5. *IMPROVEMENT CONCEPT OF PLANNIG, DESIGN AND CONSTRUCTION OF DELAY ACTION DAMS*

5.1 Groundwater Recharge Device

Groundwater recharge process is categorized in a gravitative infiltration recharge of the precipitation through original ground and river bed, and an artificial recharge through recharge devices such as infiltration well and pond. Gravitative recharge is quantitatively less expected because of small precipitation of 230 mm per annum in and around the Study Area. River run-off does not contribute to groundwater recharge due to its short duration, in addition the severe surface erosion caused by floods devastated the groundwater conservation conditions in the drainage area. Consequently, artificial recharge devices especially delay action dams have been practicably constructed in the Study Area. As described above, several recharge devices, infiltration wells and ponds have been introduced to accelerate the groundwater recharge. Delay action dams are mostly practicable among these devices taking account of the hydrological, socio-economical situation in the Study Area and readiness of the operation and maintenance (O&M) activities of the recharge devices. The comparisons of these devices are detailed in the table below:

Features of Recharge Devices

Items	Descriptions	Infiltration well	Infiltration pond	Delay action dam
Hydrological condition	River run-off continues in short duration, immediately after rainfall.	Perennial run-off is necessary to quantitatively accelerate groundwater recharge. Infiltration well is not recommended due to short duration of run-off in the Study Area.	Storage facilities such as reservoir are necessary to continuously divert water to infiltration pond. In the case of river run-off, recharge quantity is limited due to short duration of run-off.	Flood is stored in the reservoir. Most of river run-off is effectively infiltrated into ground when reservoir capacity is sufficient.
		poor	poor	good
	Alluvial fan is composed of river deposits. Recharge is accelerated through alluvial fan located upstream of beneficial area. Movement of water course and aggradation/ degradation of river bed levels are induced by debris flow.	When water is diverted from river, intake shall be constructed at where a stream is in stable. Most of the rivers are not in a regime in the Study Area.	Infiltration pond is constructed on permeable foundation. In the case that the pond is constructed on the alluvial fan, certain countermeasures are required to prevent flood damages such as scouring and silting.	Reservoir operation is unrelated to aggradation and degradation of river bed levels. However, it is necessary to allocate sediment volume in the total storage capacity of the reservoir.
		poor	fair	good
O&M	Because river flow contains fine materials, silt and clay, recharge capacity of foundation may be gradually reduced due to clogging.	Inflow of fine particles shall be controlled. It is difficult to remove fine materials because of its structure.	Silting is developed on the pond surface. Fine materials shall be periodically removed, and filter materials shall be replaced by machinery.	Sediment is accumulated in the reservoir. Accordingly, recharge device is constructed downstream of the reservoir. Proper O&M works are required for the dam and its appurtenant structures.
		poor	fair	good
Construction	Design and construction of structures	There are many achievements on infiltration wells construction.	Most of the works are leveling works. There is no difficulty on design and construction.	There are many achievements on dam construction. Technical study is required for the dams of their height of more than 15m.
		good	good	good

Items	Descriptions	Infiltration well	Infiltration pond	Delay action dam
Regional characteristics	Recharge volume depends on river run-off. Project implementation is determined by availability of the structures.	In the case that storage facility is not constructed, infiltration wells shall be constructed at where a stream is perennially observed. Hanna river area(*1) in the east of Quetta is solely proposed in the Study Area.	Most of rivers are dry up during the dry season. Storage facility such as reservoir is necessary to increase recharge volume.	Project benefit is less when quantitative availability of run-off is small. Adequate capacity for sediment volume shall be allocated in the reservoir capacity.
		poor	fair	good
Project justification	Net value by a unit of water is estimated considering capital cost and O&M cost. Project benefit is dependent on availability of recharge volume.	Storage facility is required to increase recharge volume. In the case that water is directly diverted from the river, O&M cost for rehabilitation and sediment removal shall be estimated.	Storage facility is required to increase recharge volume. In the case that water is directly diverted from the river, O&M cost for rehabilitation and sediment removal shall be estimated. Construction cost is relatively small.	Most of river run-off is available for recharge. Water utilization ratio is rather higher compared with other alternatives. Capital cost is high, besides less O&M cost is required.
		fair	fair	good

Note: In the Study, no delay action dam is proposed in the Hanna river area.

