7. *DEVELOPMENT PLAN OF PROPOSED DELAY ACTION DAMS*

7.1 Outline of Performed Survey on Proposed DAD

The development plans pertain to 13 proposed delay action dam sites consisting of 14 dams along with an integrated development plan having development core of delay action dam construction. During Phase I survey of the Study, pre-development planning along with cost estimates and benefit for all proposed dams were made, and pre-project evaluation was done. Base on economic indicators, 10 dams were selected the top as priority delay action dams. These 10 priority dams were proceeded to feasibility level in Phase II survey.

In this Chapter, development plans of all 14 proposed dams are presented. Ten priority dams are mentioned in development plans formulated through feasibility study, while remaining 4 dams are described in pre-development plan adopting latest information on the basis of completed pre-development plan during Phase I survey. Therefore, 10 priority dams are supposed to have better feasibility and accuracy of study against the other dams. Due to difference in the level of study, the 10 and 4 dams are separately presented in each section. Salient feature of downstream plan for each proposed dam is shown in Table 7.1.1. Features of proposed facilities of the priority dams and other proposed dams are shown in Table 7.2.1 and Table 7.3.1, respectively.

7.2 Proposed Delay Action Dams Conducted F/S

7.2.1 Brewary Area

(1) Groundwater recharging plan

Target aquifers recharged by the delay action dam is alluvial fan deposits extending on the downstream side. The aquifer is highly permeable sands/gravels strata spread vertically and horizontally as mentioned in Chapter 4. Specified beneficial areas are on and along the surroundings of the alluvial fan up to Sariab Lora on the downstream and to some extent towards the end side of cross profile which consists of the alternative layers of sands/gravels and silts/clay. The groundwater in the aquifers is flowing from fan-head area to the downstream supplementarily recharged from the ground surface of mid-fan on the way. Though aquifers reduce in thickness rapidly while proceeding further to down-reaches from fan-front. The groundwater not used in specified beneficial areas may runoff towards Baleli-Samungli Gap along Sariab Lora. This is considered second use in view of time scale, and it is treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate into these aquifers quickly from the upstream area.

The method of recharge into the aquifers from this dam is by water to downstream alluvial fan through conduits, because the natural infiltration from reservoir foundation and its surroundings may be very little. As only limited areas is available for recharging due to urbanization around the alluvial fan area, an infiltration pond is proposed to be constructed near the proposed stilling basin downstream of the dam site.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharge volumes are 0.306 MCM and 0.204 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The beneficial area is located near the center of Quetta city, and more than 80 % of the farm land is orchard. The level of farm economy of the beneficial farmers is considerably high. However, recently farm land has been affected by the sprawl of urban area, resulting into gradual shifting of irrigation water use to domestic water use.

Even so, the total demand of water requirement in this area will not reduce in future. And so the necessity of this Project as considerable agricultural activities in the area will continue in future. Based on this consideration, the present cropping pattern should not be changed in the development concept. To obtain maximum advantage from agriculture, the efficient use of the irrigation water, the better arrangement of marketing conditions, and the strengthen of the farmers' association should be promoted. Furthermore to prevent the disorderly urbanization in farm area and the contamination of the soil by sewage water from the residences, the Provincial Government should adopt suitable measures as early as possible.

(5) Dam and reservoir

Dam site is situated in narrow gorge composed of limestone. Gravity dam is proposed because of rock foundation up to 7.5 m depth from the river bed surface, and distance form both abutments is 6 to 15 m. Fill type dam is not suitable due to excessive rock excavation to secure spillway channel. Recharge through dam foundation is not expected because of rock foundation, so that recharge downstream of the dam site is accelerated through intake facilities.

Overflow depth is 3.2 m considering existing gorge width, and foundation replacement with lean concrete materials to a depth of 15 m river deposits is required for the 19.5 m length where energy dissipater is constructed.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Gravity	25.9	22.0	32.2	10,500	749,000	360,000	389,000	165

(6) Related components

a) Recharge facilities

Recharge pond is located downstream of the energy dissipater of the dam. Pond area is determined corresponding to the recharge requirement, and its height has enough capacity for flood flow.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Brewary	1,180	1,500	15 x 100	3.0	-	-

(7) Environment

The negative impacts caused by the construction of the dam are deprivation of surface water users resulting from changes of surface water hydrology and disruption of traffic causing inconvenience social life and economic activities due to cutting of the route. In the context compensatory works such as temporary and replaced roads should be provided in the development plan in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation through the dam project, watershed management in the catchment area controlled by the Balochistan Forest Department as State Forest should be considered continuously and environmental management based on environmental conservation plan for the delay action dam project is recommended.

(8) Others

Watershed conservation schemes have remarkable effects of water preservation and sediment control. It is, therefore, recommended to implement the schemes together with the delay action dam project. As substantial watershed management is being conducted by the Forest Department in the catchment area, no additional activity on watershed conservation is required. Flood mitigation effect of the dam is conspicuous due to urban area condition extending downstream of the dam site. However, defensive preparations, such as river dike are required against emergency release of water into river from the dam.

7.2.2 Dara Area

(1) Groundwater recharging plan

Target aquifers recharged by the dam is alluvial fan deposits lying downstream from the dam which are highly permeable sands/gravels strata with reasonable vertical and horizontal extension reaching up to Chundak Rud and forms the part of northern piedmont plain of Quetta Sub-Basin. Specified beneficial areas are on and along the surroundings of the alluvial fan up to Chundak Rud on the downstream side and to some extent towards the end side of cross profile. The groundwater in the aquifers is flowing from fan-head area to the downstream supplementarily recharged from the ground surface of mid-fan.

Groundwater may flow towards main part of Quetta Valley out of this alluvial fan area. This is considered second use in view of time scale comparing to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharge plan from the dam will be made to infiltrate the water into these aquifers quickly from the upstream area as much as possible.

The method of promoting recharge into the aquifers is by releasing water suitably to the downstream alluvial fan through conduits, because infiltration from reservoir basin and its surroundings may be reduced soon by siltation. The areas for recharging facilities may be available any where in mid-fan due to no land use in the area. Recharging may be better along the river bed of Dara nullah and its surroundings.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharge volumes 0.234 MCM and 0.156 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. As the beneficial area of this dam is overlapped with the beneficial area of Kach Dam, the overlapped portion is divided between both dams evenly. Furthermore, the beneficiaries of the dam are indicated farmers who own and operate their wells in the beneficial area of Sra Gurgi Irrigation Scheme. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area is producing fruits and vegetables located at the suburb of Quetta city, and has favorable production and marketing conditions for agriculture. However, it seems to be very difficult to develop new irrigation water sources to meet the additional water requirement for the increase of fruits trees or fresh vegetables. The cereals production should be kept at present level for self sufficiency. Therefore, the agricultural development in this area should target the increase in unit yield and profitability of the currently growing crops. This should be achieved by gradual change of local varieties to high quality ones as well as the improvement of irrigation efficiency, farm inputs application and orchard management, etc. under the improved extension services.

(5) Dam and reservoir

Dam site is located at the head of alluvial fan. Left side abutment is composed of outcrops of limestone and right side of conglomerate which has sufficient bearing capacity for a dam foundation. Dam axis is proposed at downstream of confluence of two major tributaries to increase dam storage capacity. Dam axis bends to upstream direction at the right side abutment. Dam foundation is composed of the permeable river deposits upto a depth of 20 m and hydraulic conductivity of 1.49×10^{-3} cm/sec. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits is available for the semi pervious embankment materials.

Downstream recharge through intake conduits is proposed because of gradual reduction of seepage flow through the dam foundation due to siltation. Spillway channel is at the right abutment comprising of conglomerate. Crest length of 41 m (overflow depth is 1.8 m) is required considering topographical condition. Flood flows toward large alluvial fan and energy dissipater is not required.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	16.6	405.0	22.8	297,000	589,000	240,000	349,000	196

(6) Related components

a) Recharge facilities

Recharge pond is located at the fan head around 1.0 km downstream of the dam.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Dara	3,600	11,550	105 x 110	1.4	0.2 x 0.4	1,100

b) Sediment control facilities

Detention bunds are located at 2.5 km and 3.3 km upstream of the dam.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	3,900	27	3.0	900	3.3 km upstream of dam
No. 2	5,300	16	7.6	1,200	2.5 km upstream of dam

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of the route. Compensative works such as temporary and replaced roads are designed based on development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

The beneficial area is overlapped with the command area of the Sra Ghurgi Irrigation Scheme. However, there is no farmer using both water sources, because existing private tubewells have spread to the farmers who have difficulties to use the surface water. High necessity for construction of this dam is recognized because it is located in the northern area of the Quetta Valley which faces serious problem in groundwater use.

7.2.3 Murgi Kotal Area

(1) Groundwater recharging plan

Target aquifers recharged by the delay action dam are alluvial fan deposits of Kuchlagh Sub-Basin side lying downstream of the dam and Quetta Valley forming its apex at upstream of the dam site and bounded by the Beleli river. Both the aquifers are highly permeable sands/gravels strata with reasonable vertical and horizontal dimensions.

Specified beneficial areas are on and along the surroundings of the above mentioned 2 alluvial fans in the downstream and to some extent towards the end side of cross profile. The groundwater in the aquifers is flowing from fan-head area to the downstream recharged from the ground surface of mid-fan. These aquifers reduce in thickness rapidly while proceeding down from fan-front. The unused groundwater in specified beneficial areas may flow towards

the downstream area. This is considered second use in view of time scale compared to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate the water quickly into these aquifers from the upstream area.

The method of promoting recharge into the aquifers from reservoir is by releasing water suitably to the downstream alluvial fan through conduits, because infiltration from reservoir basin and its surroundings may be reduced soon by siltation. The areas for recharging facilities may be limited to the upstream area, because trunk road between Pishin and Quetta is running on the alluvial fan on the Kuchlagh side. While in the Quetta Valley side, the alluvial fan is available for recharging in the middle. Because of these reasons and the scale of beneficial areas, Quetta Valley side may be considered to be an important beneficiary.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharge volumes are 0.189 MCM and 0.206 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

This area is located near the Quetta city with better conditions for agriculture. The area is divided into two blocks, one of which produces fruit crop and the other, is rainfed area. In former block, the increase in unit yield and improved profitability of the present crops should be targeted. This should be achieved by the gradual change of local varieties to high quality ones as well as the improvement of irrigation efficiency, farm inputs application, orchard management, etc. under the improved extension services. In the later block, livestock condition should be improved through an adequate supply of water for animals and an increase of the vegetation in areas downstream of the proposed dam.

(5) Dam and reservoir

Dam site is located at the fan head of alluvial fan in limestone gorge having a width of 80 m. Gravity dam is not suitable owing to poor bearing capacity of 40 m river deposits. There are

two alternatives of the dam axis, located upstream and upstream of the existing dam. Particular features are specified as follows:

Upstream: Embankment volume is 280,000 m^3. Removal of sediment of 110,000 m^3 in the reservoir is considerably large. Spillway is located at the right side of the reservoir.

Downstream: Embankment volume is 460,000 m^3. Spillway construction located at the right limestone abutment costs a great deal because of hard rock excavation

Comparing the two alternatives, upstream dam is economically preferable. Dam foundation is composed of the permeable river deposits of with a depth of 40 m. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits is available for the semi pervious embankment materials.

Downstream recharge through intake conduits is proposed because of gradual reduction of seepage flow through the dam foundation due to siltation. Spillway channel is at the left side of the reservoir. Excavated materials of spillway channel are utilized for the dam embankment.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	19.7	130.0	35.6	278,000	1,147,000	260,000	887,000	131

(6) Related components

a) Recharge facilities

Recharge pond is located at the fan head 200 m downstream of the dam.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Murgi Kotal	2,800	9,000	90 x 100	1.4	0.2 x 0.4	200

b) Sediment control facilities

Detention bunds are located at 2.0, 3.0, 5.0 and 7.0 km upstream of the dam.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	6,000	56	3.0	950	2.0 km upstream of dam
No. 2	3,800	36	3.0	600	3.0 km upstream of dam
No. 3	4,800	27	3.0	600	5.0 km upstream of dam
No. 4	6,200	56	3.0	800	7.0 km upstream of dam

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it

is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

There are some restrictions on site selection and dam designing, because this dam plan is to rehabilitate the existing damaged dam site. As spillway was designed to draw the excess flow into another tributary on right side, safety measures should be considered. There are some difficulties on flood routing and selection for recharging plan because areas downstream of the dam site are considerably developed.

7.2.4 Kach Area

(1) Groundwater recharging plan

Just downstream of the proposed dam is narrow channel of Chundak Rud exposing shale in its river bed extending over 2 to 3 km. Target aquifers recharged by the dam are alluvial fan deposits spread in the piedmont plain extent from west to east along the downstream of Chundak Rud. These are highly permeable sands/gravels strata with reasonable vertical and horizontal dimensions. Specified beneficial areas are on and along the surroundings of the alluvial fan up to the Manda river on the downstream side and to some extent towards the end side of cross profile whose right bank is bordered by Chundak Rud. The groundwater in the aquifers is flowing from fan-head area to the downstream recharged from the ground surface of mid-fan. Groundwater may also flow towards the downstream of Quetta Valley. This is considered second use in view of time scale comparing to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate the water into these aquifers from the upstream areas.

The method of promoting recharge into the aquifers from reservoir is by releasing water suitably to the downstream alluvial fan by way of river channel, because infiltration through reservoir and dam foundation is not expected. The areas for recharging facilities may be available any where in mid-fan due to no land use in the area. Recharging may better be carried out along the river bed of Chundak Rud and its surroundings.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharge volumes are 0.407 MCM and 0.740 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area is fruits and vegetables located in the suburb of Quetta city, and is favored with production and marketing conditions for agriculture. However, it seems to be very difficult to develop irrigation water sources to meet the additional water requirement for the increase of fruits trees or fresh vegetables. The cereals production should be kept in present level for self sufficiency. Therefore, the agricultural development in this area should target to increase the unit yield and profitability of the currently growing crops. This should be achieved by the gradual change of local varieties to high quality ones as well as the improvement in irrigation efficiency, farm inputs application, orchard management, etc. under the improved extension services.

(5) Dam and reservoir

Comparing to two alternatives of the dam axis, raising of existing dam crest is economically preferable. Particular features are specified as follows:

Raising crest: Embankment volume of dam is 480,000 m^3. In addition, 123,000 m^3 is required for the embankment of existing spillway channel.

Downstream: Embankment volume of 600,000 m^3 is almost as same volume as the total embankment of the rising crest plan In addition to the dam construction, rehabilitation works of the existing dam is necessary to prevent outflow of sediment accumulated in the reservoir.

Dam site is occupied by exposed shale. Reservoir has been completely silted up and approximately 20 m deep cut has been created along the dam crest. Unconsolidated shale surface is susceptible to erosion and bearing capacity is also insufficient for the gravity dam construction. Downstream recharge through intake conduits is proposed because of impermeable foundation. Dam axis is 50 m downstream of the existing dam crest. 49.5 m high zone type fill dam is proposed. Impervious zone is provided at the upstream side and semi-permeable zone at the downstream side of the embankment. Drainage is accelerated

through vertical drain located at the downstream of the impervious zone. Overflow depth of 2.5 m is required considering topographical condition of the right side abutment. Spillway channel is protected with concrete to prevent erosion by floods.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	56.5	330.0	45.9	480,000	2,387,000	1,200,000	1,187,000	329

(6) Related components

a) Recharge facilities

Recharge pond is located 3.5 km downstream of the dam.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Kach	1,900	6,000	75 x 80	1.4	0.2 x 0.3	3,450

b) Sediment control facilities

Detention bunds are constructed at Inzar nullah and Spol nullah.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	11,900	53	3.0	1,200	2.5 km upstream of dam
No. 2	12,200	53	3.0	800	3.3 km upstream of dam

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of the traffic route. To compensate this loss, temporary and replaced roads are provided in development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

There are some restrictions on site selection and dam designing, because this dam plan includes rehabilitation of the existing dam. Considering magnitude of sediment yield of the catchment area, large scale rehabilitation work is required. Though the beneficiary area is overlapped by command area of the Sra Ghurgi Irrigation Scheme, no problem is recognized in water use. If no countermeasure is taken for the rehabilitation of the damaged dam, some sediment effects on existing intake weir located downstream are feared in near future.

7.2.5 Jigda Area

(1) Groundwater recharging plan

Downstream of the proposed dam site is river channel of Jigda nullah extending over 6 to 7 km. The aquifers of this section are river deposits. The purpose of the dam is to improve water supply from karezes which take groundwater from the aquifers of river deposits. The recharge into the aquifers from reservoir is required to conduct water to karezes effectively, which irrigate the specified beneficial areas located at the downstream of the dam. Release of water to river bed on the downstream would be through conduits. Runoff water through river bed is flowing into the piedmont plain downstream of Jigda nullah. The farmlands in this alluvial fan are the specified beneficial areas. This alluvial fan in piedmont plain joins with the other alluvial fan so that the groundwater recharged from the dam may flow into the aquifers in these alluvial fans. This may be considered a second use in view of time scale comparing to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate the water into the aquifers from the upstream area as much as possible.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharge volumes are 0.084 MCM and 0.444 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater use in the Project is assumed by existing karezes located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area belongs to the typical small farm villages located relatively near the urban center of the Pishin District. The soil fertility is good for fruits and vegetables mainly produced at present, but the marketing condition of the area is not favorable due to poor access roads. The sizes of villages are small and the farm households in this area are closely related to each other through the karez irrigation system. Accordingly, agricultural development of this area should be focused on establishing a small but highly individual producing center of fruits and vegetables, through the improvement of irrigation condition by this proposed dam and the improvement of

farm to market roads as well as the strengthening of extension services for improving the agricultural techniques of the farmers.

(5) Dam and reservoir

Dam site is a hilly terrains composed of exposed shales which are severely weathered and cracked. River deposits are permeable (Hydraulic conductivity: 1.15 x 10^{-3} cm/sec) and are around 10 m thick. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits and excavated materials of the spillway are available for the semi pervious embankment. Downstream recharge through intake conduits is preferred because of poor seepage capacity of the 10 m thick foundation and also gradual reduction of seepage flow through dam foundation due to siltation. Spillway is constructed at left side of the dam embankment. Spillway channel slope composed of shale is protected with the stone masonry. Overflow depth of 1.5 m and crest length of 46 m is required considering topographical condition of the abutment. Flood is diverted to the adjacent valley composed of shale, so that energy dissipater is not required.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	20.8	210.0	23.9	114,000	508,000	290,000	218,000	142

(6) Related components

a) Recharge facilities

Infiltration ponds are constructed to accelerate infiltration to existing karezes along the river and to the downstream of the alluvial fan.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Jigda 1	2,200	6,000	40 x 150	1.5	0.2 x 0.4	1,200
Jigda 2	3,200	9,000	60 x 150	1.5	0.2 x 0.4	2,150

b) Sediment control facilities

Detention bunds are constructed at Inzar nullah and Spol nullah.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	39,000	69	7.6	2,140	8.0 km upstream of dam
No. 2	37,900	140	7.6	3,300	3.0 km upstream of dam
No. 3	35,000	120	7.6	3,980	2.5 km upstream of dam

c) Karez rehabilitation

Existing karezes shall be rehabilitation for a total length of 2,100 m.

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss temporary and replaced roads were provided in development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

Strong social solidarity is recognized in the beneficial villages. No difficulty is found on operation and maintenance of the existing karezes and proposed dam either. This is a new water sources keenly required because of no alternative water sources.

7.2.6 Sanzali Area

(1) Groundwater recharging plan

Downstream of the proposed dam site is river channel extending over 6 to 7 km. The aquifers of this section are river deposits and Colluvial sediments along the river. The purpose of the dam is to improve water supply from karezes which take groundwater from the aquifers of river deposits. The proper method of recharge into the aquifers from reservoir is required to conduct water to karezes effectively, which irrigate the specified beneficial areas located at the downstream end of the dam. Conduits would be a suitable prerelease facility to recharge downstream river bed aquifer.

Runoff water through river bed is flowing into the piedmont plain and valley floor on the downstream side. The farmlands in this alluvial fan may be considered partly as specified beneficial areas. However this may be considered a second use in view of time scale comparing to specified areas lying along the upstream river channel and mainly treated as the use for unspecified beneficial areas.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharge volumes are 0.034 MCM and 0.179 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater use in the Project is assumed by the existing karezes located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area belongs to the typical small farm villages located relatively near the urban center of Pishin district and they grow mainly vegetables, wheat, and tobacco. The marketing condition of the area is not favorable due to poor access roads, and unsuitable condition for fruits trees. However, as the sizes of villages are small and the farm households in this area are closely related to each other through the karez irrigation system, it will be comparatively easy to educate the farmers to do better farming. Accordingly, agricultural development of this area should be focused on establishing a small but highly individual producing center of vegetables and other cash crops, through the improvement of irrigation condition by this proposed dam and the improvement of farm to market roads as well as the strengthening of extension services for improving the agricultural techniques of the farmers.

