs of various items under this head.

The main components covered in environmental cost are access roads realignment cost, temporary relocation costs, compensation for loss to forest trees and water supply provision costs, costs for disposal of mucking material, channel lining cost etc. The environmental cost also includes compensation to water mill owners, afforestation cost and relocation costs of micro hydel schemes.

#### 7.5.5.2 INSTITUTIONAL COST

These include the cost for the running of complete set-up for environmental control and monitoring programs. This cost is included in plant operation cost.

#### 7.5.5.3 MONITORING COST

Monitoring cost mainly consists of the equipment required for checking and testing water and air quality and noise pollution checking during construction of the project. In addition fisheries management plan, construction activities and socio-economic monitoring costs, are also included. Most of these costs are also included under O&M costs.

#### 7.5.5.4 TOTAL COSTS

The estimated environmental impact mitigation works cost is the sum of all costs minus the institutional and monitoring costs, which are already included in the project O&M costs.

## List of Tables