5.2 Planning of Delay Action Dams

In this section, dam site selection, design siltation volume, groundwater recharge by the delay action dams, O&M of the delay action dams shall be discussed with reference to the reviews of the existing delay action dams planning.

(1) Dam site selection

According to the dam site selection, 1) stability to load and seepage, recharge ability of the dam foundation, 2) topographic, geologic condition and siltation volume, 3) flood control capacity, 4) dam construction method, 5) relation between dam and irrigation systems and 6) relation between existing and proposed dams shall be synthetically considered. Detailed discussions are described below.

1) Stability for load and recharge ability of the dam foundation

Stability for load and seepage of the dam foundation shall be preferentially studied during the dam site selection. In this discussion, description about a weak foundation composed of silt, clay (N-value of the standard penetration test of less than 20) is omitted because those weak foundations are scarcely observed in the Study Area. It is, however, necessary to explore profile of the foundation by drilling at the alluvial fan where silt-clay layers may exist.

Regarding permeability which dominates the groundwater recharge capability of the foundation, drilling and field permeability test shall be carried out to find the depth of the permeable layer and its permeability. These explorations are especially required when the foundation has alternative layers of aquifer and silt-clay which not only depresses seepage capacity of the foundation but increases the pore pressure of the dam embankment.

From the point of view of the accelerating of the recharge capability of the dam, a narrower valley is not recommended for a dam site, but a widely open alluvial fan is preferable to groundwater recharge even though a longer dam may be necessary.

2) Geological condition of topography and sediment production of drainage basin

Deposition of silt in the reservoir causes reduction of the storage capacity and decreases the recharge capability through the reservoir foundation. In this regard, appropriate structures which restrict sediments inflow to the reservoir shall be planned. These shall be based on the predicted sediment production with reference to topographical and geological conditions of the catchment area. It is necessary to determine the river bed gradient and tractive force which depends on grain size distribution of the sediment yield during the planning of sediment control facility.

3) Flood control capacity

With respect to the flood control by the delay action dams, flood control capacity of the reservoir shall be maintained. Thus, flow capacity of the spillway and appropriate storage capacity of the reservoir shall be secured even after the siltation over long period. Delay action dams, in general, have relatively small storage capacity, reduction of the flood control capacity due to siltation shall be particularly considered during spillway design.

Furthermore, agricultural losses caused by flood, as well as movement of the water channels on the alluvial fan shall be studied in the cases where existing flood irrigation systems are widely operated at the downstream of the dam site.

4) Dam construction

It is economically preferable to collect embankment materials from a borrow area and quarry close to the dam site. The quality and available quantity of impervious and pervious materials near the dam site are the critical factors in selection of the dam site. River deposits, gravel, sand and weathered soil materials available near the dam site have been used for the existing dam embankments. Improvement of textures of the sandy materials by mixing of soil materials shall be planned in cases where materials available near the dam site have poor gradation or subject to piping caused even though these may be more costly and require long haulage.

5) Dam and irrigation system

Recharged groundwater from the dams is extracted by tube wells or is transmitted by karezes and open canals to the beneficial areas for irrigation and domestic use. The dam must be located at most effective site resulting from the field investigation of the groundwater flow spreading between proposed dam site and beneficial area. The dam site should, therefore, be as near as possible to the beneficial area to effectively utilize water. In the case that the proposed dam is located far from the beneficial areas because of a larger storage capacity or cost reduction, an appropriate water conveyance device, such as open canal shall be constructed to convey water toward beneficial areas.

6) Alternative study associated with the existing delay action dams

When a proposed dam is constructed close to an existing dam which has been fully silted up or damaged, the following points shall be taken for consideration:

(i) The proposed dam is constructed downstream of the existing dam,

- Extrusion of siltation accumulated in the existing reservoir may be induced by floods together with dam collapse. Hence, enlargement of the storage capacity of the existing dam is maintained so as to prevent extrusion of siltation and also dam collapse.