(5) Dam and reservoir

Dam site is situated in Bostan Formation composed of sand, clay and forms hilly terrains. Dam will be constructed on the impermeable sand, clay layers having hydraulic conductivity of 1.54×10^{-4} cm/sec at the dam center. Since the dam will be constructed on pervious foundation at the left abutment, homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits and a part of the excavated materials of the spillway are available for use as semi pervious embankment materials. Downstream recharge through intake conduits is proposed because of poor seepage capacity of the dam foundation. Spillway is proposed in the gorge on the right of the dam site. Spillway channel base and side slopes will be protected with the stone masonry due to susceptibility to erosion of the unconsolidated sand and clay foundation. Overflow depth of 1.5 m and crest length of 26 m is required considering topographical condition of the gorge. Spillway channel traverses existing karezes, 40 m long energy dissipater is proposed to protect the karez.

Dam type	Catchment area(km²)	Crest length (m)	Dam height (m)	Embankment volume (m³)	Total storage volume (m³)	Effective storage volume (m³)	Sediment volume (m³)	Flood discharge (m³/sec)
Fill type	10.4	210.0	14.0	114,000	508,000	290,000	218,000	142

(6) Related components

a) Recharge facilities

Infiltration ponds will be constructed at 1.5 km downstream of the dam to accelerate infiltration to existing karezes along the river and to the downstream of the alluvial fan.

Recharge facilities	Recharge capacity ('000m³/year)	Pond surface (m²)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Sanzali	950	3,000	60 x 50	1.4	0.2 x 0.3	1,300

b) Sediment control facilities

Detention bunds will be constructed at 100 m upstream of Zebra and Aghbargai nullahs, and also 2.5 km and 3.0 km upstream from the dam site.

Detention bund	Capacity (m³)	Bund length (m)	Bund height (m)	Bund volume (m³)	Location
No. 1	9,700	30	3.0	700	Zebra nullah
No. 2	7,000	27	3.0	650	Aghbargai nullah
No. 3	8,200	30	3.0	650	3.0 km upstream of dam
No. 4	13,200	42	3.0	1,050	2.5 km upstream of dam

c) Karez rehabilitation

Existing karezes shall be rehabilitated for a total length of 2,700 m.

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

It is necessary to improve the operation and maintenance of existing karezes because some of them are in bad condition of maintenance. This is a new water sources keenly required because of no alternative water sources.

7.2.7 Sakhol Area

(1) Groundwater recharging plan

Target aquifers to be recharged by the proposed dam are alluvial fan deposits spread along the foot slope of mountains and Eolian deposits lying on the downstream side. Eolian deposits lie on the aquitards so that the groundwater recharged from the dam may flow in this deposits as sub-soil water. Specified beneficial areas are on and along these Eolian deposits extending up to the west side of trunk road running between Quetta and Mastung for 2 or 3 km along both banks of the stream channel running through the center of sand dune bounded by some concave topographical condition. The groundwater seemed to be supplementarily recharged from the ground surface of sand dune. The aquifers reduce its thickness as proceeding further down-reaches from sand dune. Recharge into the aquifers from DAD is to introduce water to karezes effectively, releasing water promptly through conduits, because infiltration from reservoir basin and its surroundings may be reduced soon by siltation.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.098 MCM and 0.108 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater use in the Project is assumed by existing karezes and wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area is located along the highway, near the center of Mastung district. The agricultural condition for crop growing and marketing seems to be comparatively favorable. However, generally the farm size per household is small and average farm income is low. The onion production is predominant, and fruits trees are not observed so much due to the soil characteristics. Accordingly, on the basis of the given situation, the future agricultural development in this area should be focused on establishing more intensive cropping pattern of vegetables including onion, with the improvement of the irrigation condition by this project, resulting to increase farm income.

(5) Dam and reservoir

Dam site is situated in 1,000 m wide fan head where semi impermeable river deposits comprising of gravel, sand, clay have been accumulated in 100 m thickness. The hydraulic conductivity of the dam foundation is 3.06×10^{-4} cm/sec. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits are available for the semi pervious embankment. Downstream recharge through intake conduits is also accelerated because seepage flow through the dam foundation is gradually reduced due to siltation in the reservoir. Spillway is constructed at center of the dam axis. Spillway channel base and side slopes are protected with the stone masonry due to susceptibility to erosion of the river deposits. Overflow depth of 1.5 m and crest length of 42 m are required considering topographical condition. Earthen channel up to a depth of 2.0 m is excavated downstream of the spillway channel to protect agricultural lands from inundation.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	22.3	1,090.0	14.5	187,000	545,000	210,000	335,000	199

(6) Related components

a) Recharge facilities

Infiltration pond is constructed adjacent to the dam embankment for the reasons that the beneficial area is located at just downstream of the dam site.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Sakhol	360	1,200	30 x 40	1.4	-	-

b) Existing karezes shall be rehabilitated for a total length of 2,500 m.

(7) Environment

The negative impacts caused by the construction of the dam are (i) difficulty of surface water use in a part of the beneficial area for flood irrigation resulting from changes of surface water hydrology and (ii) loss of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. As for flood irrigation, not only both the lands for cultivation and the productivity are limited, but also tubewells are utilized together. It implies that the negative impact is mitigated by shift to tubewell or intake facilities based on development plan. While, as to loss of traffic approach, compensative works such as temporary and replaced roads are provided in the plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In the adjacent area including the beneficial area of the dam, "Sand Dune Stabilization Project", which was completed by BFD, has been continued and handled by FAO as a part of "Watershed Planning and Management Project, Balochistan". According to the Work Plan (December, 1996) of the Project, institutional arrangements to strengthen activities for watershed and range management based on participatory approach will be implemented. It is expected that the management project will not only act as environmental conservation measures for the dam project but will also attain comprehensive environmental conservation in the area involving the dam project.

(8) Others

This is a pilot area for range management. A good effect by the delay action dam on environment can be expected in view of the improved situation of vegetation by the preventing desertification. Some karezes have been abolished among existing karezes in this area. Some difficulties on maintenance of the karezes are found which need to be removed.

7.2.8 Mangi Area

(1) Groundwater recharging plan

Target aquifers recharged by the proposed dam are alluvial fan deposits extending downstream from the dam which are highly permeable sands/gravels strata with a thickness of more than 50 m. Specified beneficial areas are on and along the surroundings of the alluvial fan up to Bhalla Dhor on the downstream side and to some extent towards the end side of cross profile. Though other alluvial fans join with this alluvial fan, yet the influenced areas is in transverse direction recharged from the dam up to the topographic concavity, with general distribution pattern of unconfined groundwater. The groundwater in the aquifers is flowing from fan-head area to the downstream recharging from the ground in mid-fan on the way. Though thickness of aquifers is reduced rapidly towards downstream, the unused groundwater in specified beneficial areas may runoff along the Bhalla Dhor river. This is considered second use in view of time scale comparing to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate water into these aquifers quickly from the upstream area as much as possible.

The method of promoting recharge into the aquifers from reservoir is by releasing water suitably to the downstream alluvial fan through conduits, because infiltration from reservoir basin and its surroundings may be reduced soon by siltation. Recharging may be better along the river bed of the Mangi river at just downstream of the dam.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.655 MCM and 0.437 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing karezes and wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The location of this area is so far from urban settlements that it is not suitable for production of perishable foods, and is also not suitable for orchards due to the soil characteristics. Therefore, onion may be adopted as a main crop with high cropping intensity. However, some storable cash crops may be grown with suitable control on water consumption through an improvement of irrigation method. If possible, some fruits trees may be introduced for raising farm income. Because long distance from the markets including cities outside the Province, the production and marketing system should be strengthened to get market information quickly and sell products profitably through the improvement of farmers' organizations.

(5) Dam and reservoir

Dam site is situated in 700 m wide fan head where a blanket of 27 m thick semi impermeable river deposits comprising of gravel, sand, clay have been accumulated. The hydraulic conductivity of the dam foundation is 1.06×10^{-4} cm/sec. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits are available for the semi pervious embankment. Downstream recharge through intake conduits is also required because seepage flow through the dam foundation is gradually reduced due to siltation in the reservoir. Spillway is constructed on the left abutment. Spillway channel behind overflow section is protected with concrete to prevent erosion because of its high susceptibility to erosion. Overflow depth of 2.0 m and crest length of 85 m is required considering topographical condition.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	39.4	530.0	12.7	171,000	1,011,000	420,000	391,000	6,000

(6) Related components

a) Recharge facilities

Infiltration pond is constructed adjacent to the dam embankment due to availability of suitable porous formation downstream of the dam site.

Recharge facilities	Recharge capacity ('000m³/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Mangi	4,730	15,000	116 x 130	1.4	-	-

b) Existing karezes shall be rehabilitated for a total length of 6,000 m.

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area further through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

Since the karez users have shifted to tubewells, substantial karez improvement is not required. The present water use from the spring located in the catchment area of the dam to Bizini village is planned to be maintained, no problem will be faced by present water users. However, it is recommended that the canal may be rehabilitated applying On-Farm Water Management Program. There is existing Sarbund dam in the catchment area of the proposed dam.

7.2.9 Kad Kocha II Area

(1) Groundwater recharging plan

Target aquifers recharged by the proposed dam are the typically shaped alluvial fan deposits extending downstream and are usually highly permeable sands/gravels strata with reasonable and thickness as mentioned in Chapter 4. Specified beneficial areas are on and along the

surroundings of the alluvial fan up to western side of trunk road connecting between Mastung and Kalat and to some extent towards the end of cross profile. The groundwater in the aquifers is flowing from fan-head downwards recharging the ground surface of mid-fan. Silts/clay strata is gradually increasing while proceeding further downstream from fan-front, and is recharged from the upstream alluvial fan area. This is considered second use in view of time scale comparing to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate water into these aquifers quickly from the upstream areas.

The method of promoting recharge into the aquifers from reservoir is by releasing water suitably to the downstream alluvial fan through conduits, because the natural infiltration from reservoir basin and its surroundings may be reduced soon by siltation. As only limited areas is available for recharging due to agricultural development around the alluvial fan, recharging pond is proposed near stilling basin on the Kad Kocha river downstream of dam site.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.305 MCM and 0.204 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The farm households in this area are relatively large and their income level is higher. More than fifty percent of crops is fruit trees, and vegetables production and livestock raising are also prevailing. Some of the agricultural support projects have been introduced in this area. Farmers are eager to develop their agriculture. On the basis of these situations the growth capability of this area seems to be considerable high. The compound type of agriculture, including fruits, vegetables and livestock, vegetables and forage production under the orchard trees may be increased.

(5) Dam and reservoir

Dam site is situated in 700 m wide fan head where a blanket of 40 m thick semi impermeable river deposits comprising of gravel, sand, clay have been accumulated. The hydraulic

conductivity of the river surface is 3.18×10^{-5} cm/sec. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits are available for the semi pervious embankment. Downstream recharge through intake conduits is also required because seepage flow through the dam foundation is gradually reduced due to siltation in the reservoir. Spillway is constructed on the right side river bed. Stone masonry is constructed between the embankment and spillway channel. Spillway channel is connected to scoured portion of the existing river. Minimum flow section with overflow depth of 2.5 m and crest length of 50 m is planned to avoid excessive rock excavation.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	15.2	595.0	14.0	152,000	368,000	140,000	228,000	389

(6) Related components

a) Recharge facilities

Infiltration pond is constructed 500 m downstream of the dam site because the highly permeable aquifer is not widely spread downstream of the dam site.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Kad Kocha II	4,730	15,000	100 x 150	1.4	0.2 x 0.5	500

(7) Environment

The negative impacts caused by the construction of the dam are difficulty of surface water use in a part of the beneficial area for flood irrigation resulting from changes of surface water hydrology and loss of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. The negative impacts for flood irrigation by the construction of the proposed dam could be negligible because the flood irrigated area is limited, and alternative water sources such as tubewells are available. It implies that the negative impact is mitigated by shift to tubewell or intake facilities based on development plan. To compensate the loss of road cutting, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In the beneficial area of the dam, "Integrated Area Development Programme" handled by FAO has been implemented. At present social activities for watershed and range management based on participatory approach has just been started. It is expected that the management project will not only act as environmental conservation measures for the dam but will also attain comprehensive environmental conservation in the area involving the dam project.

(8) Others

Agriculture of the beneficial area of the proposed dam brings in prosperity. Construction of the proposed dam is desired in order to maintain present agricultural productivity. This area seems to be a model area for drip irrigation introduction because there is a model farm for drip irrigation in the downstream of the proposed dam site. There is existing Kad Kocha I dam upstream of the catchment area of the proposed dam.

7.2.10 Ghazlona Area

(1) Groundwater recharging plan

Dam site is located at the midstream of Ghazlona nullah. The aquifers are river deposits lying in the river bed of Ghazlona nullah and of wide Arambi manda. Specified beneficial areas are located along Ghazlona nullah and at downstream from the confluence of Ghazlona nullah and Arambi manda. In the areas along Ghazlona nullah, all the water is supplied from karezes or dug-wells intaking sub-soil water flowing in the river deposits. While on Arambi manda, water is mainly pumped up by tubewells from the aquifers, of which thickness may be between 20 to 30 m. Groundwater in Arambi manda may be recharged from surface or sub-soil water flow from upstream of the dam. The purpose of the dam is to improve water supply from these karezes and tubewells. Remaining unused groundwater in specified beneficial areas may runoff towards the downstream of Arambi manda, and contribute to unspecified beneficial use. Groundwater recharging plan from the dam will be made to infiltrate it into these aquifers from the upstream area as much as possible.

The method of promoting recharge into the aquifers from reservoir is by releasing water suitably to river bed in the downstream through conduits. Recharging may better be carried out along the river bed of Ghazlona nullah just downstream of the proposed dam.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.041 MCM and 0.099 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells

located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area has abundant fruits trees, but is located far from urban center. The soil is suitable for most crops, but marketing condition is unfavorable because of poor access roads. Although karezes and tubewells supply the irrigation water, it will be difficult to increase the amount of irrigation water, in addition to restoration with the proposed delay action dam. Based on such a situation, the future agriculture in this area should be focused on up grading the fruits in quality and unit yield, with the soil conservation as well as the improvement of access roads and marketing facilities.

(5) Dam and reservoir

Dam site is composed of shale and forms hilly terrains. Shale has been weathered and cracky and vertically dipping direction. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the 5 to 6 m thick dam foundation against piping. River deposits composed of shale are available for the semi pervious embankment. Compaction criteria for weathered shale materials is carefully examined to prevent settlement of embankment by saturation. Downstream recharge through intake conduits is also required because seepage flow through 5 to 6 m dam foundation is not so high, and it is gradually reduced due to siltation in the reservoir. Spillway is constructed on the left abutment. Spillway channel slope composed of shale is protected with stone masonry. Overflow depth of 1.5 m and crest length of 35 m is planned considering topographical condition of the abutment. Flood is diverted to the adjacent valley composed of shale, so that energy dissipater is not required.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	9.1	195.0	20.9	76,000	331,000	140,000	191,000	109

(6) Related components

a) Recharge facilities

Infiltration pond is constructed at right side river bank, 1.3 km downstream of the dam site because of poor seepage capacity of shallow river deposits, as well as narrow river width downstream of the dam site.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Ghazlona	240	800	26 x 30	1.4	0.1 x 0.2	1,300

b) Sediment control facilities

Detention bunds are constructed at 2.0 km and 3.5 km upstream of the dam site.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	7,800	33	3.0	600	3.5 km upstream of the dam
No. 2	7,300	58	3.0	1,200	2.0 km upstream of the dam

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

Recently, "Watershed Planning and Management Project, Balochistan" handled by FAO was completed in the beneficial area. Although the conservation effectiveness derived from the watershed project can not be applied to the dam project directly due to difference of the catchment area, it is expected that range and watershed management as environmental conservation measures for the dam project is launched smoothly due to high awareness of inhabitants regarding importance and necessity of rehabilitation in the catchment area.

(8) Others

As recharged water of this proposed dam once become underground stream of the Arambi manda, it is not always assured to benefit downstream area. While, good improvement in water use at the village located exactly downstream of the proposed dam site is expected.

7.3 Proposed Delay Action Dams (Non-F/S)

7.3.1 Ghutai Shela Area

(1) Groundwater recharging plan

Target aquifers recharged by the proposed dam is alluvial fan deposits extending downstream where is located in the outlet of Quetta Valley. Though the aquifers are usually highly permeable sands/gravels strata, their scale is relatively small enclosed by the aquitards around the downstream of Sariab Lora. The method of promoting recharge into the aquifers from reservoir is considered releasing water suitably to the downstream alluvial fan through conduits.

As only limited areas is available for groundwater recharge due to urbanization around the alluvial fan area, recharge may be expected within the area of residual basin just downstream of the dam site.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.015 MCM and 0.016 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area is located in a suburb of the Quetta city. Most of the farmers have side job and generally their farm size is small. Recently farm land has been affected with the sprawl of urban area, resulted to the gradual shifting of irrigation water use to domestic water use. Although the total demand of water requirement in this area will not lessen in future, there will not be a big room for agricultural development of this area in future.

The agricultural activities should be carried out more efficiently on the basis of the current farming with the advantageous marketing condition.

(5) Dam and reservoir

Dam site is located at the fan head, and composed of Subrecent deposits forming hilly terrains. Unconsolidated and permeable river deposits of its hydraulic conductivity of 9.50×10^{-3} cm/sec has been accumulated 28 m in thick. In this connection, homogeneous type fill dam is suitable to reduce hydraulic gradient along the dam foundation against piping. River deposits are available for the semi pervious embankment. Downstream recharge through intake conduits is also accelerated because the seepage flow capacity is gradually reduced due to siltation in the reservoir. Spillway is constructed on the right abutment. Overflow depth of 1.7 m and crest length of 6.0 m is planned considering topographical condition of the abutment. Energy dissipater is not facilitated.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill type	1.8	155.0	13.0	33,000	80,000	42,000	38,000	28

(6) Related components

a) Recharge facilities

Infiltration pond is constructed 500 m downstream of the dam site because of impermeability of the silt, sand foundation.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Ghutai Shela	1,760	4,900	70 x 70	1.5	0.2 x 0.4	500

b) Sediment control facilities

Detention bunds are constructed at 2.0 km and 3.0 km upstream of the dam site.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	3,200	30	3.0	700	3.0 km upstream of the dam
No. 2	5,400	50	3.0	1,200	2.0 km upstream of the dam

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

As there are an airport and military installations downstream of the proposed dam, the beneficial area of the dam seems to be not agricultural area but residential area. This dam scheme is effective for improving life standard of Afghan refugees living adjacent to the dm site.

7.3.2 Wali Dad Area

(1) Groundwater recharging plan

Target aquifers recharged by the proposed dam are alluvial fan deposits lying downstream and are highly permeable sands/gravels strata with reasonable vertical and horizontal dimensions. Because dam site is situated in narrow gorge composed of hard and massive limestone, infiltration from reservoir and dam foundation may be not expected. The method of recharge into the aquifers from reservoir is by releasing water at fan-head area. As only limited areas is available for groundwater recharge due to urbanization around the alluvial fan area, recharge may be expected with the area of residual just downstream of the dam site.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.083 MCM and 0.055 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The beneficial area is located near the center of Quetta city, and recently farm land has been affected with the sprawl of urban area. However, the total demand of water requirement in this area will not lessen, while, because of an advantageous situation, considerable agricultural

activities in the area will be remained in future. Based on this consideration, the present cropping pattern should not be changed in the development concept. To maintain advantageous situations for agriculture, the efficient use of the irrigation water, the better arrangement of marketing conditions, and the strengthen of the farmers' association should be promoted. Furthermore to prevent the disorder urbanization in farm area and the contamination of the soil by sewage water from the residences, the Provincial Government should give some proper assistance and measures as much as possible.

(5) Dam and reservoir

Proposed dam site is located at a narrow gorge of limestone, 400 m upstream of the existing dam site. Rock foundation exists 5 m depth from the river surface, and both of dam abutments are composed of outcrops of limestone with its distance of 10 to 15 m. In this respect, gravity dam is selected. Fill type dam is not suitable due to excessive rock excavation to secure spillway channel. Recharge through dam foundation is not expected because of rock foundation, so that recharge downstream of the dam site is accelerated through intake facilities. Overflow depth is 2.0 m considering existing gorge width, and length of energy dissipater is 16.0 m

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Gravity	5.4	20.0	23.0	3,700	139,000	90,000	49,000	86

(6) Related components

a) Recharge facilities

Infiltration pond is constructed at the fan head, 3.0 km downstream of the dam site because of shallow depth of aquifer. Conduit type is selected for water conveyance canal due to outcrops along the river.

Recharge facilities	Recharge capacity ('000m^3/year)	Pond surface (m^2)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Wali Dad	2,600	8,500	85 x 100	1.4	ø300	3,250

b) Sediment control facilities

Detention bunds are constructed at 2.0, 2.5 and 3.0 km upstream of the dam site.

Detention bund	Capacity (m^3)	Bund length (m)	Bund height (m)	Bund volume (m^3)	Location
No. 1	2,200	20	7.0	900	3.0 km upstream of the dam
No. 2	2,200	20	7.0	900	2.5 km upstream of the dam
No. 3	2,200	20	7.0	900	2.0 km upstream of the dam

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

This is a dam plan to rehabilitate destructed dam. As residential area is extending downstream of the dam site, substantial effect on flood mitigation is much expected as well as improving in water use.