- Flowout of fine materials, which causes reduction of the recharge rate through the proposed dam foundation, is dominant rather than coarse materials during floods. Removal of fine materials or installation of intake devices shall be realized to maintain the recharge capability of the proposed dam.

(ii) The proposed dam is constructed upstream of the existing dam,

- Proposed dam shall be located at where back water of the existing dam does not reach.

- Impermeable materials accumulated in the existing dam may obstruct groundwater recharge. Substitutional conduits shall be installed to ensure the smooth groundwater flow to the downstream area.

(iii) The existing dam crest is raised to enlarge its storage capacity.

- Because drain capacity of the existing dam have been calculated corresponding to the previous water level, additional drains with sufficient drainage capacity shall be planned corresponding to the elevated water level. (in the case of rising crest height of more than 5 m)

- Existing dam has been consolidated for a long period. The joint between existing embankment and supplemental embankment may encourage piping. In this regard, drainage layers shall be installed along those boundaries to safety drain out and release the pressure.

- Sufficient drains shall be installed against rising of the seepage line in the dam embankment.

(2) Design sedimentation volume

Sedimentation volume of the delay action dam is estimated on the basis of topographical, geological and meteoro-hydrological conditions in the drainage basin. Sediment volume equivalent to the dam service life of the dam shall be allocated in the reservoir capacity.

The following were the sediment volume of the existing delay action dams of Murgi Kotal, Kach, Wali Dad and Wali Tangi. The specific sediment volumes of these dams widely ranges between 300 to 2,100 $m^3/km^2/year$ reflecting topographical and geological conditions of the basin. Therefore, it is important to evaluate the basin conditions such as vegetation, geological property, landslide, erosion, etc. In addition, the detention bund (erosion control dam) against debris flow shall be constructed if possible flankslip is observed in the catchment area.

Survey of Sedimentation

Dam name	Catchment area (km^2)	Sediment volume (m^3)	Trap efficiency*1 (%)	Duration time (years)	Specific sediment ($m^3/km^2/year$)
Murgi Kotal dam	19.65	124,400	45	8	1,760
Kach dam	56.50	494,000	-	4	2,190 *2
Wali Dad dam	5.35	12,500	80	10	292
Wali Tangi dam	18.13	-	-	-	723 *3

Source: JICA Study Team

Notes: *1 Trap efficiency was estimated according to average C/I ratio of each reservoir (Sedimentation, Design of Small Dams)

*2 Source: Pre-feasibility Study for Rehabilitation of Kach Dam (NESPAK, 1987)

*3 Source: Feasibility Study for Flood Protection of Hanna-Urak Valley (National Development Consultants, 1988)

For estimates of the sedimentation volume of the existing dam, the following were introduced referred to the Research Study on Survey and Evaluation of Delay Action Dams in Balochistan, Pakistan Council of Research in Water Resources. The observed data of Khost river at Chappar Rift (catchment area: 25.6 km^2) for the period 1962 to 1971 was used for the estimates of the sedimentation volume.

Average suspended sediment load: 462 $ton/km^2/year$, or 444 $m^3/km^2/year$
(equivalent to 1.040 ton/m^3 of sediment unit weight)

To estimate sedimentation of the reservoir, further 15 % of bed load and trap efficiency of 100 % should be applied, accordingly, the specific sedimentation volume was calculated at 531 $ton/km^2/year$ or 511 $m^3/km^2/year$.

Besides of this, the following are also referred to the estimates of the sedimentation of the reservoir, based on sedimentation observation records adjacent to the Study Area:

Observation Records of Sedimentation

River name	Observation point	Catchment area (km^2)	Annual rainfall (mm)	Suspended sediment load (million tons)	(ton/km^2)	Bed load volume 1) (ton/km^2)	Sediment 2) (ton/km^2)	Sediment 3) (m^3/km^2)
Khost	Chappar Rift	1,321	254	0.41	310	341	256	242
Beiji	Ghatti Bridge	9,609	323	4.5	469	516	387	366
Pishin Lora	Burj Aziz Khan	7,601	220	3.05	400	440	330	313
Average								307

Notes: 1): Bed load is equivalent to 10 % of suspended sedimentation load.
2): Sedimentation of dam is calculated in accordance with its trap efficiency in the reservoir of 75 %.
3): Unit weight of sediment of 1.056 ton/m^3 is applied.