7.3.3 Samaki Area

(1) Groundwater recharging plan

The dam site is located in the branch of Arambi manda. Beneficial areas of the dam are mainly irrigated by tubewells nowadays pumped up from aquifers in this area distributing along the downstream of branch stream. Recharged water from the dam in the upstream area will be conducted by karezes and dug-wells. The thickness of aquifers in the downstream is approximately 20 m. Groundwater in the aquifers existing as subsoil water in the upstream is utilized when it flows towards downstream. Remaining unused groundwater may runoff towards the piedmont plain in the downstream area. This is considered second use in view of time scale compared to specified areas and treated as the use for unspecified beneficial areas. Groundwater recharging plan from the dam will be made to infiltrate the water quickly into the aquifers from the upstream area.

The method of promoting recharge into the aquifers from reservoir is by releasing water suitably to the downstream river bed in through conduits. Recharging may better be carried out along the river bed in the downstream of the dam.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.017 MCM and 0.041 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area has abundant fruits trees, but is located far from urban center. The soil is suitable for most crops, but marketing condition is unfavorable because of poor access roads. Although karezes and tubewells supply the irrigation water, it will be difficult to increase the amount of irrigation water, in addition to restoration with the proposed delay action dam. Based on such a situation, the future agriculture in this area should be focused on up grading the fruits in quality and unit yield, with the soil conservation as well as the improvement of access roads and marketing facilities.

(5) Dam and reservoir

Dam site is composed of shale and sandstone, and forms mountainous hilly terrains. Shale has been weathered and cracky, vertically dipping direction. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the 17 m semi pervious dam foundation against piping. River deposits are available for the semi pervious embankment. Downstream recharge through intake conduits is also accelerated because seepage flow through dam foundation is not so high, and these is gradually reduced due to siltation in the reservoir. Spillway is constructed on the right abutment composed of hard shale. Spillway channel slope is only protected with stone masonry. Overflow depth of 2.0 m and crest length of 12 m is planned to prevent excessive rock excavation. Energy dissipater is constructed to control flow discharge and to prevent scouring of the dam embankment.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill dam	2.5	80.0	15.5	35,000	153,000	100,000	53,000	53

(6) Related components

a) Recharge facilities

Infiltration pond is constructed at the fan head, 50 m downstream of the dam site.

Recharge facilities	Recharge capacity ('000m³/year)	Pond surface (m²)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Samaki	4,700	1,600	40 x 40	1.4	0.1 x 0.3	65

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

Recently, "Watershed Planning and Management Project, Balochistan" handled by FAO was completed in the beneficial area. Social activities for watershed management based on participatory approach was implemented in the project. It is expected that strengthening of the management project is considered due to importance for environmental conservation measures for the dam.

(8) Others

As recharged water of this dam once become underground stream of the Arambi manda, it is not always assured to benefit downstream area. Little effect of groundwater recharge can be expected due to small catchment area.

7.3.4 Iskalkoo Area

(1) Groundwater recharging plan

Target aquifers recharged by the proposed dam is alluvial fan deposits lying downstream. The dam site is located at the hill's breast. Limestone exposes in the river bed so that natural recharge from the river bed may be little. The plan of recharge into the aquifers from reservoir is considered to release water promptly from reservoir into river bed in the downstream through conduits. The foundation of reservoir and dam is composed of limestone which is underlain by impervious shale. This shale is usually lying directly under river deposits in the downstream

area and alluvial fan deposits in the lowlands. Limestone in this area is generally porous and cavernous, and has complicate conduits of groundwater flow inside. Because of that, it is very difficult to confirm whether released water from the dam recharges certainly into the aquifers in the alluvial fan area.

(2) Expected incremental groundwater recharge

The expected incremental groundwater recharge by implementation of the proposed delay action dam are divided into water for specified use and unspecified use. For this proposed dam, the recharged volumes are 0.032 MCM and 0.077 MCM, respectively.

(3) Specified beneficial area

Specified beneficial area is demarcated over the targeted aquifer as shown in the figures attached in Chapter 4. Groundwater exploitation in the Project is assumed by existing wells located within the demarcated specified beneficial area. No increase of wells is assumed in the Project.

(4) Agricultural development plan

The area is located near the center of Kalat district. The main crops are onion and wheat with some of orchards. But soil condition is not so good that the drainage and fertilization of soil should be taken into consideration for leveling up of cropping intensity and unit yield.

(5) Dam and reservoir

Dam site is composed of shale and mudstone, and forms mountainous hilly terrains. Shale has been weathered and cracky, vertically dipping direction. Homogeneous type fill dam is suitable to reduce hydraulic gradient along the 5 m semi pervious dam foundation against piping. River deposits are available for the semi pervious embankment. Downstream recharge through intake conduits is also accelerated because seepage flow through dam foundation is not so high, and these is gradually reduced due to siltation in the reservoir. Spillway is constructed on the right abutment. Inflow and chute sections of the spillway channel, comprising of weathered shale and mudstone is protected. Overflow depth of 2.0 m and crest length of 28 m is planned considering narrow abutment width of 40 m. Energy dissipater is constructed to control flow discharge and to prevent scouring of the dam embankment.

Dam type	Catchment area(km^2)	Crest length (m)	Dam height (m)	Embankment volume (m^3)	Total storage volume (m^3)	Effective storage volume (m^3)	Sediment volume (m^3)	Flood discharge (m^3/sec)
Fill dam	5.8	100.0	16.0	46,000	170,000	80,000	90,000	135

(6) Related components

a) Recharge facilities

Infiltration pond is constructed on the fan head, 500 m downstream of the dam site because of low seepage capacity of the river deposits downstream of the dam. Conduit type is selected for water conveyance canal due to outcrops along the river.

Recharge facilities	Recharge capacity ('000m³/year)	Pond surface (m²)	Pond W x L (m)	Pond depth (m)	Canal section W x H (m)	Canal length (m)
Iskalkoo	950	3,000	50 x 60	1.4	φ200	500

b) Sediment control facilities

Detention bunds are constructed at 2.0, 2.5 km upstream of the dam site. Furthermore, two of the bunds are constructed in the tributaries 500 m upstream of the dam site.

Detention bund	Capacity (m³)	Bund length (m)	Bund height (m)	Bund volume (m³)	Location
No. 1	2,200	30	3.0	570	2.5 km upstream of the dam
No. 2	2,200	30	3.0	570	2.0 km upstream of the dam
No. 3	2,200	30	3.0	570	0.4 km upstream of confluence
No. 4	2,200	30	3.0	570	0.8 km upstream of confluence

(7) Environment

The negative impact caused by the construction of the dam is disruption of traffic causing inconvenience for social life and economic activities due to cutting of traffic route. To compensate this loss, temporary and replaced roads are provided in the development plan proposed in the Study. As the works have appropriate design to mitigate the negative impact, it is not necessary to establish additional environmental conservation measures against the impacts.

In order to improve the environment situation in the area through the dam project, environmental management based on environmental conservation plan for the delay action dam projects is recommended as mid or long-term conservation plan.

(8) Others

Well harvested agricultural lands are extended in the downstream area where water source is an existing karez. Substantial effect can be expected if the water source is improved in its water availability. However, it is difficult to identify the beneficial area of the dam because of complex geo-hydrolic characteristics.

7.4 Construction Plan and Cost Estimates

7.4.1 Construction Plan

(1) Project components and work volume

Proposed facilities of 14 delay action dams and related structures described in previous section are listed below.

Major Construction Works

Dam Name	Dam Type	Spillway	Intake Structure	Recharge facilities	Sediment Control	Karez Repair
Brewary dam	Gravity dam	B =15.0m L= 19.5 m	ø250mm L=17.0m	B15.0mxL100.0m xH3.0m	-	-
Dara dam	Homogeneous type fill dam	B=41.0m L=220.0m	Incline ø400mm L=24.0m	B105.0mxL110.0m xH1.4m	Concrete type (1) Gabion type (2)	-
Murgi Kotal dam (Upstream)	Homogeneous type fill dam	B=36.0m L=300.0m	Incline ø400mm L=30.0m	B90.0mxL100.0m xH1.4m	Gabion type (4)	-
Murgi Kotal dam (Dowwnstream)	Homogeneous type fill dam	B=40.0m L=251.0m	Incline ø400mm L=25.0m	B90.0mxL100.0m xH1.4m	- ditto -	-
Kach dam (Rising of crest)	Zone type fill dam	B=42.0m L=276.0m	Incline ø250mm L=12.0m	B75.0mxL80.0m xH1.4m	Gabion type (2)	-
Kach dam (Downstream)	Zone type fill dam	B=40.0m L=250.0m	Incline ø250mm L=29.0m	B75.0mxL80.0m xH1.4m	- ditto -	-
Jigda dam	Homogeneous type fill dam	B=46.0m L=80.0m	Incline ø00mm L=33.0m	B40mxL150mxH1.5m B60mxL150mxH1.5m	Masonry type (3)	2,100m
Sanzali dam	Homogeneous type fill dam	B=26.0m L=400.0m	Incline ø200mm L=24.0m	B50.0mxL60.0m xH1.4m	Gabion type (4)	2,700m
Sakhol dam	Homogeneous type fill dam	B=42.0m L=200.0m	Inlet ø150mm L=190.0m	B30.0mxL40.0m xH1.4m	-	2,500m
Mangi dam	Homogeneous type fill dam	B=85.0m L=120.0m	Incline ø500mm L=16.0m	B116.0mxL130.0m xH1.4m	-	6,000m
Kad Kocha II dam	Homogeneous type fill dam	B=50.0m L=150.0m	Incline ø600mm L=11.0m	B100.0mxL150.0m xH1.4m	-	-
Ghazlona dam	Homogeneous type fill dam	B=35.0m L=65.0m	Incline ø200mm L=38.0m	B26.0mxL30.0m xH1.4m	Gabion type (2)	
Ghotai Shela dam	Homogeneous type fill dam	B=6.0m L=100.0m	Incline ø200mm L=15.0m	B70.0mxL70.0m xH1.5m	Gabion type (2)	-
Wali Dad dam	Gravity dam	B=15.0m L=14.0m	ø300mm L=10.0m	B85.0mxL100.0m xH1.4m	Concrete type (3)	-
Samaki dam	Homogeneous type fill dam	B=12.0m L=150.0m	Incline ø200mm L=15.0m	B40.0mxL40.0m xH1.4m	-	-
Iskalkoo dam	Homogeneous type fill dam	B=20.0m L=90.0m	Incline ø200mm L=10.0m	B50.0mxL60.0m xH1.4m	Gabion type (4)	-

Notes: ( ) shows number of sediment control bund
Masonry type: Stone masonry with concrete grouting
(Upstream) : Dam axis is located at upstream of the existing embankment.
(Downstream) : Dam axis is located at downstream of the existing embankment.
Incline: Inclined conduit type
Energy dissipator length is listed for gravity dam.

Major Work Volume

Dam Name	Dam Body		Spillway		Recharge facilities		Bund
	Embankment (m^3)	Riprap (m^2)	Concrete (m^3)	Masonry (m^3)	Excavation (m^3)	Pipe Length Canal Length (m)	Embankment (m^3)
Brewary dam (Gravity dam)	9,600	-	1,230 (Energy dissipater)	-	12,500	-	-
Dara dam	297,000	15,800	-	-	5,000	- 110	1,100 1,900
Murgi Kotal dam (Upstream)	278,000	7100	-	-	4,600	- 200	- 3,100
Murgi Kotal dam (Downstream)	453,000	10,200	1,400	-	4,600	- 200	- 3,100
Kach dam (Rising of existing dam crest)	480,000	15,300	5,900	1,000	1,100	- 3,450	- 1,400
Kach dam (Downstream)	593,000	19,900	5,900	1,000	1,100	- 1,500	- 1,400
Jigda dam	114,000	7,400	-	1,100	10,500	470 3,350	- 10,400
Sanzali dam	106,000	7,400	-	6,900	1,100	- 1,300	- 3,000
Sakhol dam	187,000	19,600	-	2,000	800	- -	- -
Mangi dam	171,000	14,200	4,200	400	3,300	- -	- -
Kad Kocha II dam	152,000	14,700	300	2,400	3,300	- 500	- -
Ghazlona dam	76,000	5,300	-	2,100	250	- 300	- 1,800
Ghutai Shela dam	33,000	3,500	100	1,300	1,200	- 500	- 1,900
Wali Dad dam (Gravity dam)	3,700	-	1,200 (Energy dissipater)	-	8,300	- -	2,800 -
Samaki dam	36,000	2,400	-	1,200	700	- 65	- -
Iskalkoo dam	47,000	3,200	300	2,400	1,100	- -	- 2,300

Note: Spillway concrete is total volume of reinforcement concrete and plain concrete.
Work volume of karez rehabilitation is shown in previous table.

(2) Construction planning

(a) Construction method

Proposed facilities are composed of dam facilities, recharge facilities, sediment control facilities (detention bund), and road replacement. Dam type whether gravity type or fill type is selected according to topo-geological condition and from economic point of view of each site. Regarding the inlet structure, an inclined conduit type is selected in the plan, and the inlet is constructed preceding the embankment works. Recharge facilities are composed of the infiltration ponds and water conveyance canal connecting the reservoirs and the infiltration ponds. A series of detention bunds are constructed far upstream of the reservoir area and their structures are gabion or stone masonry.

Major work process of the gravity dam is an excavation of foundation, concrete placing for the dam body and energy dissipater. It is important to examine the strength of the foundation during the foundation excavation. Dam concrete is mixed in the batching plant and placed using concrete bucket or cable crane. Concrete placing shall not be made during periods of

severe heat to avoid shrinkage of placed concrete caused by high temperature of concrete itself. In case cooling is not employed during concrete placing including curing period, it is essential to limit the height for placing. Contrary to this, heat-curing is required to avoid freezing of concrete surface during winter, especially at night time. Equipment and facilities for aggregate shall be able to effectively extract and haul the designated quantity of aggregate materials.

Process of the fill dam embankment is an excavation of dam foundation and cut-off trench, embankment, drain placing and slope protection works. Sufficient bearing capacity of the foundation to withstand load, shearing strength and porosity against piping shall be examined during the excavation. The embankment materials shall satisfy suitable moisture content and grain distribution to mitigate excessive settlement, slope slide and piping, for this, criteria for quality control of embankment shall be determined through test banking and various soil tests. Tube well and water tank shall be facilitated for moisture content of the materials. For fill dam materials, river deposits available in the vicinity of the dam site are utilized in principle. Excavated materials from appurtenant structures such as spillway is also diverted to the dam embankment aiming at reducing construction cost. Bulldozer, wheel loader, backhoe for excavation, dumptruck for hauling and vibratory roller, tamping roller for compaction are used for the embankment works.

Bulldozer is required for the recharge pond excavation and compaction of small dike around the pond. Water conveyance canal is structurally categorized as conduit type and open canal type. Excavation of the canal construction is made by backhoe or manually. Concrete for the canal lining is mixed by the portable concrete mixer.

Stone materials for the gabion and masonry of the detention bunds are extracted and placed manually. In case the quarry site of the materials is far from the site, dumptruck, cargo truck and tractor are useful for transportation. It is recommended to mix the concrete for stone masonry. However, portable concrete mixer should also be available when the concrete requirement is relatively small.

Road replacement works are composed of excavation and embankment of road sub grade, gravel pavement and drainage works. River deposits are suitable for pavement. Bulldozer and wheel loader are available for excavation and roller are used for compaction after spreading the material by motor grader,

(b) Construction facilities

Temporary works shall be planned to achieve the appropriate quality control, to minimize construction cost, to secure the safety of labors, machinery and equipment, to maintain appropriate construction schedule, etc. The following are the temporary works required for the construction of the gravity and fill dam.

i) Construction of batching plant (quality control and minimization of construction period)

ii) Establishment of stock yards for the construction materials and motor pool for machinery (quality and safety control)

iii) Installation of electric, water/air supply facilities (quality and minimization of construction period)

iv) Maintenance of temporary roads (safety control of labors and machinery)

v) Installation of scaffold and staging (Safety for labors)

(c) Quality control

In order to maintain the uniformity of the concrete quality, the following controls are carried out:

i) Material quality: Quality of cement and admixtures, size of aggregate, amount of moisture in aggregate

ii) Equipment: Maintenance of mixers and measuring apparatus

iii) Concrete tests: Mixing temperature for concrete, slump, air volume and compressive strength

In order to ensure the strength and grain size of embankment materials, the following control are carried out:

i) Material quality: Physical, geophisical soil tests

ii) Equipment: Planning and maintenance of construction machinery

iii) Embankment: Dry density, degree of saturation, criteria of embankment compaction

(3) Construction work schedule

Construction works are composed of dam, spillway (energy dissipater), intake facility, recharge facilities and sediment control facilities including a preparatory work at the beginning and a cleaning work after the completion of the construction. Accordingly, two types of construction work schedules are to be planned as follows:

i) Work schedule from the initial preparatory work to the cleaning work after completion of the construction.

ii) Individual work schedule for main construction works such as concrete placing work for the gravity dam and embankment work for the fill dam.

As for the planning method, the following two procedures are generally applied:

i) To formulate the most economical work schedule for all related works within the limitation of the construction period for the major works which have been determined in advance, or

ii) To determine the most economical construction period by examining the preferable schedule for individual works, without setting up a time limitation in advance.

The following are basic concept to estimate the construction work schedule for the delay action dam.

a) Concrete placing period of the gravity dam is estimated based on daily placing of concrete volume of 150 to 200 m^3, maximum placing height of 1.5 m and minimum curing period of 4 days.

b) Construction period of the dam embankment is calculated on the basis that the daily embankment volume is at least 1,100 m^3 performed by one compaction roller for the dam with dam height of less than 15 m. For the dam with height of more than 15 m, construction period of the dam embankment is calculated based on a proper combination of the following earth machinery and their working capacities.

Earth works	Machinery	Working capacity (m^3/day/set)	Remarks
Excavation	Bulldozer (21 ton)	330	(Moving length: 50m)
Excavation	Bulldozer (21 ton)	670	(Moving length: 20m)
Loading	Wheel Loader (2.0m^3)	540	(20m^3 flat loading)
Hauling	Dumptruck (11 ton)	220	(Distance: 200m)

c) Half river section is utilized for the temporary diversion works during the construction of the fill dam. Because of high rainfall intensity during Kharif period, this diversion method is not applied for the dams of which sufficient diversion capacity is not attained in the river section.

Concrete of the gravity dam is not placed in the period of air temperature lower than 4°C and higher than 35°C in the case that cooling or heat-curing is not performed.

d) Regarding the fill dam construction, half month is required for the preparatory work, temporary work and site cleaning in each. Besides, the construction works including installation of the concrete batching plant due to large requirement of concrete placement such as the gravity dam construction, two and one month are estimated for the temporary works and site cleaning works, respectively.

Construction schedule of proposed dams is shown in Fig. 7.4.1.

7.4.2 Cost Estimates

(1) Assumptions

The project cost is estimated based on the following assumptions:

a) Unit prices are analyzed on the basis of average prices as of end of 1996.

b) The exchange rate used in the estimates is:
US$ 1.00 = Rs. 40.00 = J¥120.00

c) All construction works will be undertaken on the contract basis. Contractor(s) will be selected by the international competitive tender. All construction machinery, equipment and construction materials are to be provided by the contractor(s).

d) Taxes on the construction materials, machinery and equipment imported from abroad are to be exempted and are not included in the cost estimate.

e) The construction cost based on unit cost is divided into foreign and local currency portions. Local currency portion is estimated on the basis of the current price in Balochistan Province and foreign currency based on CIF prices at Karachi.

f) Cost for the road replacement is included in the temporary work cost of the construction works.

g) Construction period of the proposed dams is illustrated in previous paragraph of construction work schedule.

h) The physical contingency of 10 % of the total costs of detailed design, construction, engineering is included in the project cost.

i) Price contingency is also taken into account at an annual escalation rate of 4.5 % for the foreign currency portion and 10 % for local currency portion.

(2) Project cost

Financial project cost is composed of the following items:

a) Construction cost
Construction cost is composed of direct construction cost, cost for temporary and preparatory works. The cost for the temporary and preparatory works are assumed at about 10 % of the direct construction cost.

b) Administration cost
Construction works are undertaken by the government staff with assistance and advice of the consultants. Administration cost is estimated based on the required number of the government staff for the detailed design, construction supervisory works.

c) Engineering service cost
Engineering service cost on the detailed deign and construction supervisory works is composed of engineering fee for the engineer and field survey such as geophisical investigation and soil tests during the detailed deign period to utilize for the dam design.

d) Land acquisition
Land acquisition cost is not required assuming that all proposed facilities, dams and recharge facilities are constructed in the public land.

e) Contingency
As described in the previous Section, the physical contingency is fixed at 10 % of the total of the above four items. Price contingency is also fixed at 4.5 % and 10 % for foreign and local currency portions.

Detailed project cost of each proposed dam is summarized in Table 7.4.1.

7.5 O &M and Monitoring Plan

7.5.1 O & M Plan

Present irrigation systems in the Study Area are only implemented small irrigation schemes and karezes, excluding private tubewells for irrigation water supply. The small irrigation schemes are categorized as surface water irrigation scheme, flood irrigation scheme and delay action dam scheme. For the operation of the facilities, no regular handling such as gate operation is required. Users organization has been made for the schemes of surface water irrigation scheme and flood irrigation scheme only, in which the member is obligated to pay water charge, while low collecting rate is recorded.

For the delay action dam scheme, there is no user organization, and no water charge is imposed. The reason is that the delay action dam dose not require regular operation, and has no specified beneficiaries.

The irrigation Department has carried out re-newing and repairing work for small irrigation schemes as required. Though around two percent of project cost of the schemes are planned for annual O&M cost from Non-Development Fund of the Provincial Government, it has not been possible to allocate such funds due to shortage of budget.

Taking these conditions into consideration, common plan for operation and maintenance of delay action dam scheme was devised corresponding to its development strategy and plan mentioned before. Points of the plan are as follows:

- Regular and permanent operation is not required in delay action dam schemes.
- When repair work in dam slope and related structures, shoveling of siltation in the reservoir and operation of flow valves are required, beneficiaries should corporatly conduct it under the control of the Irrigation Department.
- Proposed recharge pond constructed downstream of the dam may possibly be silted within a few years. It is required to shovel silt from the recharge pond by bulldozer about once in one or two years. Alternatively new pond near the

silted pond may be constructed. Diverting canal to the pond is also required to be repaired.

- Necessary activities on watershed conservation and groundwater use control should be done by formers through a farmers organization. Existing users group for karez use is effective foundation for the farmers organization.

- Existing irrigation canal being in bad condition should be rehabilitated with lining, under the On-Farm Water Management Program if possible.

- No cost recovery, and no irrigation charges are considered for the delay action dam, even for the specified beneficiaries. Necessary budget for repair and maintenance for delay action dams shall be borne by the Irrigation Department. While beneficiaries should participate in repair work on the scheme and watershed conservation without incentives.

In line with the operation and maintenance plan for the delay action dam, annual cost for operation and maintenance was estimated in Table 7.5.1, and summarized as follows:

Items	Frequency	Unit Cost
Dam slope protection	as required	3% of const. cost of dam slope
Repairing	as required	-
Shoveling recharge pond	annually	shoveling of 50 cm thick sedimentation
Karez cleaning	annually	borne by the beneficiaries
Watershed conservation	continuously	borne by Forestry Department with participation of beneficiaries
Soveling silt in Reservoir	as required	-

(Rs.'000/year)

Dam name	O & M cost	Dam name	O & M cost
Brewary	81	Ghutai Shela	105
Wali Dad	138	Dara	313
Murgi Kotal	238	Kach	341
Jigda	295	Sanzali	198
Ghazlona	143	Samaki	119
Sakhol	328	Mangi	382
Kad Kocha II	387	Iskalkoo	131

7.5.2 Monitoring Plan

Bureau of Water Resources (BWR) of the Irrigation Department which has succeeded groundwater monitoring unit of WAPDA, is the responsible agency for monitoring and analysis. Monitoring has been done by means of deep wells with automatic recorder and piezometers through 107 number of observation points, located in Quetta northern sub-basin, northern part of Pishin sub-basin, and Mastung sub-basin.

While groundwater situation in concerned basins by the monitoring data is being revealed, it is recommended to increase monitoring station with a density of one station per 20 km², against present density of one station per 100 km². New stations in other basins out of present monitoring range, such as Kuchlagh, Shirinab and Mangocher sub-basins may also be set up.

A realistic development scenario should be formulated by means of simulation method in the valleys under critical situation in groundwater use. For this purposes, making mathematical model and preparing computer software shall be done in collaboration with collection of monitoring data.

Further, installation of observation wells are recommended around existing facilities for groundwater recharging including delay action dams, for the purpose of continuous assessing of recharging effects. The monitoring management is done by the BWR, and its results should be utilized not only be used locally but also for policy making on groundwater management to be handled in future by the proposed new institutions.

Table 7.1.1 Development Features of Proposed Delay Action Dams

	Brewary		Dara		Mulgi Kotal		Kach		Jigda		Sanzali		Sakhoi		Mangi		Kad Kocha II		Ghaziona		Ghutai Sheia *		Wali Dad *		Samaki *		Iskalkoo *	
1 District	Quetta		Quetta		Quetta		Quetta		Pishin		Pishin		Mastung		Kalat		Mastung		Qila Abdullah		Quetta		Quetta		Qila Abdullah		Kalat	
2 Villages	Kirrani Gulzar Sardar		Sra Ghargi Ragha		Smali Mulazai Kateer C. Achozai		Sra Ghargi Umar		Jigda Sharan (Kamarzai)		Sanzali Schibzada (Haji Abd.Jan)		Ladha M.Rashid,K. Afghan Murgha		Mall Shapchi Khal		Khurma Kalozai H.Qutod K. Kabul M.		Mullayan Silad		Khrotabad Khairzi		Saldar Chiltan Serday		Kamran Kaul		Iskalkoo	
3 Irrigated area (ha)	188		133		113		136		56		21		60		349		303		69		41		71		53		75	
4 Population	2,400		1,700		4,600		3,000		1,500		500		2,000		4,800		2,500		3,200		4,000		3,000		2,400		1,500	
5 Nos. of household	220		120		330		330		100		30		180		440		270		260		410		230		200		85	
6 Water sources	26 wells 2 Karezes		40 wells 1 spring		30 wells 1 spring		30 wells 1 spring		2 karezes (20 wells)		5 karezes (12 wells)		20 wells 3 karezes		20 wells 2 karezes		62 wells		10 wells 6 karezes		4 wells		8 wells		12 wells		2 wells 1 spring	
7 Cropping Pattern**																												
Rabi (ha)		13.0		47.2		23.0		41.3		37.3		13.4		30.9		187.0		51.0		1.0		11.7		20.6		21.4		42.0
Wheat(Irrigated)	3.9%	7.3	34.6%	45.8	3.9%	4.4	28.2%	38.4	10.0%	5.6	56.2%	11.8	42.2%	25.3	29.5%	102.9	12.0%	36.2	1.4%	1.0	21.9%	8.9	21.9%	15.5	34.0%	18.0	37.1%	27.7
Barley	0.0%	0.0	1.1%	1.4	13.2%	15.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	9.3%	5.6	0.5%	1.9	0.7%	2.0	0.0%	0.0	1.7%	0.7	1.7%	1.2	2.2%	1.2	4.6%	3.4
Cumin	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	19.3%	67.3	0.0%	0.0	0.0%	0.0	1.3%	0.5	1.3%	0.9	2.1%	1.1	5.7%	4.3
R.Vegetables	1.7%	3.3	0.0%	0.0	0.4%	0.5	2.1%	2.9	46.6%	26.1	7.7%	1.6	0.0%	0.0	0.5%	1.9	2.4%	7.1	0.0%	0.0	2.5%	1.0	2.5%	1.8	1.0%	0.5	0.5%	0.4
Fodder	1.3%	2.5	0.0%	0.0	2.8%	3.2	0.0%	0.0	10.0%	5.6	0.0%	0.0	0.0%	0.0	3.8%	13.1	1.9%	5.6	0.0%	0.0	1.6%	0.6	1.6%	1.1	1.1%	0.6	8.4%	6.3
Kharif (ha)		175.8		87.9		106.0		99.1		32.1		9.6		29.1		162.0		301.0		69.0		27.1		47.4		29.8		32.5
Apple	27.1%	51.0	36.3%	48.3	55.3%	62.5	44.4%	60.5	20.1%	11.2	0.0%	0.0	0.0%	0.0	1.9%	6.5	54.7%	165.8	48.0%	33.1	20.0%	8.1	20.0%	14.2	10.0%	5.3	10.0%	7.5
Apricot	13.1%	24.6	15.9%	21.1	15.0%	17.0	15.3%	20.8	1.1%	0.6	0.0%	0.0	0.0%	0.0	0.0%	0.0	5.0%	15.0	19.0%	13.1	1.6%	0.6	1.6%	1.1	5.7%	3.0	1.4%	1.0
Grape	44.0%	82.6	2.0%	2.6	5.6%	6.4	2.2%	3.0	0.0%	0.0	5.9%	1.2	6.3%	3.8	0.0%	0.0	6.6%	20.0	10.0%	6.9	20.0%	8.1	20.0%	14.2	10.0%	5.3	5.0%	3.7
Cherry	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
Almond	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.6%	1.7	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
Onion	0.0%	0.0	0.0%	0.0	0.9%	1.1	0.0%	0.0	0.0%	0.0	18.3%	3.8	38.8%	23.3	43.2%	150.7	23.8%	72.0	9.0%	6.2	3.6%	1.5	3.6%	2.6	7.0%	3.7	16.3%	12.2
Potato	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	3.4%	2.0	0.0%	0.0	0.6%	1.7	7.0%	4.8	0.8%	0.3	0.8%	0.6	4.2%	2.2	7.0%	5.2
K.Vegetables	8.4%	15.8	11.9%	15.8	10.3%	11.7	10.9%	14.9	29.2%	16.4	3.2%	0.7	0.0%	0.0	0.0%	0.0	3.9%	11.7	7.0%	4.8	12.1%	4.9	12.1%	8.6	3.7%	2.0	1.4%	1.0
Melons	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	2.2%	6.6	0.0%	0.0	6.4%	2.6	6.4%	4.5	9.4%	5.0	0.8%	0.6
Fodder	0.9%	1.8	0.0%	0.0	6.6%	7.4	0.0%	0.0	6.9%	3.9	0.0%	0.0	0.0%	0.0	1.4%	4.9	2.1%	6.5	0.0%	0.0	2.3%	0.9	2.3%	1.6	1.6%	0.8	1.7%	1.3
Tobacco	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	18.3%	3.8	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	4.6%	2.4	0.0%	0.0
Cropped area		188.8		135.1		129.0		140.4		69.4		23.0		60.0		349.0		352.0		70.0		38.8		67.9		51.2		74.5
Crop Intensity		100%		102%		114%		103%		124%		110%		100%		100%		116%		101%		96%		96%		97%		100%

*: Development features of the 4 dams are based upon the results of pre-F/S studies because F/S were not conducted in the Study.

**: Proposed cropping patterns are applyed its own present pattern, while 4 non-F/S dams are applyed avaraged patterns in the districts.

Table 7.2.1 Features of Proposed Delay Action Dams (F/S Sites)

	Dam Name	District	Dam Type	Crest Length (m)	Dam Height (m)	Spillway Length (m)	Spillway Crest Length (m)	Design Flood Discharge (m^3/sec)	Specific Flood Discharge (m^3/sec/km^2)	Total Storage Volume (m^3)	Embankment Volume (m^3)	Sediment Volume (m^3)	Specific Sediment Volume (m^3/km^2/year)	Catchment Area (km^2)
1	Brewary DAD	Quetta	Gravity	42.0	32.4	19.5	15.0	165.0	6.4	749,000	9,600	360,000	500	25.9
2	Dara DAD	Quetta	Earth dam	405.0	22.8	220.0	41.0	109.0	6.6	589,000	285,000	349,000	700	16.6
3	Murghi Kotal DAD	Quetta	Earth dam	130.0	35.6	300.0	36.0	131.0	6.7	1,147,000	278,000	887,000	1,500	19.7
4	Kach DAD	Quetta	Earth dam	330.0	45.9	276.0	42.0	333.0	5.9	2,387,000	480,000	1,187,000	1,700	56.5
5	Jigda DAD	Pishin	Earth dam	210.0	23.9	80.0	46.0	142.0	6.8	508,000	114,000	218,000	700	20.8
6	Sanzali DAD	Pishin	Earth dam	297.0	19.2	400.0	26.0	80.0	7.7	394,000	106,000	234,000	1,500	10.4
7	Sahkol DAD	Mastung	Earth dam	1090.0	14.5	47.0	42.0	199.0	8.9	545,000	187,000	335,000	500	22.3
8	Mangi DAD	Kalat	Earth dam	530.0	12.7	120.0	85.0	400.0	10.2	1,011,000	171,000	591,000	500	39.4
9	Khad Kucha II DAD	Mastung	Earth dam	595.0	14.0	53.5	50.0	389.0	25.7	368,000	152,000	228,000	500	15.2
10	Ghazlona DAD	Qila Abdullah	Earth dam	195.0	20.9	65.0	35.0	109.0	12.0	331,000	76,000	191,000	700	9.1

Source : JICA Study Team

1) Earth dam means homogeneous type fill dam. Kach dam has impervious zone in the center, and semi-pervious zone at both side of the embankment.

Table 7.3.1 Features of Proposed Delay Action Dams (Non-F/S Sites)

	Dam Name	District	Dam Type	Crest Length (m)	Dam Height (m)	Spillway Length (m)	Spillway Crest Length (m)	Design Flood Discharge (m^3/sec)	Specific Flood Discharge (m^3/sec/km^2)	Total Storage Volume (m^3)	Embankment Volume (m^3)	Sediment Volume (m^3)	Specific Sediment Volume (m^3/km^2/year)	Catchment Area (km^2)
1	Ghutai Sbela DAD	Quetta	Earth dam	155.0	13.0	100.0	6.0	28.0	15.7	80,000	33,000	38,000	700	1.8
2	Wali Dad DAD	Quetta	Gravity	20.0	23.0	27.0	15.0	86.0	16.1	139,000	3,700	49,000	300	5.4
3	Samaki DAD	Qila Abdullah	Earth dam	80.0	15.5	150.0	12.0	53.0	21.0	153,000	35,000	53,000	700	2.5
4	Iskalkoo DAD	Kalat	Earth dam	100.0	16.0	90.0	20.0	133.0	23.1	170,000	46,000	90,000	500	5.8

Source : JICA Study Team

1) Earth dam means homogeneous type fill dam.

Table 7.4.1 Project Cost

(Unit : '000Rs.)

	Direct Cost	Administration Cost	Engineering Cost	Sub Total	Contingency (Phisical)	Contingency (Price)	Total Project Cost
Brewary dam	36,489	1,824	3,649	41,962	4,196	3,530	49,688
Dara dam	63,904	3,195	6,390	73,489	7,349	4,888	85,726
Murgi Kotal dam*							
(Upstream)	56,335	2,817	5,634	64,786	6,478	4,210	75,474
(Downstream)	77,812	3,891	7,781	89,484	8,949	5,893	104,326
Kach dam**							
Rising of crest)	112,834	5,642	11,283	129,759	12,976	9,170	151,905
(Downstream)	125,970	6,298	12,597	144,865	14,487	11,162	170,514
Jigda dam	67,890	3,394	6,789	78,073	7,807	5,859	91,739
Sanzali dam	42,296	2,115	4,229	48,640	4,864	3,705	57,209
Sakhol dam	51,518	2,576	5,152	59,246	5,925	4,351	69,522
Mangi dam	58,356	2,918	5,835	67,109	6,711	5,049	78,869
Kad Kocha II dam	47,636	2,381	4,764	54,781	5,478	4,022	64,281
Ghazlona dam	21,037	1,052	2,103	24,192	2,419	1,740	28,351
Ghutai Shela dam	10,962	548	1,096	12,606	1,260	919	14,785
Wali Dad dam	34,471	1,723	3,448	39,642	3,965	3,090	46,697
Samaki dam	12,344	617	1,234	14,195	1,420	1,073	16,688
Iskalkoo dam	17,684	884	1,768	20,336	2,033	1,586	23,955

Source: Jica Study Team

Notes: *Upstream plan is economically vital rather than downstream plan.

**Rising of crest plan is economically vital rather than downstream plan.

Table 7.5.1 Annual O&M Cost

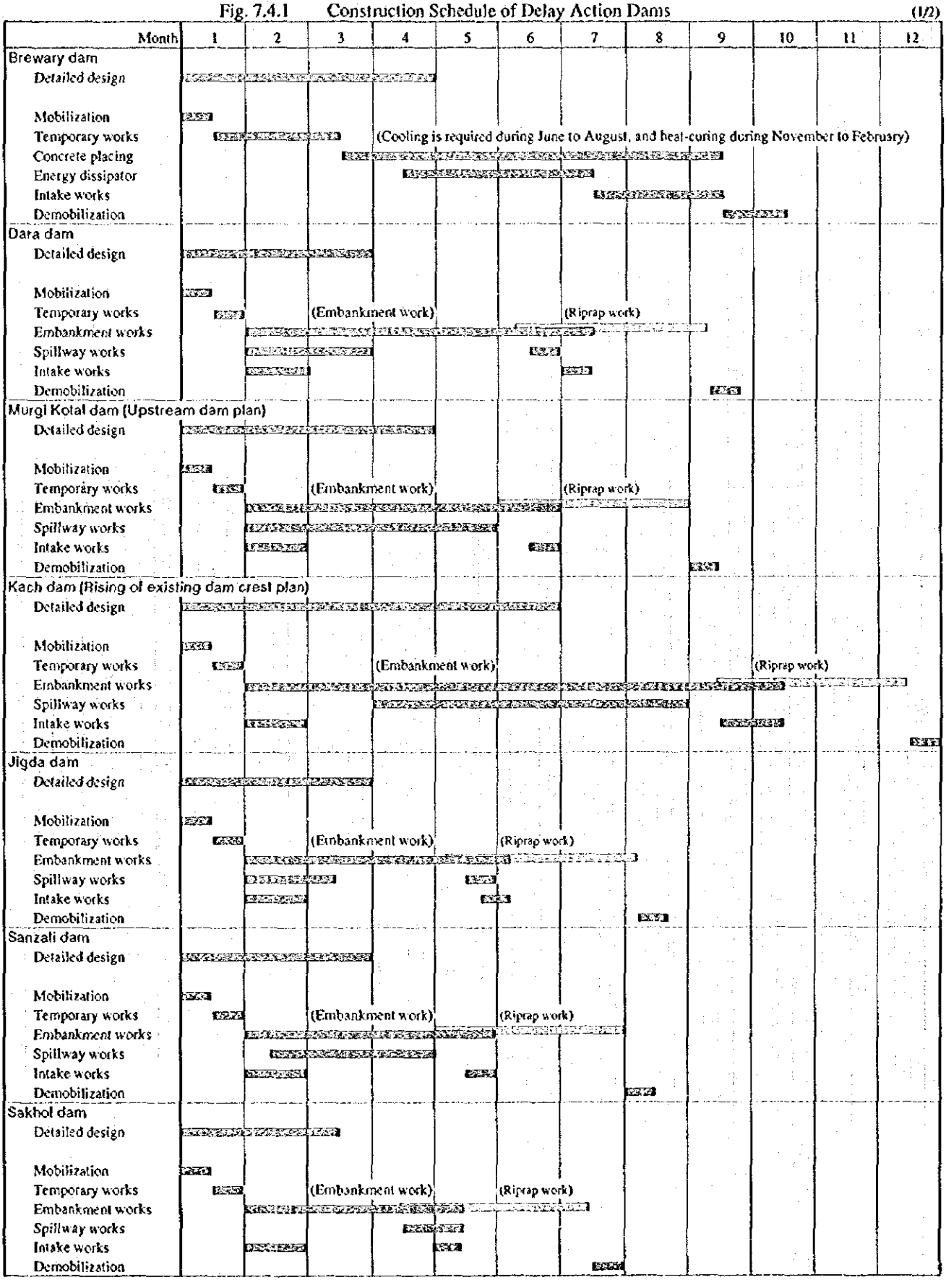
(Unit : '000Rs.)

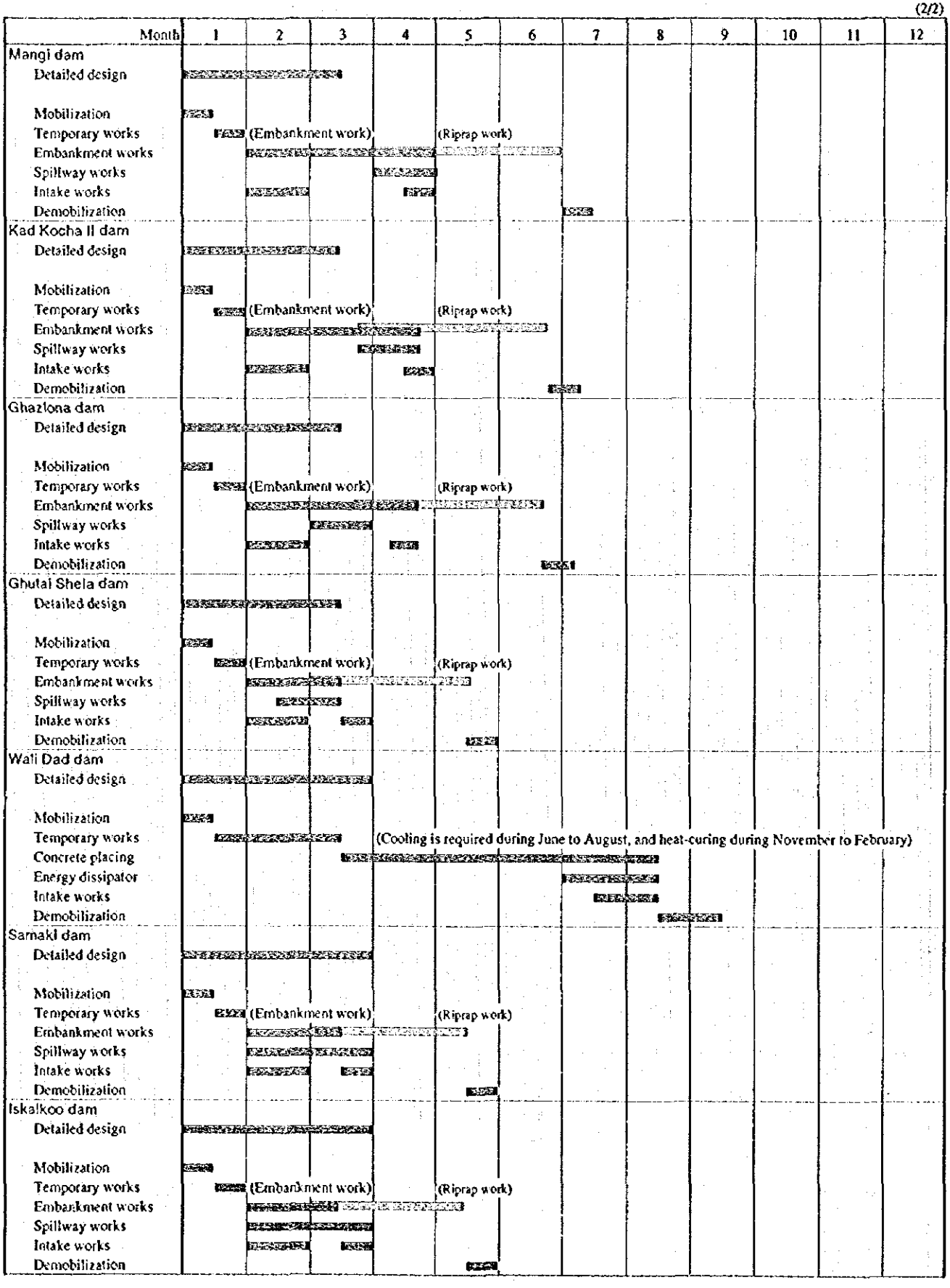
	Personnel Cost	Transportation Cost	O&M Cost for Structures			Administration	Total Annual O&M Cost
			Dam riprap	Transmission	Infiltration pond		
Brewary dam	36	30	–	–	13	2	81
Dara dam	36	30	149	1	95	2	313
Murgi Kotal dam	36	30	93	2	75	2	238
Kach dam	36	30	198	25	50	2	341
Jigda dam	36	30	69	34	124	2	295
Sanzali dam	36	30	96	9	25	2	198
Sakhol dam	36	30	250	–	10	2	328
Mangi dam	36	37	183	–	124	2	382
Kad Kocha II dam	36	30	189	6	124	2	387
Ghazlona dam	36	44	50	5	6	2	143
Ghutai Shela dam	36	30	24	–	13	2	105
Wali Dad dam	36	30	–	–	70	2	138
Samaki dam	36	44	24	–	13	2	119
Iskalkoo dam	36	37	31	–	25	2	131

Notes: Personnel cost is estimated based on monthly payment of Goverment staff. Engagement of 6 days is responsible for.