Inferring from the above, sedimentation volume of the reservoir is estimated at 390 to 510 m^3/km^2/year (450 m^3/km^2/year in average) assuming that the bed load volume is 15 % equivalent to those of suspended sediment load and trap efficiency of 100 % is applied because all flood run-off be stored in the reservoir since the reservoir is empty before flooding. In the case that the storage capacity of the reservoir is comparatively smaller than run-off, reduction of sedimentation volume can be considered based on C/I ratio (capacity-inflow ratio), i.e. reduction of trap efficiencies of 80 % in C/I 0.05, 85 % in 0.1, 95 % in 0.5, empirically.

(3) Groundwater recharge by the delay action dams

1) Recharge rate and storage capacity of the delay action dams

Reservoir capacity is estimated on the basis of the run-off (daily or monthly rainfall) at the dam site and recharge rate through the dam foundation and/or river deposits downstream of the dam. Reservoir capacity is statistically estimated based on annual variation of water balance of the reservoir aiming at economizing the construction cost. Reservoir capacity-elevation curve shall be prepared to determine the details of the dam and reservoir.

2) Reduction of recharge rate due to siltation

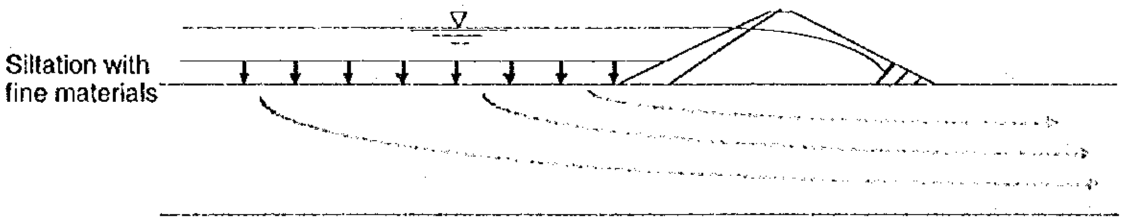
The reduction of the recharge rate due to siltation in the reservoir is concluded as follows:

1) Fine materials being a suspended load is accumulated near the dam embankment. It induces a reduction of a recharge rate through reservoir foundation because fine materials are subject to being accumulated near the dam embankment as a suspended load and have small hydraulic conductivity.

2) Sand-gravel siltation of hydraulic conductivity of 10^{-3} cm/sec causes 15 % reduction of recharge rate with its thickness of 1.0 m, or 30 % reduction of recharge rate with its thickness of 5.0 m. Silt-clay siltation of hydraulic conductivity of 10^{-5} cm/sec causes 30 % reduction of recharge rate with its thickness of 1.0 m, or 50 % reduction of recharge rate with its thickness of 5.0 m. (see Annex I.3)

3) Decrease of the storage capacity due to siltation directly reduces the quantitative recharge capacity of the reservoir.

Fine materials accumulated near the dam embankment form impervious layer. Horizontal flow does not occur, and hydraulic gradient also become small. Accordingly, recharge capacity (recharge amount) is reduced.



3) Downstream recharge through conduits

Downstream recharge through conduits (steel pipe: ø 150 mm) installed in the dam foundation has been applied recently together with upstream recharge through the dam foundation. Supplemental improvement is discussed below:

(i) Inlet shall be adjusted to inflow elevation to prevent clogging by rising sediment surface.

(ii) Mud flow is restrained to flow into the conduits by means of strainer screen installed around the inlet pipe. However, accumulation of fine materials on the strainer surface reduces flow capacity of the intake, especially near the dam embankment where fine materials are accumulated.

(iii) Seepage capacity of the trench pit of 3 m x 3 m x 3 m is insufficient. Seepage capacity by trench pit is estimated at around 200 - 300 m^3/day.