Administration cost is 3% of total cost of personnel, transportation and O&M for structures.

Fig. 7.4.1 Construction Schedule of Delay Action Dams (1/2)




Month
1
2
3
4
5
6
7
8
9
10
11
12
Mangi dam
Detailed design
Mobilization
Temporary works
(Embankment work)
(Riprap work)
Embankment works
Spillway works
Intake works
Demobilization
Kad Kocha II dam
Detailed design
Mobilization
Temporary works
(Embankment work)
(Riprap work)
Embankment works
Spillway works
Intake works
Demobilization
Ghazlona dam
Detailed design
Mobilization
Temporary works
(Embankment work)
(Riprap work)
Embankment works
Spillway works
Intake works
Demobilization
Ghutai Shela dam
Detailed design
Mobilization
Temporary works
(Embankment work)
(Riprap work)
Embankment works
Spillway works
Intake works
Demobilization
Wali Dad dam
Detailed design
Mobilization
Temporary works
(Cooling is required during June to August, and heat-curing during November to February)
Concrete placing
Energy dissipator
Intake works
Demobilization
Samakl dam
Detailed design
Mobilization
Temporary works
(Embankment work)
(Riprap work)
Embankment works
Spillway works
Intake works
Demobilization
Iskalkoo dam
Detailed design
Mobilization
Temporary works
(Embankment work)
(Riprap work)
Embankment works
Spillway works
Intake works
Demobilization

8. *PROJECT EVALUATION AND IMPLEMENTATION PLAN*

8.1 General

This chapter explains the evaluation of the 14 proposed delay action dams at 13 sites and then describes formulation of the project implementation plan on DADs. The economic evaluation, in principle, synthesizes such engineering considerations of the schemes on the cost side and benefit side on agricultural and social conditions. Ten DADs prioritized at the end of Phase I study are examined at feasibility study level and the rest 4 DADs are at pre-feasibility study level. This results together with social soundness and environmental considerations are used for the prioritization of the all 14 DADs and for the formulation of the project implementation plan.

8.2 Economic Evaluation

(1) Outline of economic evaluation

The delay action dams have a main function of artificial recharge of groundwater aiming to secure sustainable water use. At present the water balance falls into significant deficit of natural recharge to exploitation in all sub-basins of Pishin Lora basin. The DAD project accelerates water recharge to groundwater basin and improves the water balance. The benefits of the groundwater recharge are considered to appear in the downstream areas of the DADs, as well as the basin in which the DAD is located, because the water artificially recharged is not fully consumed in the specified beneficial areas but some portion of the water is reserved in groundwater resources in unspecified areas of the basin.

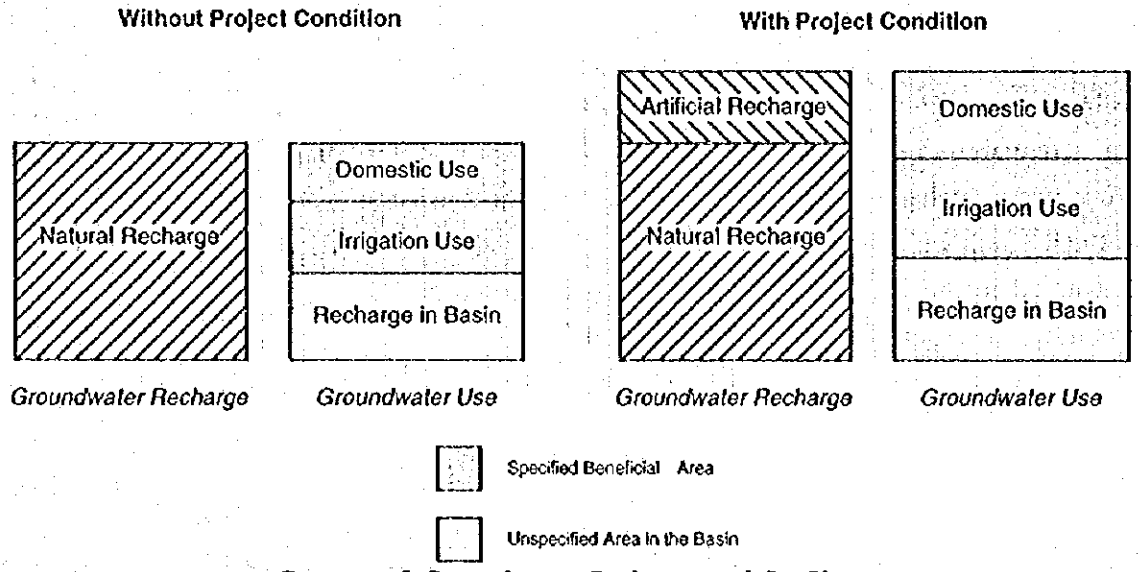
The artificially infiltrated water is lifted up by tubewell or flows down for both irrigation and domestic use in the specified beneficial areas. Under without-project condition, groundwater only naturally recharged is able to be used in the beneficial area. Excessive exploiting quantity of water over the naturally recharging groundwater must be unavailable in near future if groundwater use is continued in same manner. Under with-project condition, the groundwater potential becomes much larger owing to artificial recharge by the DADs. The difference of water use under these two future conditions becomes the groundwater recharge benefit of the DADs, counting demand values of domestic and irrigation water in each specified beneficial area.

On the procedure of this project benefit estimation, the recharge volume of water for the unspecified area of the basin is initially allocated from the total recharge volume of the DAD by topographic and hydrogeological consideration of the site. When the rechargeable quantity of

water allocated to the specified area is surplus to water demand of the area, the surplus water is counted as a part of the unspecified recharge for other areas. The lowest cost among the costs of possible several alternatives for groundwater recharge is used as a unit value of additional water resources for the unspecified area to be recharged by the DAD. The unspecified benefit of the DAD is to create additional groundwater availability for the unspecified area, which is possibly quantified multiplying rechargeable volume of water for unspecified area by the unit value.

Further, the DADs make additional positive impacts on flood control, because the Study Area is used to suffer from flooding caused by occasional heavy rain in summer season even though it is considered as arid area. The proposed dams prevent flushing water from mountain range from running down directly to agricultural and residential areas. The dams also perform as check dams which catch soils eroded in denuded mountains.

The concept of groundwater recharge and use under with- and without-project condition and the anticipated benefit of the DAD scheme is summarized as follows:



Concept of Groundwater Recharge and Its Use

Concept of Project Benefits

Function of DAD	Effective area	Item of Benefit	Valuation of Benefit
Acceleration of Groundwater Recharge	Specified beneficial area	Increase of groundwater potential for sustainable domestic use	Filling deficit in water demand for domestic use
		Increase of groundwater potential for sustainable irrigation use	Filling deficit in water demand for irrigation use
	Unspecified area in the basin	Conservation of groundwater resources for multiple use	Unit water value equivalent to the most economical artificial recharge cost
Flood Control	Downstream area of the DAD	Mitigation of flood damage	avoidance of expected flood damage

(2) Economic project cost

In the economic evaluation, the project cost basically consists of construction cost and operation and maintenance cost for the delay action dam and other project facilities. The delay action dams can be considered to have double function to keep flood water and sand, because the design capacity of dams is decided by flood discharge and sediment volume in the reservoir. The erosion control facility is fundamentally necessary to be constructed in the area for the sake of proper maintenance of rangeland as well as farm land downstream. Although the assessment of the erosion control is ideally to be done, the evaluation method is not established concretely as yet. Therefore, all the costs as well as benefits for soil erosion control are excluded from this assessment of the DAD schemes. The project cost is calculated by subtracting the direct and indirect cost on detention bunds to be constructed, if any, and the construction cost of check dam to trap the design sedimentation volume from the total project cost.

The construction cost is converted into the economic cost using some conversion factors. This process is; 1) reducing of transfer costs, 2) multiplying unskilled labor costs by the shadow wage rate of 0.75, 3) multiplying other local costs by the standard conversion factor of 0.87, and 4) multiplying all foreign costs by 1.00. The computed economic cost of the project is shown in the following table. The economic cost for operation and maintenance is also calculated applying the same conversion method as the construction cost.

Project Cost in Economic Price

(Unit: Rs. '000)

DAD	DAD Construction Cost*	Cost Owing to Sedimentation**	Project Cost for Evaluation	Annual O&M Cost
Brewary	40,249	20,974	19,275	69
Ghutai Shela	12,562	6,774	5,788	99
Wali Dad	39,077	9,535	29,542	123
Dara	69,585	35,852	33,733	266
Murgi Kotal	62,295	14,630	47,665	204
Kach	128,765	44,851	83,914	285
Jigda	38,381	13,293	25,088	255
Sanzali	43,740	18,698	25,042	157
Arambi (Ghazlona)	21,867	9,662	12,205	119
Arambi (Samaki)	14,044	3,749	10,295	100
Sakhol	59,008	33,769	25,239	264
Mangi	66,535	24,825	41,710	322
Kad Kocha II	54,573	30,618	23,955	321
Iskalkoo	19,874	5,685	14,189	107

Note *: Excluding direct and indirect cost for erosion control facilities from the construction cost explained in Chapter 7.
Note **: Assuming necessary check dam to store design sedimentation volume.
Source: JICA Study Team

The project life limited by sedimentation is 40 years adding 10 years of effectiveness of storage to 30 years of the base design period against sedimentation in principle. Exceptionally, the topographic condition allows only 35-year project life for Murgi Kotal and Jigda, 25-year for Sanzali and 20-year for Kach. Besides, the project does not require any replacement costs nor take salvage value into account.

(3) Benefit on agriculture in specified beneficial area

There is no doubt that today's rapid growth of agricultural production in the Study Area stands on an over exploitation of groundwater resources. Such excessive water use for irrigation may exhaust the groundwater resources in near future. The agricultural production under without-project condition is assumed to be lower than at present due to limitation of groundwater potential. Under with-project condition, the additional groundwater potential derived from the DAD is expected to support the higher production in agriculture sector. This incremental value of the farm products is taken as the benefit of agriculture in the specified beneficial area of the DAD.

The only enlargement of the sustainable irrigation area will bring such agricultural production benefit. The irrigated area in the specified beneficial area of the DAD under without-project condition derived from the present irrigated area multiplied by the percentage of water shortage in the basin. The additional water potential for irrigation use is the additional recharge volume in water excluding the demand for domestic use. The irrigated area under with-project condition is the present irrigated area or maximum irrigated area achieved by balanced water

potential. The project does not aim at extending the irrigation outside the present irrigated area.

Assuming that the cropping pattern does not change under the project, the present cropping pattern at each beneficial area is used for unit water requirement and net agricultural production value. The agricultural production value is expressed at economic value using the international prices on wheat and chemical fertilizers and the conversion factors on other inputs and outputs. In this evaluation, wheat, tomatoes, apples, onion and fodder is taken up as the representative crops of cereals, vegetables, fruits, other crops and fodder crops, respectively.

(4) Benefit on water supply in specified beneficial area

The common water sources for domestic use in the specified beneficial area is groundwater lifting through tubewells, open wells and karezes, but natural groundwater is running short in the area. The project benefit on domestic water supply is measured as a increment of sustainable water supply capacity to the residents in the specified beneficial area. The additional water demand is represented by the product of the total population, over-exploiting ratio of groundwater and unit water requirement. The benefit is derived from multiplying it by the unit value of domestic water. In this calculation, the unit water requirement is 0.06 cu.m/day/person as an average in the area, and the unit value of domestic water is estimated at Rs. 8.80 /cu.m based on average construction cost, O&M cost and exploitation volume of a tubewell.

(5) Benefit on groundwater recharge in unspecified area

The general recharge to groundwater basin must bring substantial benefit because the area which faces to crisis of groundwater resources and has no other water resources to be developed need immediate countermeasures of recharge acceleration or water saving. As it is difficult to measure such benefit directly, the cost-effectiveness analysis method is applied for this purpose.

The volume of the additional groundwater recharge in the unspecified area by the DAD is basically estimated by hydrogeological and topographical information of the site. If there is surplus groundwater after using for domestic and irrigation purposes in the specified beneficial area, the surplus volume of water is added to the water potential in the unspecified area. In the evaluation of the benefit on groundwater recharge in the unspecified area, the minimum unit cost among the several alternative measures is used as unit water value in the basin. The benefit is estimated from multiplication of the artificial recharge volume in the unspecified area and the unit water value of Rs. 4.98 /cu.m.

(6) Benefit on flood control

The DAD construction brings mitigation of flood damage in the downstream area due to its storage function of flood water. The expected annual flood damage is analyzed on the rainfall data and the records of flood damages on crops, domestic animals, houses, irrigation facilities, roads and so on. The annual flood damage is estimated at Rs. 18,800 for every 1 sq.km of the catchment area. This expected damage is avoided under with-project condition. The benefit on flood control for each DAD is evaluated on the basis of the catchment area and the expected annual flood damage.

(7) Results of economic evaluation

The average annual benefit on the proposed DAD schemes was estimated on the assumptions mentioned above. The total benefits is evolved by summing up the values of each benefit items.

Average Annual Benefit of the Proposed DADs

(Unit: Rs. '000)

DAD	Specified Area		Unspecified	Flood	Total
	Domestic Use	Irrigation Use	Groundwater Recharge	Control	Annual Benefit
Brewary	89	2,809	1,016	487	4,402
Ghutai Shela	132	0	82	34	248
Wali Dad	112	524	275	102	1,012
Dara	63	1,883	992	312	3,250
Murgi Kotal	153	1,430	1,027	370	2,982
Kach	112	2,123	4,632	829	7,759
Jigda	40	484	2,283	235	3,042
Sanzali	13	112	955	117	1,198
Arambi (Ghazlona)	86	274	495	103	957
Arambi (Samaki)	64	64	203	38	369
Sakhol	190	386	536	419	1,532
Mangi	292	3,099	2,174	1,395	4,960
Kad Kocha II	238	2,563	1,014	681	4,496
Iskalkoo	53	137	384	87	662

Source: JICA Study Team

The Net Present Value (NPV) and Benefit Cost (B/C) Ratio and Economic Internal Rate of Return (EIRR) are calculated on the assumptions mentioned above, making cash flow of the scheme at the social discount rate of 10 %. As a key economic indicator, EIRR on each proposed DAD scheme as well as the rank by EIRR is shown in the following table.

Economic Internal Rate of Return and Its Rank of the Proposed DADs

DAD	B/C Ratio	Rank
Brewary	22.5 %	1
Ghutai Shela	0.1 %	14
Wali Dad	0.9 %	11
Dara	8.6 %	5
Murgi Kotal	4.6 %	8
Kach	6.3 %	6
Jigda	10.8 %	4
Sanzali	0.3 %	12
Arambi (Ghazlona)	6.3 %	7
Arambi (Samaki)	0.2 %	13
Sakhol	4.0 %	9
Mangi	15.9 %	3
Kad Kocha II	17.4 %	2
Iskalkoo	2.4 %	10

Source: JICA Study Team

Brewary DAD shows the highest EIRR value at 22.5 %, followed by Kad Kocha II at 17.4 %, Mangi at 15.9 % and Jigda at 10.8 %. The EIRR values of the other 10 DADs are lower than the social discount rate of 10 %. In other words, the NPVs of them become minus at the discount rate. The DADs of Iskalkoo, Wali Dad, Sanzali, Samaki and Ghutai Shela are less advantageous in terms of economic efficiency.

(8) Sensitivity analysis

The sensitivity analysis is done in order to evaluate soundness of the project against possible adverse change in the future. The 3 cases; 1) project cost overrun by 20 %, 2) benefit decrease by 20 % and 3) delay in construction for 1 years, are analyzed as shown in the following table.

Sensitivity Analysis of the Proposed DADs (EIRR Value)

DAD	Cost overrun by 20%	Benefit decrease by 20%	Construction delay for 1 years
Brewary	18.7 %	17.9 %	20.4%
Ghutai Shela	-0.7 %	-1.7 %	0.1 %
Wali Dad	0.0 %	-0.4 %	0.9 %
Dara	6.9 %	6.4 %	8.1 %
Murgi Kotal	3.3 %	2.9 %	4.5 %
Kach	4.1 %	3.5 %	5.9 %
Jigda	8.8 %	8.1 %	10.2 %
Sanzali	-1.1 %	-1.7 %	0.3 %
Arambi (Ghazlona)	4.9 %	4.3 %	6.0 %
Arambi (Samaki)	-0.7 %	-1.3 %	0.2 %
Sakhol	2.8 %	2.2 %	3.8 %
Mangi	13.2 %	12.5 %	14.8 %
Kad Kocha II	14.5 %	13.6 %	16.1 %
Iskalkoo	1.4 %	0.9 %	2.3 %

Source: JICA Study Team

8.3 Impact on Farm Economy

The financial analysis on the farm economy is made for the evaluation of the impact of the project implementation to the farm income in the beneficial area. The typical farmers to be analyze are; 1) small-scale fruit producer and 2) medium-scale cereal producer. As a result, fruit producer, even small-scale farmer, is expected to get greater profit than cereal producer.

In addition, the comparative study of the small-scale cereal producer is made in cases of; 3a) no change in cropping pattern, 3b) introducing vegetables, and 3c) introducing fruit crops in future. The following table shows that the incremental annual income under the project increase from Rs. 7,100 in the case 3a to Rs. 53,200 in the case 3b, and eventually to Rs. 150,000 in the case 3c. Thus, when the recommended effort toward improvement of cropping is made together with the DAD construction, the additive effects by combining them is significantly expected especially in less-developed farmers.

Financial Impact on Farm Economy

Type of Farmer (Scale/Cropping System)	Cropping Pattern (Cereal:Fruit:Vegetable, %) With Project	Without Project	Incremental Farm Income (Rs./year)
No change in Cropping Pattern			
1 Small Fruits Producer (2 ha)	10:70:20	10:70:20	51,500
2 Medium Cereal Producer (6 ha)	80:10:10	80:10:10	33,300
Change in Cropping Pattern			
3a Small Cereal Producer (2 ha)	80:00:20	80:00:20	7,100
3b Small Cereal Producer (2 ha)	30:00:70	80:00:20	53,200
3c Small Cereal Producer (2 ha)	30:60:10	80:00:20	150,000

Source: JICA Study Team

8.4 Social Soundness

The benefit from the groundwater recharge accelerated by DAD construction can be given into the beneficiaries without any additional expense to construction and O&M works on the DAD. The Project itself does not make the people change their water use custom, farming practices and social structure. Further, the negative impact in social aspects, such as inundation of house or farm land, is expected to be negligible. Therefore, the Project might be acceptable to the all people who desire security of their water resources.

The interview survey on the opinion to the DAD plan at the sites shows that almost all beneficiaries wish the plan and are willing to participate or cooperate in the planning, construction and O&M of the schemes. Although a few people offered the opinions on the

security and function of the DAD itself, the explanation and discussion on the technical matters in planning and design will help mutual understanding.

In conclusion, the Project is judged to be socially sound due to its function of conservation of the groundwater resources and social structure. The necessity and anxiousness of the water conservation might push the plan toward immediate implementation even if the economic feasibility of the project is relatively low.

8.5 Environmental Consideration

The IEE was executed in the proposed DAD sites, in order to identify whether each DAD project is likely to cause an adverse environmental impacts which are not able to mitigate by means of any conservation measures, and to proceed the EIA. Prior to the IEE, environmental issues described in the Environmental Impact Assessment Guidelines published by Government of Pakistan were consulted, and then environmental issues covered by the IEE were selected through the discussion among the administrative institutions related to environment issues. In the scoping processes, the characteristics of physical environment under very serious climate of arid and semi-arid, of biotic environment of lost bio-diversity and ecosystem, of human environment in complicated social community comprised of many tribes, and also of peculiarity of objective structure of DAD, was considered.

The selected environmental items are as follows:

1) Physical Environment
   Land Use, Soil Erosion, Soil Salinity, Soil Contamination, Surface Water Availability, Groundwater Availability, Groundwater Level, Groundwater Quality, Flooding, Siltation, River Morphology
2) Biotic Environment
   Fauna Community/Habits, Vegetation
3) Human Environment
   Settlement, Resettlement, Social Equity, Lifestyle, Health, Population Growth Population Structure, Income, Employment, Water Right, Institutional Activities, Historic Sites, Cultivation, Livestock, Domestic Water Supply

Although the results of the IEE revealed that there were some potential negative impacts, EIA was not required, because the negative impacts were permissible magnitude, extent and frequency.

8.6 Project Implementation Plan

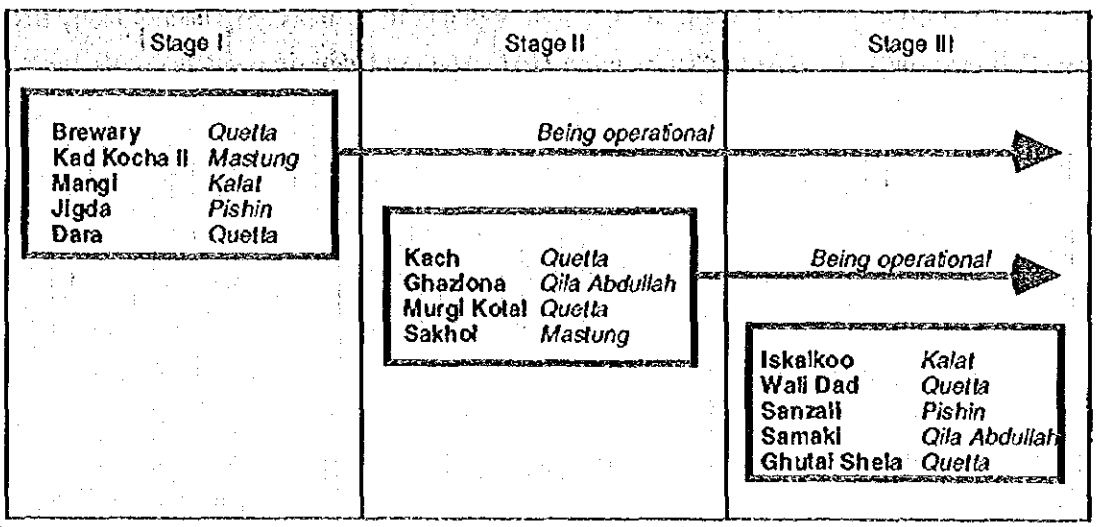
The economic evaluation of each scheme shows a wide range from highly feasible DADs with above EIRR of 10 % to low priority DADs with below EIRR of 5 %. Within the low-priority DADs, however, there exists some DADs having considerable importance in exhibition, social impact or environmental conservation. In this Study, the 14 DADs is classified into 3 groups in consideration of the economic indicator and balance of location, as follows:

Group I High priority DADs with high economic feasibility and high status as a model. Immediate implementation is recommended.

Group II Middle DAD class in economic viability. Implementation is recommended from a viewpoint of medium term development.

Group III Lower priority DADs with possible effect on groundwater basin. Implementation is conditionally recommended from a viewpoint of long term aspect on groundwater conservation.

The Study recommends the stage-wide implementation of the DAD schemes due to capability of implementation agency and additive effects obtained by some DADs. The 3 stages is set for each DAD group above. The project implementation plan is concluded as follows:



Project Implementation Plan

Along with the implementation plan, the integrated scale, benefit and economic efficiency of the DAD groups are analyzed, assuming group I is implemented in the first year, group II in the second year and group III in the third year. When the project achieves at the end of the stage I, the 5 DADs accelerate groundwater recharge at 3.0 MCM/year benefiting Rs. 22.2 million per year. The implementation of group I is judged to be highly feasible due to the integrated EIRR

of the stage I of 14.5 % as well as necessity and anxiousness. As progressing to stage II, the integrated EIRR decreases to 10.2 %, which is still higher than opportunity cost of 10 %. The implementation of group I and II is also feasible in public investment. Eventually, the integrated IRR becomes 8.7 % at the end of the stage III. However, the social and environmental importance of the DADs leaves room for consideration toward implementation. If the construction of DADs of group II and III takes medium and long term, instead of continuous implementation within 3 years as this analysis, the economic indicator may become lower.

Accumulative Project Evaluation under Stage Wide Implementation

DAD	Stage I	Stage I & II	Stage I, II & III
Dam Site (Number)	5	9	14
Recharge Volume ('1000 cu.m/year)	3,028	4,924	5,466
Total Beneficiaries (person)	12,900	24,200	37,100
Irrigation Area (ha)	1,029	1,368	1,667
Financial Project Cost (Rs.'000) *	370,283	683,222	854,869
Annual Benefit (Rs.'000)	22,150	35,045	38,868
EIRR (%) **	14.5	10.2	8.7
NPV (Rs.'000) **	74,569	4,696	-36,210

Note: *) Based on Table 7.4.1.
**) Assuming implementation of group I is in the first year, group II and III are in the second year and third year, respectively.
Source: JICA Study Team

Table 8.2.1 Economic Project Cost of Each DAD

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAD	Brewary						Ghutai Shefa					
I Construction Cost of DAD*	46,159	2,642	1,476	22,302	19,740	40,249	13,854	536	1,037	3,803	8,475	12,562
A Direct Cost	36,490	2,083	1,278	17,519	15,604	31,804	10,951	425	898	2,928	6,700	9,921
1 Dam	26,401	1,573	886	13,274	10,668	22,881	6,609	230	530	1,536	4,313	6,047
2 Spillway	3,361	190	119	1,589	1,463	2,935	1,651	100	213	685	653	1,409
3 Intake Facility	180	5	3	46	126	168	1,048	34	21	281	712	973
4 Infiltration Facility	1,788	48	103	325	1,312	1,672	215	7	17	43	148	198
6 Rehabilitation of Karez	0	0	0	0	0	0	0	0	0	0	0	0
7 Temporary Works	4,760	272	167	2,285	2,035	4,148	1,428	55	117	382	874	1,294
B Indirect Cost	5,473	313	64	2,756	2,341	4,786	1,643	64	45	529	1,005	1,499
1 Administration Cost	1,824	104	64	876	780	1,590	548	21	45	146	335	496
2 Engineering Cost	3,649	209	0	1,880	1,560	3,196	1,095	43	0	383	670	1,003
C Physical Contingency	4,156	240	134	2,027	1,795	3,659	1,259	49	94	346	770	1,142
II Cost on Sedimentation (less)	24,054	1,377	769	11,622	10,286	20,974	7,963	309	596	2,186	4,872	8,774
III Economic Project Cost on OAD (III = I - II)						19,275						5,788
IV Annual O&M Cost	81	5	3	38	36	69	119	5	9	52	53	99

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAD	Wali Dad						Dara					
I Construction Cost of DAD*	43,606	2,050	668	17,782	23,106	39,077	74,458	2,002	4,422	13,593	54,443	69,585
A Direct Cost	34,471	1,621	578	14,007	18,265	30,886	58,860	1,582	3,828	10,412	43,038	54,968
1 Dam	10,153	607	340	5,121	4,085	8,795	34,690	1,008	2,494	6,580	24,608	32,203
2 Spillway	1,926	111	65	937	813	1,677	12,747	253	722	1,558	10,214	12,111
3 Intake Facility	16,880	871	49	6,000	10,159	15,419	2,983	94	58	788	2,043	2,772
4 Infiltration Facility	1,016	20	58	122	816	966	763	20	55	129	559	712
6 Rehabilitation of Karez	0	0	0	0	0	0	0	0	0	0	0	0
7 Temporary Works	4,496	211	75	1,827	2,382	4,029	7,677	206	499	1,358	5,614	7,170
B Indirect Cost	5,171	243	29	2,159	2,740	4,639	8,829	237	191	1,945	6,456	8,291
1 Administration Cost	1,724	81	29	700	913	1,544	2,943	79	191	521	2,152	2,748
2 Engineering Cost	3,447	162	0	1,459	1,827	3,095	5,886	158	0	1,424	4,304	5,543
C Physical Contingency	3,964	186	61	1,617	2,101	3,552	6,769	182	402	1,236	4,949	6,326
II Cost on Sedimentation (less)	10,778	507	165	4,395	5,711	9,535	40,283	1,083	2,392	7,354	29,454	35,852
III Economic Project Cost on OAD (III = I - II)						29,542						33,733
IV Annual O&M Cost	138	6	2	48	81	123	313	8	19	155	131	286

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAD	Murgi Kotal						Kech					
I Construction Cost of DAD*	66,479	1,729	3,605	11,955	49,191	62,295	140,391	4,919	7,935	36,332	91,206	128,765
A Direct Cost	52,553	1,367	3,121	9,179	38,886	49,212	110,991	3,888	6,870	28,123	72,099	101,719
1 Dam	34,277	874	2,263	5,608	25,534	32,108	67,378	1,902	4,754	12,368	48,354	62,679
2 Spillway	5,406	115	307	725	4,259	5,120	26,882	1,401	1,128	11,484	12,849	23,686
3 Intake Facility	5,432	187	109	1,574	3,562	5,013	1,761	54	37	452	1,218	1,639
4 Infiltration Facility	583	12	35	77	459	552	504	23	55	152	274	447
6 Rehabilitation of Karez	0	0	0	0	0	0	0	0	0	0	0	0
7 Temporary Works	6,855	178	407	1,197	5,072	6,419	14,476	507	896	3,668	9,404	13,268
B Indirect Cost	7,883	205	156	1,689	5,833	7,420	16,647	583	344	4,905	10,815	15,340
1 Administration Cost	2,628	68	156	459	1,944	2,451	5,549	194	344	1,406	3,605	5,086
2 Engineering Cost	5,255	137	0	1,230	3,889	4,959	11,098	389	0	3,499	7,210	10,254
C Physical Contingency	6,044	157	328	1,087	4,472	5,663	12,763	447	721	3,303	8,291	11,706
II Cost on Sedimentation (less)	16,322	424	885	2,935	12,077	14,630	51,271	1,796	2,898	13,268	33,308	44,851
III Economic Project Cost on DAD (III = I - II)						47,665						83,914
IV Annual O&M Cost	239	6	13	114	105	204	341	12	19	194	116	285

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAD	Jigda						Sanzali					
I Construction Cost of DAD*	41,856	1,484	2,121	11,233	27,018	38,381	49,216	2,273	4,544	15,912	26,497	43,740
A Direct Cost	33,088	1,173	1,837	8,720	21,358	30,322	38,906	1,797	3,934	12,237	20,938	34,536
1 Dam	16,015	474	1,149	3,115	11,277	14,849	17,319	553	1,316	3,651	11,799	15,961
2 Spillway	5,269	275	333	2,142	2,519	4,632	13,385	848	2,029	5,599	4,909	11,302
3 Intake Facility	3,594	114	71	951	2,458	3,339	770	27	18	223	505	711
4 Infiltration Facility	2,273	60	17	527	1,669	2,140	273	10	25	68	170	248
6 Rehabilitation of Karez	1,621	97	27	848	649	1,407	2,084	125	35	1,090	834	1,809
7 Temporary Works	4,316	153	240	1,137	2,786	3,955	5,075	234	513	1,596	2,731	4,505
B Indirect Cost	4,953	176	92	1,492	3,204	4,570	5,836	270	197	2,223	3,141	5,228
1 Administration Cost	1,654	59	92	436	1,068	1,516	1,945	90	197	612	1,047	1,727
2 Engineering Cost	3,309	117	0	1,056	2,136	3,054	3,891	180	0	1,617	2,094	3,501
C Physical Contingency	3,805	135	193	1,021	2,456	3,489	4,474	207	413	1,447	2,409	3,976
II Cost on Sedimentation (less)	15,124	536	766	4,059	9,762	13,293	22,818	1,054	2,107	7,377	12,280	18,698
III Economic Project Cost on DAD (III = I - II)						25,088						25,042
IV Annual O&M Cost	295	10	15	115	155	255	198	9	18	102	69	157

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAD	Arambi (Ghezlona)						Arambi (Semaki)					
I Construction Cost of DAD*	24,078	937	1,492	6,939	14,710	21,667	15,615	673	938	5,120	8,884	14,044
A Direct Cost	19,034	740	1,291	5,373	11,629	17,272	12,344	532	812	3,977	7,023	11,093
1 Dam	10,651	324	776	2,139	7,412	9,855	5,084	154	370	1,014	3,546	4,706
2 Spillway	4,913	285	316	2,252	2,060	4,256	4,913	285	316	2,252	2,060	4,256
3 Intake Facility	874	29	18	247	580	808	640	22	14	180	425	592
4 Infiltration Facility	113	5	13	35	60	100	97	2	6	13	76	92
6 Rehabilitation of Karez	0	0	0	0	0	0	0	0	0	0	0	0
7 Temporary Works	2,483	97	168	701	1,517	2,253	1,610	69	106	519	916	1,447
B Indirect Cost	2,855	111	65	935	1,744	2,607	1,852	80	41	678	1,053	1,674
1 Administration Cost	952	37	65	269	581	864	617	27	41	199	351	555
2 Engineering Cost	1,903	74	0	666	1,163	1,743	1,234	53	0	479	702	1,119
C Physical Contingency	2,189	85	136	631	1,337	1,988	1,420	61	85	465	808	1,277
II Cost on Sedimentation (less)	11,213	436	695	3,231	6,851	9,662	4,388	189	264	1,439	2,497	3,749
III Economic Project Cost on DAD (III = I - II)						12,295						10,295
IV Annual OAM Cost	143	6	9	74	55	119	119	5	7	54	53	100

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAD	Sekhot						Mangi					
I Construction Cost of DAD*	65,170	2,578	4,747	18,453	39,392	59,008	73,820	3,140	3,937	24,322	42,421	68,535
A Direct Cost	51,518	2,038	4,110	14,230	31,140	46,604	58,356	2,482	3,409	18,931	33,534	52,561
1 Dam	36,443	1,246	2,935	8,279	23,983	33,387	28,469	967	2,245	6,456	18,801	26,102
2 Spillway	5,441	381	583	2,844	1,633	4,545	12,621	760	526	6,317	5,018	10,908
3 Intake Facility	881	27	17	230	607	820	4,620	146	91	1,219	3,164	4,293
4 Infiltration Facility	102	2	6	12	82	97	462	8	23	48	323	392
6 Rehabilitation of Karez	1,931	116	33	1,009	773	1,676	4,632	278	79	2,421	1,854	4,020
7 Temporary Works	6,720	266	536	1,856	4,062	6,079	7,612	324	445	2,469	4,374	6,856
B Indirect Cost	7,728	306	206	2,546	4,671	7,040	8,753	372	170	3,189	5,030	7,925
1 Administration Cost	2,576	102	206	712	1,557	2,330	2,918	124	170	947	1,677	2,628
2 Engineering Cost	5,152	204	0	1,834	3,114	4,710	5,836	248	0	2,234	3,353	5,297
C Physical Contingency	5,925	234	432	1,678	3,581	5,384	6,711	285	358	2,211	3,856	6,049
II Cost on Sedimentation (less)	39,691	1,570	2,891	11,239	23,991	33,769	26,822	1,226	1,537	9,496	16,563	24,825
III Economic Project Cost on DAD (III = I - II)						25,239						41,710
IV Annual OAM Cost	328	13	24	207	84	264	382	16	20	178	167	322

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Economic Project Cost

Component	Financial Cost					Economic Cost	Financial Cost					Economic Cost
	Total Cost	Local Cost			Foreign Cost		Total Cost	Local Cost			Foreign Cost	
		Transfer Cost	Unskilled Labor	Other Cost				Transfer Cost	Unskilled Labor	Other Cost		
Conversion Factor		0.00	0.75	0.87	1.00			0.00	0.75	0.87	1.00	
Name of DAO	Kad Kocha II						Iskalkoo					
I Construction Cost of DAD*	60,259	2,382	4,311	17,123	36,443	54,573	22,370	1,053	1,768	7,709	11,840	19,874
A Direct Cost	47,635	1,883	3,733	13,211	28,809	43,102	17,684	832	1,531	5,961	9,360	15,694
1 Dam	30,779	1,038	2,397	6,929	20,417	28,243	6,432	196	474	1,288	4,474	5,950
2 Spillway	7,773	515	769	3,863	2,626	6,564	8,098	502	835	3,679	3,083	6,910
3 Intake Facility	2,375	74	45	617	1,639	2,210	715	24	15	200	476	661
4 Infiltration Facility	495	13	35	78	369	463	132	3	7	16	106	126
6 Rehabilitation of Karez	0	0	0	0	0	0	0	0	0	0	0	0
7 Temporary Works	6,213	246	487	1,723	3,758	5,622	2,307	109	200	777	1,221	2,047
B Indirect Cost	7,145	282	187	2,355	4,321	6,510	2,653	125	77	1,047	1,404	2,373
1 Administration Cost	2,382	94	187	661	1,440	2,155	884	42	77	298	468	785
2 Engineering Cost	4,764	188	0	1,694	2,881	4,355	1,769	83	0	749	936	1,588
C Physical Contingency	5,478	217	392	1,557	3,313	4,961	2,034	96	161	701	1,076	1,807
II Cost on Sedimentation (less)	35,938	1,420	2,571	10,212	21,734	30,618	6,856	323	542	2,363	3,629	5,695
III Economic Project Cost on DAD (III = I - II)						23,955						14,180
IV Annual O&M Cost	387	15	28	179	165	321	131	6	10	56	58	107

Note*: Excl. Erosion Contol Facility

Source: JICA Study Team

Table 8.2.2 Irrigation Area, Cropping Pattern and Economic Benefit

	Brewary	Ghutai Shola	Wali Dad	Dara	Murgi Kotal	Kach	Jigda	Sanzali	Arambi (Ghazlona)	Arambi (Samaki)	Sakhol	Mangi	Kad Kocha II	Iskalkoo
Net Benefit (Rs/ha, net)	99,426	63,420	63,601	73,251	94,361	81,037	62,005	38,770	96,416	50,364	36,074	35,817	91,653	40,996
Wheat	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940	20,940
Apple	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390	111,390
Onion	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970	42,970
Vegetable (Tomato)	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450	46,450
Fodder	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Cropping Pattern (ha)	188.9	38.7	67.9	135.0	129.2	140.5	69.4	22.9	70.0	51.1	60.0	349.2	351.9	73.6
Rabi	13.1	11.7	20.5	47.2	23.1	41.3	37.3	13.4	1.0	21.4	30.9	187.1	50.9	42.1
Wheat (Irrigated)	7.3	8.9	15.5	45.8	4.4	38.4	5.6	11.8	1.0	18.0	25.3	102.9	36.2	27.7
Barley	0.0	0.7	1.2	1.4	15.0	0.0	0.0	0.0	0.0	1.2	5.6	1.9	2.0	3.4
Cumin	0.0	0.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	67.3	0.0	4.3
R. Vegetables	3.3	1.0	1.8	0.0	0.5	2.9	26.1	1.6	0.0	0.5	0.0	1.9	7.1	0.4
R. Fodder	2.5	0.6	1.1	0.0	3.2	0.0	5.6	0.0	0.0	0.6	0.0	13.1	5.6	6.3
Kharif	175.8	27.0	47.4	87.8	106.1	99.2	32.1	9.5	69.0	29.7	29.1	162.1	301.0	31.5
Apple	51.0	8.1	14.2	48.3	62.5	60.5	11.2	0.0	33.1	5.3	0.0	6.5	165.8	7.5
Apricot	24.6	0.6	1.1	21.1	17.0	20.8	0.6	0.0	13.1	3.0	0.0	0.0	15.0	1.0
Grape	82.6	8.1	14.2	2.6	6.4	3.0	0.0	1.2	6.9	5.3	3.8	0.0	20.0	3.7
Cherry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Almond	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0
Onion	0.0	1.5	2.6	0.0	1.1	0.0	0.0	3.8	6.2	3.7	23.3	150.7	72.0	12.2
Potato	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	4.9	2.2	2.0	0.0	1.7	5.2
K. Vegetables	15.8	4.9	8.6	15.8	11.7	14.9	16.4	0.7	4.8	2.0	0.0	0.0	11.7	0.0
Melon	0.0	2.6	4.5	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	6.6	0.6
K. Fodder	1.8	0.9	1.6	0.0	7.4	0.0	3.9	0.0	0.0	0.8	0.0	4.9	6.5	1.3
Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	2.4	0.0	0.0	0.0	0.0
Net Cropped Area (ha)	188.0	40.5	70.9	133.0	113.0	136.0	56.0	21.0	69.0	53.0	60.0	349.0	303.0	74.6
Crop Intensity (%)	100%	96%	96%	102%	114%	103%	124%	109%	101%	96%	100%	100%	116%	99%

Note: Wheat=Wheat+Barley, Apple=Apple+Apricot+Grape+Cherry+Almond, Onon=Onion+Cumin+Tobacco, Vegetable=Vegetable+Potato+Melon

Source: JICA Study Team

Table 8.2.3 Groundwater and Economic Benefits of Each DAD

	Brewary	Ghutai Shela	Wali Dad	Dera	Murgi Kotal	Kach	Jigda	Sanzali	Arambi (Ghaziona)	Arambi (Samaki)	Sakhot	Mangi	Kad Kocha II	Iskalkoo
Recharge/Exploitation (%)	80.7%	80.7%	80.7%	80.7%	82.7%	80.7%	86.1%	86.1%	86.1%	86.1%	50.6%	68.4%	50.6%	81.6%
Recharge-Specified Area (m3)	306,100	15,000	82,700	233,700	188,600	407,400	84,100	34,000	41,400	17,000	98,400	654,800	305,300	32,100
Recharge-Unspecified Area (m3)	204,100	16,400	55,200	155,800	206,300	739,600	444,000	179,300	99,300	40,800	107,700	436,500	203,600	77,200
Available for Domestic Use (m3)	306,100	15,000	82,700	233,700	188,600	407,400	84,100	34,000	41,400	17,000	98,400	654,800	305,300	32,100
Domestic Use (m3)	10,144	15,000	12,680	7,185	17,428	12,680	4,566	1,522	9,741	7,306	21,637	33,218	27,047	6,044
Available for Irrigation Use (m3)	295,956	0	70,020	226,515	171,172	394,720	79,534	32,478	31,659	9,694	76,763	621,582	278,254	26,056
Irrigation Use (m3)	295,956	0	70,020	183,113	171,172	204,142	65,000	20,083	31,659	9,694	76,763	621,582	278,254	26,056
Unspecific Use (m3)	204,100	16,400	55,200	199,202	206,300	930,178	458,534	191,695	99,300	40,800	107,700	436,500	203,600	77,200
No. of Beneficiary	2,400	4,000	3,000	1,700	4,600	3,000	1,500	500	3,200	2,400	2,000	4,800	2,500	1,500
Population in Water Shortage	463	772	579	328	796	579	209	70	445	334	988	1,517	1,235	276
Unit Water Value (Rs/m3)	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
Unit Water Requirement (m3/md)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Water Requirement (m3)	10,144	16,907	12,680	7,185	17,428	12,680	4,566	1,522	9,741	7,306	21,637	33,218	27,047	6,044
Water Capacity (m3)	306,100	15,000	82,700	233,700	188,600	407,400	84,100	34,000	41,400	17,000	98,400	654,800	305,300	32,100
Water Use (m3)	10,144	15,000	12,680	7,185	17,428	12,680	4,566	1,522	9,741	7,306	21,637	33,218	27,047	6,044
Benefit on Domestic Water (Rs/year)	89,268	132,000	111,585	63,231	153,367	111,585	40,182	13,394	85,722	64,291	190,407	292,318	238,009	53,191
Net Irrigated Area (ha)	188.0	40.5	70.9	133.0	113.0	136.0	56.0	21.0	69.0	53.0	60.0	349.0	303.0	74.6
Max. Beneficial Area (ha)	36.3	7.8	13.7	25.7	19.5	26.2	7.8	2.9	9.6	7.4	29.6	110.3	149.7	13.7
Base Unit Water Requirement (m3/ha)	12,570	8,500	8,500	8,550	13,550	9,350	10,000	8,310	13,350	7,620	8,600	8,620	11,940	7,800
Unit Water Requirement (m3/ha)	10,475	8,500	8,500	7,125	11,292	7,792	8,333	6,925	11,125	7,620	7,167	7,183	9,950	7,800
Max. Water Requirement (m3)	380,243	66,300	116,450	183,113	220,188	204,142	65,000	20,083	106,800	56,388	212,133	792,322	1,489,515	105,860
Available Water (m3)	295,956	0	70,020	226,515	171,172	394,720	79,534	32,478	31,659	9,694	76,763	621,582	278,254	26,056
Water Use (m3)	295,956	0	70,020	183,113	171,172	204,142	65,000	20,083	31,659	9,694	76,763	621,582	278,254	26,056
Unit Benefit (Rs/ha)	99,426	63,420	63,601	73,251	94,361	81,037	82,005	38,770	96,416	50,364	36,074	35,817	91,653	40,996
Benefit on Crop Production (Rs/year)	2,809,132	0	523,922	1,882,546	1,430,432	2,123,179	463,641	112,433	274,376	64,073	386,390	3,099,318	2,563,082	136,945
Catchment Area (km2)	25.9	1.8	5.4	16.6	19.7	59.3	20.8	10.4	9.1	2.5	22.3	74.2	36.2	5.8
Unit Benefit (Rs/km2)	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800
Apportionment Ratio (%)	100%	100%	100%	100%	100%	80%	60%	60%	60%	80%	100%	100%	100%	80%
Benefit on Flood Mitigation (Rs/year)	486,920	33,840	101,520	312,080	370,360	891,872	234,624	117,312	102,648	37,600	419,240	1,394,960	680,560	87,232
Water-Unspecified Area (m3)	204,100	16,400	55,200	199,202	206,300	930,178	458,534	191,695	99,300	40,800	107,700	436,500	203,600	77,200
Unit Water Value (Rs/m3)	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98	4.98
Benefit on Unspecified Recharge (Rs/year)	1,016,418	81,672	274,896	992,027	1,027,374	4,632,288	2,283,499	954,643	494,514	203,184	536,346	2,173,770	1,013,928	384,456
Total Benefit (Rs/year)	4,401,738	247,512	1,011,923	3,249,084	2,981,533	7,758,924	3,041,945	1,197,782	957,260	369,149	1,532,383	6,960,366	4,495,579	661,824

Source: JICA Study Team

Table 8.2.4 Cash Flow of Each DAD and DAD Group

Brewary

Project Life (year)	40
Construction Cost (Rs)	19,275,000
Annual Benefit (Rs)	4,401,738
IRR (%)	22.47%
NPV (Rs., discount rate=10%)	24,908,681
B/C (Rs., discount rate=10%)	2.373

Year	Cost	Benefit	B-C
1	19,275,000		-19,275,000
2	69,000	4,401,738	4,332,738
3	69,000	4,401,738	4,332,738
4	69,000	4,401,738	4,332,738
5	69,000	4,401,738	4,332,738
6	69,000	4,401,738	4,332,738
7	69,000	4,401,738	4,332,738
8	69,000	4,401,738	4,332,738
9	69,000	4,401,738	4,332,738
10	69,000	4,401,738	4,332,738
11	69,000	4,401,738	4,332,738
12	69,000	4,401,738	4,332,738
13	69,000	4,401,738	4,332,738
14	69,000	4,401,738	4,332,738
15	69,000	4,401,738	4,332,738
16	69,000	4,401,738	4,332,738
17	69,000	4,401,738	4,332,738
18	69,000	4,401,738	4,332,738
19	69,000	4,401,738	4,332,738
20	69,000	4,401,738	4,332,738
21	69,000	4,401,738	4,332,738
22	69,000	4,401,738	4,332,738
23	69,000	4,401,738	4,332,738
24	69,000	4,401,738	4,332,738
25	69,000	4,401,738	4,332,738
26	69,000	4,401,738	4,332,738
27	69,000	4,401,738	4,332,738
28	69,000	4,401,738	4,332,738
29	69,000	4,401,738	4,332,738
30	69,000	4,401,738	4,332,738
31	69,000	4,401,738	4,332,738
32	69,000	4,401,738	4,332,738
33	69,000	4,401,738	4,332,738
34	69,000	4,401,738	4,332,738
35	69,000	4,401,738	4,332,738
36	69,000	4,401,738	4,332,738
37	69,000	4,401,738	4,332,738
38	69,000	4,401,738	4,332,738
39	69,000	4,401,738	4,332,738
40	69,000	4,401,738	4,332,738
41	69,000	4,401,738	4,332,738

Ghufal Shola

Project Life (year)	40
Construction Cost (Rs)	5,766,000
Annual Benefit (Rs)	247,512
IRR (%)	0.13%
NPV (Rs., discount rate=10%)	-5,721,500
B/C (Rs., discount rate=10%)	0.394

Year	Cost	Benefit	B-C
1	5,766,000		-5,766,000
2	99,000	247,512	148,512
3	99,000	247,512	148,512
4	99,000	247,512	148,512
5	99,000	247,512	148,512
6	99,000	247,512	148,512
7	99,000	247,512	148,512
8	99,000	247,512	148,512
9	99,000	247,512	148,512
10	99,000	247,512	148,512
11	99,000	247,512	148,512
12	99,000	247,512	148,512
13	99,000	247,512	148,512
14	99,000	247,512	148,512
15	99,000	247,512	148,512
16	99,000	247,512	148,512
17	99,000	247,512	148,512
18	99,000	247,512	148,512
19	99,000	247,512	148,512
20	99,000	247,512	148,512
21	99,000	247,512	148,512
22	99,000	247,512	148,512
23	99,000	247,512	148,512
24	99,000	247,512	148,512
25	99,000	247,512	148,512
26	99,000	247,512	148,512
27	99,000	247,512	148,512
28	99,000	247,512	148,512
29	99,000	247,512	148,512
30	99,000	247,512	148,512
31	99,000	247,512	148,512
32	99,000	247,512	148,512
33	99,000	247,512	148,512
34	99,000	247,512	148,512
35	99,000	247,512	148,512
36	99,000	247,512	148,512
37	99,000	247,512	148,512
38	99,000	247,512	148,512
39	99,000	247,512	148,512
40	99,000	247,512	148,512
41	99,000	247,512	148,512

Well Dad

Project Life (year)	40
Construction Cost (Rs)	29,542,000
Annual Benefit (Rs)	1,011,923
IRR (%)	0.94%
NPV (Rs., discount rate=10%)	-19,054,183
B/C (Rs., discount rate=10%)	0.356

Year	Cost	Benefit	B-C
1	29,542,000		-29,542,000
2	123,000	1,011,923	888,923
3	123,000	1,011,923	888,923
4	123,000	1,011,923	888,923
5	123,000	1,011,923	888,923
6	123,000	1,011,923	888,923
7	123,000	1,011,923	888,923
8	123,000	1,011,923	888,923
9	123,000	1,011,923	888,923
10	123,000	1,011,923	888,923
11	123,000	1,011,923	888,923
12	123,000	1,011,923	888,923
13	123,000	1,011,923	888,923
14	123,000	1,011,923	888,923
15	123,000	1,011,923	888,923
16	123,000	1,011,923	888,923
17	123,000	1,011,923	888,923
18	123,000	1,011,923	888,923
19	123,000	1,011,923	888,923
20	123,000	1,011,923	888,923
21	123,000	1,011,923	888,923
22	123,000	1,011,923	888,923
23	123,000	1,011,923	888,923
24	123,000	1,011,923	888,923
25	123,000	1,011,923	888,923
26	123,000	1,011,923	888,923
27	123,000	1,011,923	888,923
28	123,000	1,011,923	888,923
29	123,000	1,011,923	888,923
30	123,000	1,011,923	888,923
31	123,000	1,011,923	888,923
32	123,000	1,011,923	888,923
33	123,000	1,011,923	888,923
34	123,000	1,011,923	888,923
35	123,000	1,011,923	888,923
36	123,000	1,011,923	888,923
37	123,000	1,011,923	888,923
38	123,000	1,011,923	888,923
39	123,000	1,011,923	888,923
40	123,000	1,011,923	888,923
41	123,000	1,011,923	888,923

Dera

Project Life (year)	40
Construction Cost (Rs)	33,733,000
Annual Benefit (Rs)	3,249,884
IRR (%)	9.51%
NPV (Rs., discount rate=10%)	-1,250,337
B/C (Rs., discount rate=10%)	0.962

Year	Cost	Benefit	B-C
1	33,733,000		-33,733,000
2	266,000	3,249,884	2,983,884
3	266,000	3,249,884	2,983,884
4	266,000	3,249,884	2,983,884
5	266,000	3,249,884	2,983,884
6	266,000	3,249,884	2,983,884
7	266,000	3,249,884	2,983,884
8	266,000	3,249,884	2,983,884
9	266,000	3,249,884	2,983,884
10	266,000	3,249,884	2,983,884
11	266,000	3,249,884	2,983,884
12	266,000	3,249,884	2,983,884
13	266,000	3,249,884	2,983,884
14	266,000	3,249,884	2,983,884
15	266,000	3,249,884	2,983,884
16	266,000	3,249,884	2,983,884
17	266,000	3,249,884	2,983,884
18	266,000	3,249,884	2,983,884
19	266,000	3,249,884	2,983,884
20	266,000	3,249,884	2,983,884
21	266,000	3,249,884	2,983,884
22	266,000	3,249,884	2,983,884
23	266,000	3,249,884	2,983,884
24	266,000	3,249,884	2,983,884
25	266,000	3,249,884	2,983,884
26	266,000	3,249,884	2,983,884
27	266,000	3,249,884	2,983,884
28	266,000	3,249,884	2,983,884
29	266,000	3,249,884	2,983,884
30	266,000	3,249,884	2,983,884
31	266,000	3,249,884	2,983,884
32	266,000	3,249,884	2,983,884
33	266,000	3,249,884	2,983,884
34	266,000	3,249,884	2,983,884
35	266,000	3,249,884	2,983,884
36	266,000	3,249,884	2,983,884
37	266,000	3,249,884	2,983,884
38	266,000	3,249,884	2,983,884
39	266,000	3,249,884	2,983,884
40	266,000	3,249,884	2,983,884
41	266,000	3,249,884	2,983,884

Murghi Kotal

Project Life (year)	35
Construction Cost (Rs)	47,665,000
Annual Benefit (Rs)	2,981,533
IRR (%)	4.83%
NPV (Rs., discount rate=10%)	-18,365,998
B/C (Rs., discount rate=10%)	0.627

Year	Cost	Benefit	B-C
1	47,665,000		-47,665,000
2	204,000	2,981,533	2,777,533
3	204,000	2,981,533	2,777,533
4	204,000	2,981,533	2,777,533
5	204,000	2,981,533	2,777,533
6	204,000	2,981,533	2,777,533
7	204,000	2,981,533	2,777,533
8	204,000	2,981,533	2,777,533
9	204,000	2,981,533	2,777,533
10	204,000	2,981,533	2,777,533
11	204,000	2,981,533	2,777,533
12	204,000	2,981,533	2,777,533
13	204,000	2,981,533	2,777,533
14	204,000	2,981,533	2,777,533
15	204,000	2,981,533	2,777,533
16	204,000	2,981,533	2,777,533
17	204,000	2,981,533	2,777,533
18	204,000	2,981,533	2,777,533
19	204,000	2,981,533	2,777,533
20	204,000	2,981,533	2,777,533
21	204,000	2,981,533	2,777,533
22	204,000	2,981,533	2,777,533
23	204,000	2,981,533	2,777,533
24	204,000	2,981,533	2,777,533
25	204,000	2,981,533	2,777,533
26	204,000	2,981,533	2,777,533
27	204,000	2,981,533	2,777,533
28	204,000	2,981,533	2,777,533
29	204,000	2,981,533	2,777,533
30	204,000	2,981,533	2,777,533
31	204,000	2,981,533	2,777,533
32	204,000	2,981,533	2,777,533
33	204,000	2,981,533	2,777,533
34	204,000	2,981,533	2,777,533
35	204,000	2,981,533	2,777,533
36	204,000	2,981,533	2,777,533

Kach

Project Life (year)	20
Construction Cost (Rs)	83,914,000
Annual Benefit (Rs)	7,759,924
IRR (%)	8.26%
NPV (Rs., discount rate=10%)	-12,435,150
B/C (Rs., discount rate=10%)	0.842

Year	Cost	Benefit	B-C
1	83,914,000		-83,914,000
2	285,000	7,758,924	7,473,924
3	285,000	7,758,924	7,473,924
4	285,000	7,758,924	7,473,924
5	285,000	7,758,924	7,473,924
6	285,000	7,758,924	7,473,924
7	285,000	7,758,924	7,473,924
8	285,000	7,758,924	7,473,924
9	285,000	7,758,924	7,473,924
10	285,000	7,758,924	7,473,924
11	285,000	7,758,924	7,473,924
12	285,000	7,758,924	7,473,924
13	285,000	7,758,924	7,473,924
14	285,000	7,758,924	7,473,924
15	285,000	7,758,924	7,473,924
16	285,000	7,758,924	7,473,924
17	285,000	7,758,924	7,473,924
18	285,000	7,758,924	7,473,924
19	285,000	7,758,924	7,473,924
20	285,000	7,758,924	7,473,924
21	285,000	7,758,924	7,473,924

Jigde

Project Life (year)	35
Construction Cost (Rs)	25,089,000
Annual Benefit (Rs)	3,041,945
IRR (%)	10.80%
NPV (Rs., discount rate=10%)	4,294,039
B/C (Rs., discount rate=10%)	1.171

Year	Cost	Benefit	B-C
1	25,089,000		-25,089,000
2	255,000	3,041,945	2,786,945
3	255,000	3,041,945	2,786,945
4	255,000	3,041,945	2,786,945
5	255,000	3,041,945	2,786,945
6	255,000	3,041,945	2,786,945
7	255,000	3,041,945	2,786,945
8	255,000	3,041,945	2,786,945
9	255,000	3,041,945	2,786,945
10	255,000	3,041,945	2,786,945
11	255,000	3,041,945	2,786,945
12	255,000	3,041,945	2,786,945
13	255,000	3,041,945	2,786,945
14	255,000	3,041,945	2,786,945
15	255,000	3,041,945	2,786,945
16	255,000	3,041,945	2,786,945
17	255,000	3,041,945	2,786,945
18	255,000	3,041,945	2,786,945
19	255,000	3,041,945	2,786,945
20	255,000	3,041,945	2,786,945
21	255,000	3,041,945	2,786,945
22	255,000	3,041,945	2,786,945
23	255,000	3,041,945	2,786,945
24	255,000	3,041,945	2,786,945
25	255,000	3,041,945	2,786,945
26	255,000	3,041,945	2,786,945
27	255,000	3,041,945	2,786,945
28	255,000	3,041,945	2,786,945
29	255,000	3,041,945	2,786,945
30	255,000	3,041,945	2,786,945
31	255,000	3,041,945	2,786,945
32	255,000	3,041,945	2,786,945
33	255,000	3,041,945	2,786,945
34	255,000	3,041,945	2,786,945
35	255,000	3,041,945	2,786,945
36	255,000	3,041,945	2,786,945

Sanzali

Project Life (year)	25
Construction Cost (Rs)	25,042,000
Annual Benefit (Rs)	1,197,782
IRR (%)	0.30%
NPV (Rs., discount rate=10%)	-13,188,581
B/C (Rs., discount rate=10%)	0.452

Year	Cost	Benefit	B-C
1	25,042,000		-25,042,000
2	157,000	1,197,782	1,040,782
3	157,000	1,197,782	1,040,782
4	157,000	1,197,782	1,040,782
5	157,000	1,197,782	1,040,782
6	157,000	1,197,782	1,040,782
7	157,000	1,197,782	1,040,782
8	157,000	1,197,782	1,040,782
9	157,000	1,197,782	1,040,782
10	157,000	1,197,782	1,040,782
11	157,000	1,197,782	1,040,782
12	157,000	1,197,782	1,040,782
13	157,000	1,197,782	1,040,782
14	157,000	1,197,782	1,040,782
15	157,000	1,197,782	1,040,782
16	157,000	1,197,782	1,040,782
17	157,000	1,197,782	1,040,782
18	157,000	1,197,782	1,040,782
19	157,000	1,197,782	1,040,782
20	157,000	1,197,782	1,040,782
21	157,000	1,197,782	1,040,782
22	157,000	1,197,782	1,040,782
23	157,000	1,197,782	1,040,782
24	157,000	1,197,782	1,040,782
25	157,000	1,197,782	1,040,782
26	157,000	1,197,782	1,040,782

Arambi (Ghazlona)

Project Life (year)	40
Construction Cost (Rs)	12,205,000
Annual Benefit (Rs)	957,260
IRR (%)	6.24%
NPV (Rs., discount rate=10%)	-2,792,277
B-C (Rs., discount rate=10%)	0.770

Year	Cost	Benefit	B-C
1	12,205,000		-12,205,000
2	119,000	957,260	838,260
3	119,000	957,260	838,260
4	119,000	957,260	838,260
5	119,000	957,260	838,260
6	119,000	957,260	838,260
7	119,000	957,260	838,260
8	119,000	957,260	838,260
9	119,000	957,260	838,260
10	119,000	957,260	838,260
11	119,000	957,260	838,260
12	119,000	957,260	838,260
13	119,000	957,260	838,260
14	119,000	957,260	838,260
15	119,000	957,260	838,260
16	119,000	957,260	838,260
17	119,000	957,260	838,260
18	119,000	957,260	838,260
19	119,000	957,260	838,260
20	119,000	957,260	838,260
21	119,000	957,260	838,260
22	119,000	957,260	838,260
23	119,000	957,260	838,260
24	119,000	957,260	838,260
25	119,000	957,260	838,260
26	119,000	957,260	838,260
27	119,000	957,260	838,260
28	119,000	957,260	838,260
29	119,000	957,260	838,260
30	119,000	957,260	838,260
31	119,000	957,260	838,260
32	119,000	957,260	838,260
33	119,000	957,260	838,260
34	119,000	957,260	838,260
35	119,000	957,260	838,260
36	119,000	957,260	838,260
37	119,000	957,260	838,260
38	119,000	957,260	838,260
39	119,000	957,260	838,260
40	119,000	957,260	838,260
41	119,000	957,260	838,260

Arambi (Semaki)

Project Life (year)	40
Construction Cost (Rs)	10,295,000
Annual Benefit (Rs)	369,149
IRR (%)	0.22%
NPV (Rs., discount rate=10%)	-8,838,172
B-C (Rs., discount rate=10%)	0.353

Year	Cost	Benefit	B-C
1	10,295,000		-10,295,000
2	100,000	369,149	269,149
3	100,000	369,149	269,149
4	100,000	369,149	269,149
5	100,000	369,149	269,149
6	100,000	369,149	269,149
7	100,000	369,149	269,149
8	100,000	369,149	269,149
9	100,000	369,149	269,149
10	100,000	369,149	269,149
11	100,000	369,149	269,149
12	100,000	369,149	269,149
13	100,000	369,149	269,149
14	100,000	369,149	269,149
15	100,000	369,149	269,149
16	100,000	369,149	269,149
17	100,000	369,149	269,149
18	100,000	369,149	269,149
19	100,000	369,149	269,149
20	100,000	369,149	269,149
21	100,000	369,149	269,149
22	100,000	369,149	269,149
23	100,000	369,149	269,149
24	100,000	369,149	269,149
25	100,000	369,149	269,149
26	100,000	369,149	269,149
27	100,000	369,149	269,149
28	100,000	369,149	269,149
29	100,000	369,149	269,149
30	100,000	369,149	269,149
31	100,000	369,149	269,149
32	100,000	369,149	269,149
33	100,000	369,149	269,149
34	100,000	369,149	269,149
35	100,000	369,149	269,149
36	100,000	369,149	269,149
37	100,000	369,149	269,149
38	100,000	369,149	269,149
39	100,000	369,149	269,149
40	100,000	369,149	269,149
41	100,000	369,149	269,149

Sakhot

Project Life (year)	40
Construction Cost (Rs)	25,239,000
Annual Benefit (Rs)	1,532,383
IRR (%)	3.95%
NPV (Rs., discount rate=10%)	-10,306,265
B-C (Rs., discount rate=10%)	0.593

Year	Cost	Benefit	B-C
1	25,239,000		-25,239,000
2	264,000	1,532,383	1,268,383
3	264,000	1,532,383	1,268,383
4	264,000	1,532,383	1,268,383
5	264,000	1,532,383	1,268,383
6	264,000	1,532,383	1,268,383
7	264,000	1,532,383	1,268,383
8	264,000	1,532,383	1,268,383
9	264,000	1,532,383	1,268,383
10	264,000	1,532,383	1,268,383
11	264,000	1,532,383	1,268,383
12	264,000	1,532,383	1,268,383
13	264,000	1,532,383	1,268,383
14	264,000	1,532,383	1,268,383
15	264,000	1,532,383	1,268,383
16	264,000	1,532,383	1,268,383
17	264,000	1,532,383	1,268,383
18	264,000	1,532,383	1,268,383
19	264,000	1,532,383	1,268,383
20	264,000	1,532,383	1,268,383
21	264,000	1,532,383	1,268,383
22	264,000	1,532,383	1,268,383
23	264,000	1,532,383	1,268,383
24	264,000	1,532,383	1,268,383
25	264,000	1,532,383	1,268,383
26	264,000	1,532,383	1,268,383
27	264,000	1,532,383	1,268,383
28	264,000	1,532,383	1,268,383
29	264,000	1,532,383	1,268,383
30	264,000	1,532,383	1,268,383
31	264,000	1,532,383	1,268,383
32	264,000	1,532,383	1,268,383
33	264,000	1,532,383	1,268,383
34	264,000	1,532,383	1,268,383
35	264,000	1,532,383	1,268,383
36	264,000	1,532,383	1,268,383
37	264,000	1,532,383	1,268,383
38	264,000	1,532,383	1,268,383
39	264,000	1,532,383	1,268,383
40	264,000	1,532,383	1,268,383
41	264,000	1,532,383	1,268,383

Mangi

Project Life (year)	40
Construction Cost (Rs)	41,710,000
Annual Benefit (Rs)	6,960,366
IRR (%)	15.87%
NPV (Rs., discount rate=10%)	27,284,934
B-C (Rs., discount rate=10%)	1.669

Year	Cost	Benefit	B-C
1	41,710,000		-41,710,000
2	322,000	6,960,366	6,638,366
3	322,000	6,960,366	6,638,366
4	322,000	6,960,366	6,638,366
5	322,000	6,960,366	6,638,366
6	322,000	6,960,366	6,638,366
7	322,000	6,960,366	6,638,366
8	322,000	6,960,366	6,638,366
9	322,000	6,960,366	6,638,366
10	322,000	6,960,366	6,638,366
11	322,000	6,960,366	6,638,366
12	322,000	6,960,366	6,638,366
13	322,000	6,960,366	6,638,366
14	322,000	6,960,366	6,638,366
15	322,000	6,960,366	6,638,366
16	322,000	6,960,366	6,638,366
17	322,000	6,960,366	6,638,366
18	322,000	6,960,366	6,638,366
19	322,000	6,960,366	6,638,366
20	322,000	6,960,366	6,638,366
21	322,000	6,960,366	6,638,366
22	322,000	6,960,366	6,638,366
23	322,000	6,960,366	6,638,366
24	322,000	6,960,366	6,638,366
25	322,000	6,960,366	6,638,366
26	322,000	6,960,366	6,638,366
27	322,000	6,960,366	6,638,366
28	322,000	6,960,366	6,638,366
29	322,000	6,960,366	6,638,366
30	322,000	6,960,366	6,638,366
31	322,000	6,960,366	6,638,366
32	322,000	6,960,366	6,638,366
33	322,000	6,960,366	6,638,366
34	322,000	6,960,366	6,638,366
35	322,000	6,960,366	6,638,366
36	322,000	6,960,366	6,638,366
37	322,000	6,960,366	6,638,366
38	322,000	6,960,366	6,638,366
39	322,000	6,960,366	6,638,366
40	322,000	6,960,366	6,638,366
41	322,000	6,960,366	6,638,366

Kad Kocha B

Project Life (year)	40
Construction Cost (Rs)	23,955,000
Annual Benefit (Rs)	4,495,579
IRR (%)	17.40%
NPV (Rs., discount rate=10%)	18,331,521
B-C (Rs., discount rate=10%)	1.765

Year	Cost	Benefit	B-C
1	23,955,000		-23,955,000
2	321,000	4,495,579	4,174,579
3	321,000	4,495,579	4,174,579
4	321,000	4,495,579	4,174,579
5	321,000	4,495,579	4,174,579
6	321,000	4,495,579	4,174,579
7	321,000	4,495,579	4,174,579
8	321,000	4,495,579	4,174,579
9	321,000	4,495,579	4,174,579
10	321,000	4,495,579	4,174,579
11	321,000	4,495,579	4,174,579
12	321,000	4,495,579	4,174,579
13	321,000	4,495,579	4,174,579
14	321,000	4,495,579	4,174,579
15	321,000	4,495,579	4,174,579
16	321,000	4,495,579	4,174,579
17	321,000	4,495,579	4,174,579
18	321,000	4,495,579	4,174,579
19	321,000	4,495,579	4,174,579
20	321,000	4,495,579	4,174,579
21	321,000	4,495,579	4,174,579
22	321,000	4,495,579	4,174,579
23	321,000	4,495,579	4,174,579
24	321,000	4,495,579	4,174,579
25	321,000	4,495,579	4,174,579
26	321,000	4,495,579	4,174,579
27	321,000	4,495,579	4,174,579
28	321,000	4,495,579	4,174,579
29	321,000	4,495,579	4,174,579
30	321,000	4,495,579	4,174,579
31	321,000	4,495,579	4,174,579
32	321,000	4,495,579	4,174,579
33	321,000	4,495,579	4,174,579
34	321,000	4,495,579	4,174,579
35	321,000	4,495,579	4,174,579
36	321,000	4,495,579	4,174,579
37	321,000	4,495,579	4,174,579
38	321,000	4,495,579	4,174,579
39	321,000	4,495,579	4,174,579
40	321,000	4,495,579	4,174,579
41	321,000	4,495,579	4,174,579

Ishaikoo

Project Life (year)	40
Construction Cost (Rs)	14,189,000
Annual Benefit (Rs)	661,824
IRR (%)	2.39%
NPV (Rs., discount rate=10%)	-7,376,314
B-C (Rs., discount rate=10%)	0.467

Year	Cost	Benefit	B-C
1	14,189,000		-14,189,000
2	107,000	661,824	554,824
3	107,000	661,824	554,824
4	107,000	661,824	554,824
5	107,000	661,824	554,824
6	107,000	661,824	554,824
7	107,000	661,824	554,824
8	107,000	661,824	554,824
9	107,000	661,824	554,824
10	107,000	661,824	554,824
11	107,000	661,824	554,824
12	107,000	661,824	554,824
13	107,000	661,824	554,824
14	107,000	661,824	554,824
15	107,000	661,824	554,824
16	107,000	661,824	554,824
17	107,000	661,824	554,824
18	107,000	661,824	554,824
19	107,000	661,824	554,824
20	107,000	661,824	554,824
21	107,000	661,824	554,824
22	107,000	661,824	554,824
23	107,000	661,824	554,824
24	107,000	661,824	554,824
25	107,000	661,824	554,824
26	107,000	661,824	554,824
27	107,000	661,824	554,824
28	107,000	661,824	554,824
29	107,000	661,824	554,824
30	107,000	661,824	554,824
31	107,000	661,824	554,824
32	107,000	661,824	554,824
33	107,000	661,824	554,824
34	107,000	661,824	554,824
35	107,000	661,824	554,824
36	107,000	661,824	554,824
37	107,000	661,824	554,824
38	107,000	661,824	554,824
39	107,000	661,824	554,824
40	107,000	661,824	554,824
41	107,000	661,824	554,824

Group I

Beasary, Cera, Jogia, Mangi, KadKocha II

Project Life (year)	40
Construction Cost (Rs)	143,761,000
Annual Benefit (Rs)	22,149,513
IRR (%)	14.48%
NPV (Rs., discount rate=10%)	74,565,896
B/C (Rs., discount rate=10%)	1.527

Year	Cost	Benefit	B-C
1	143,761,000		-143,761,000
2	1,233,000	22,149,513	20,916,513
3	1,233,000	22,149,513	20,916,513
4	1,233,000	22,149,513	20,916,513
5	1,233,000	22,149,513	20,916,513
6	1,233,000	22,149,513	20,916,513
7	1,233,000	22,149,513	20,916,513
8	1,233,000	22,149,513	20,916,513
9	1,233,000	22,149,513	20,916,513
10	1,233,000	22,149,513	20,916,513
11	1,233,000	22,149,513	20,916,513
12	1,233,000	22,149,513	20,916,513
13	1,233,000	22,149,513	20,916,513
14	1,233,000	22,149,513	20,916,513
15	1,233,000	22,149,513	20,916,513
16	1,233,000	22,149,513	20,916,513
17	1,233,000	22,149,513	20,916,513
18	1,233,000	22,149,513	20,916,513
19	1,233,000	22,149,513	20,916,513
20	1,233,000	22,149,513	20,916,513
21	1,233,000	22,149,513	20,916,513
22	1,233,000	22,149,513	20,916,513
23	1,233,000	22,149,513	20,916,513
24	1,233,000	22,149,513	20,916,513
25	1,233,000	22,149,513	20,916,513
26	1,233,000	22,149,513	20,916,513
27	1,233,000	22,149,513	20,916,513
28	1,233,000	22,149,513	20,916,513
29	1,233,000	22,149,513	20,916,513
30	1,233,000	22,149,513	20,916,513
31	1,233,000	22,149,513	20,916,513
32	1,233,000	22,149,513	20,916,513
33	1,233,000	22,149,513	20,916,513
34	1,233,000	22,149,513	20,916,513
35	1,233,000	22,149,513	20,916,513
36	1,233,000	22,149,513	20,916,513
37	978,000	19,107,567	18,129,567
38	978,000	19,107,567	18,129,567
39	978,000	19,107,567	18,129,567
40	978,000	19,107,567	18,129,567
41	978,000	19,107,567	18,129,567

Group II

Murgi Kotal, Kach, Sanzal, Ghazlora

Project Life (year)	41
Construction Cost (Rs)	312,567,000
Annual Benefit (Rs)	35,045,011
IRR (%)	10.21%
NPV (Rs., discount rate=10%)	4,606,418
B/C (Rs., discount rate=10%)	1.016

Year	Cost	Benefit	B-C
1	143,761,000	0	-143,761,000
2	170,059,000	22,149,513	-147,909,487
3	1,998,000	35,045,011	33,047,011
4	1,998,000	35,045,011	33,047,011
5	1,998,000	35,045,011	33,047,011
6	1,998,000	35,045,011	33,047,011
7	1,998,000	35,045,011	33,047,011
8	1,998,000	35,045,011	33,047,011
9	1,998,000	35,045,011	33,047,011
10	1,998,000	35,045,011	33,047,011
11	1,998,000	35,045,011	33,047,011
12	1,998,000	35,045,011	33,047,011
13	1,998,000	35,045,011	33,047,011
14	1,998,000	35,045,011	33,047,011
15	1,998,000	35,045,011	33,047,011
16	1,998,000	35,045,011	33,047,011
17	1,998,000	35,045,011	33,047,011
18	1,998,000	35,045,011	33,047,011
19	1,998,000	35,045,011	33,047,011
20	1,998,000	35,045,011	33,047,011
21	1,998,000	35,045,011	33,047,011
22	1,998,000	35,045,011	33,047,011
23	1,713,000	27,286,087	25,573,087
24	1,713,000	27,286,087	25,573,087
25	1,713,000	27,286,087	25,573,087
26	1,713,000	27,286,087	25,573,087
27	1,713,000	27,286,087	25,573,087
28	1,556,000	26,088,305	24,532,305
29	1,556,000	26,088,305	24,532,305
30	1,556,000	26,088,305	24,532,305
31	1,556,000	26,088,305	24,532,305
32	1,556,000	26,088,305	24,532,305
33	1,556,000	26,088,305	24,532,305
34	1,556,000	26,088,305	24,532,305
35	1,556,000	26,088,305	24,532,305
36	1,556,000	26,088,305	24,532,305
37	1,301,000	23,046,360	21,745,360
38	1,097,000	20,064,827	18,967,827
39	1,097,000	20,064,827	18,967,827
40	1,097,000	20,064,827	18,967,827
41	1,097,000	20,064,827	18,967,827
42	118,000	957,280	838,280

Group III

Project Life (year)	42
Construction Cost (Rs)	997,640,000
Annual Benefit (Rs)	38,887,802
IRR (%)	8.69%
NPV (Rs., discount rate=10%)	-36,210,126
B/C (Rs., discount rate=10%)	0.888

Year	Cost	Benefit	B-C
1	143,761,000	0	-143,761,000
2	170,059,000	22,149,513	-147,909,487
3	97,051,000	35,045,011	-52,005,989
4	2,691,000	38,867,802	36,176,802
5	2,691,000	38,867,802	36,176,802
6	2,691,000	38,867,802	36,176,802
7	2,691,000	38,867,802	36,176,802
8	2,691,000	38,867,802	36,176,802
9	2,691,000	38,867,802	36,176,802
10	2,691,000	38,867,802	36,176,802
11	2,691,000	38,867,802	36,176,802
12	2,691,000	38,867,802	36,176,802
13	2,691,000	38,867,802	36,176,802
14	2,691,000	38,867,802	36,176,802
15	2,691,000	38,867,802	36,176,802
16	2,691,000	38,867,802	36,176,802
17	2,691,000	38,867,802	36,176,802
18	2,691,000	38,867,802	36,176,802
19	2,691,000	38,867,802	36,176,802
20	2,691,000	38,867,802	36,176,802
21	2,691,000	38,867,802	36,176,802
22	2,691,000	38,867,802	36,176,802
23	2,406,000	31,108,878	28,702,878
24	2,406,000	31,108,878	28,702,878
25	2,406,000	31,108,878	28,702,878
26	2,406,000	31,108,878	28,702,878
27	2,406,000	31,108,878	28,702,878
28	2,249,000	29,911,096	27,662,096
29	2,249,000	29,911,096	27,662,096
30	2,249,000	29,911,096	27,662,096
31	2,249,000	29,911,096	27,662,096
32	2,249,000	29,911,096	27,662,096
33	2,249,000	29,911,096	27,662,096
34	2,249,000	29,911,096	27,662,096
35	2,249,000	29,911,096	27,662,096
36	2,249,000	29,911,096	27,662,096
37	1,994,000	26,869,151	24,875,151
38	1,793,000	23,887,618	22,097,618
39	1,793,000	23,887,618	22,097,618
40	1,793,000	23,887,618	22,097,618
41	1,793,000	23,887,618	22,097,618
42	812,000	4,780,051	3,968,051
43	693,000	3,822,791	3,129,791

Table 8.2.5 Summary of Economic Analysis of Each DAD and DAD Group

	Brewary	Ghutai Shela	Wali Dad	Dara	Murgi Kotal	Kach	Jigda	Sanzali	Arambi, Ghazlona	Arambi, Samaki	Sakhol	Mangi	Kad Kocha	Iskalkoo	Stage I	Stage II	Stage III
Group		III	III		II	II		II	II	III	III		II	III		II	III
Annual Recharge Volume by DAD ('000cu.m)	510	31	138	390	395	1,147	528	213	141	58	206	1,091	509	109	3,028	4,924	5,466
Rank-Recharge	4	14	11	7	6	1	3	8	10	13	9	2	5	12			
Total Population at the Specified Beneficiary Area	2,400	4,000	3,000	1,700	4,600	3,000	1,500	500	3,200	2,400	2,000	4,800	2,500	1,500	12,900	24,200	37,100
Rank-Population	8	3	5	11	2	5	12	14	4	8	10	1	7	12			
Total Irrigation Area at the Specified Beneficiary Area (ha)	188	41	71	133	113	136	56	21	69	53	60	349	303	75	1,029	1,368	1,667
Rank-Area	3	13	8	5	6	4	11	14	9	12	10	1	2	7			
Total Benefit (Rs.'000/year)	4,402	248	1,012	3,250	2,982	7,759	3,042	1,198	957	369	1,532	6,960	4,496	662	22,150	35,045	38,868
Rank-Benefit	4	14	10	5	7	1	6	9	11	13	8	2	3	12			
Domestic Water Benefit (Rs.'000/year)	89	132	112	63	153	112	40	13	86	64	190	292	238	53	723	1,087	1,639
Rank-Domestic	8	5	6	11	4	6	13	14	9	10	3	1	2	12			
Irrigation Benefit (Rs.'000/year)	2,809	0	524	1,883	1,430	2,123	484	112	274	64	386	3,099	2,563	137	10,838	14,778	15,889
Rank-Irrigation	2	14	7	5	6	4	8	12	10	13	9	1	3	11			
Flood Control Benefit (Rs.'000/year)	487	34	102	312	370	892	235	117	103	38	419	1,395	681	87	3,109	4,591	5,271
Rank-Flood	4	14	11	7	6	2	8	9	10	13	5	1	3	12			
Unspecified Benefit (Rs.'000/year)	1,016	82	275	992	1,027	4,632	2,283	955	495	203	536	2,174	1,014	384	7,480	14,588	16,069
Rank-Unspecified	5	14	12	7	4	1	2	8	10	13	9	3	6	11			
Total Construction Cost, Financial (Rs.'000)	49,668	14,785	46,697	85,726	75,474	151,905	91,739	57,209	28,351	16,688	69,522	78,869	64,281	23,955	370,283	683,222	854,869
Rank-F. Cost	6	1	5	12	10	14	13	7	4	2	9	11	8	3			
Project Cost, Economic (Rs.'000)	19,275	5,788	29,542	33,733	47,665	83,914	25,088	25,042	12,205	10,295	25,239	41,710	23,955	14,189	143,761	312,587	397,640
Rank-E. Cost	5	1	10	11	13	14	8	7	3	2	9	12	6	4			
EIRR	22.5%	0.1%	0.9%	8.5%	4.6%	6.3%	10.8%	0.3%	6.3%	0.2%	4.0%	15.9%	17.4%	2.4%	14.5%	10.2%	8.7%
Rank-EIRR	1	14	11	5	8	6	4	12	7	13	9	3	2	10			
NPV (Rs.'000)	24,909	-3,722	-18,054	-1,250	-16,366	-12,435	4,294	-13,189	-2,792	-6,638	-10,306	27,285	19,332	-7,378	74,569	4,696	-36,210
Rank-NPV	2	7	14	5	13	11	4	12	6	8	10	1	3	9			
B/C	2.373	0.394	0.354	0.962	0.637	0.842	1.171	0.452	0.770	0.352	0.593	1.669	1.785	0	1.527	1.016	0.898
Rank-B/C	1	12	13	5	8	6	4	11	7	14	9	3	2	10			

Source: JICA Study Team