(iv) In view of no control devices, the out flow discharge corresponding to the recharge rate is not regulated.

Considering the above, the following improvements are suggested.

(i) Inlet should be installed upstream of the reservoir, where only coarse materials are deposited, or additional inlet holes should be installed with proper allowance against rising of sediment surface.

(ii) Infiltration trenches or ponds should be constructed to accelerate a recharge at the downstream of the dam embankment.

(iii) Excessive out flow from the reservoir exceeding the recharge rate of the recharge device increases evaporation loss from the ground surface downstream of the dam. To avoid such losses, a discharge control device, i.e. valve should be installed to properly control out flow discharge.

(iv) Plural intake conduits with scouring device should be planned to prevent clogging with soil and foreign materials.

(4) Operation and maintenance (O&M) of the delay action dams

In order to ensure safety of the dams, the necessary supervision works shall be included.

a) Ordinary supervision

- Observation of impounding level and leakage of the dam and foundation
- Inspection of intake/recharge device

b) Periodic supervision

- Monitoring of deformation and settlement of embankment
- Observation of seepage line (dam height of 15 m or more)
- Inspection of slope protection and spillway
- Monitoring of siltation in the reservoir and natural ground around abutment, etc.

c) Emergency (during flood, earthquake)

- Inspection of dam embankment (leakage, slope protection, cracks and landslide, etc.), natural ground around abutment and spillway (abrasion and scour) shall be carried out during or after flood and earthquake.

5.3 Design Aspects

In this section, designs of dam embankment, spillway and groundwater recharge devices shall be discussed.

(1) Dam design

1) Embankment materials (Fill dam)

Fill materials are classified into soil materials and rock materials. The latter is further classified into sand-gravel and rock. Soil are employed as an impervious materials, and sand-gravel and rock are utilized as a semi-pervious or pervious materials. Impervious are defined as those materials where the hydraulic conductivity after compaction is less than 1×10^{-5} cm/sec, and pervious are those where the hydraulic conductivity after compaction is less than 1×10^{-3} cm/sec. Semi-pervious materials lie between these two limits. Suitability of the fill materials are given in the table below.

Suitability of Fill Materials

	Characteristics				Suitability				
					Dam			Foundation	
Symbol	Permeability after compaction	Shearing strength in saturated	Compressibility in saturated condition	Workability as banking material	Homo-genous dam	Impervious zone	Pervious zone	Seepage flow considered	Seepage flow not considered
GW	Pervious	Excellent	Almost nothing	Excellent	-	-	1	-	1
GP	Highly pervious	Good	Almost nothing	Good	-	-	2	-	3
GM	Semi-pervious - impervious	Good	Almost nothing	Good	2	4	-	1	4
GC	Impervious	Good-fair	Extremely small	Good	1	1	-	2	6
SW	Pervious	Excellent	Almost nothing	Excellent	-	-	3*	-	2
SP	Pervious	Good	Extremely small	Fair	-	-	4*	-	5
SM	Semi-pervious - impervious	Good	Small	Fair	4	5	-	3	7
SC	Impervious	Good-fair	Small	Good	3	2	-	4	8
ML	Semi-pervious - impervious	Fair	Medium	Fair	6	6	-	6	9
CL	Impervious	Fair	Medium	Good-fair	5	3	-	5	10
MH	Semi-pervious - impervious	Fair-poor	Large	Poor	9	9	-	8	12
CH	Impervious	Poor	Large	Poor	7	7	-	9	13

Source: Fill Dam, Ministry of Agriculture, Forestry and Fisheries, Japan
Notes: (*) means high gravel content. Under "Suitability", the larger number shows lesser suitability.

With the increase in the height of dam, pervious zones and impervious zones become necessary for seepage and mechanics. In most cases, materials for the homogeneous type fill dam consists principally of that for which the percentage of the fine grained impervious and semi-pervious materials is high. Accordingly, as dam height increased, slope gradient is reduced. Consequently, embankment volume increases and the dam becomes relatively costly than a zone type fill dam. On the other hand, where the dam height is low, the homogeneous type fill dam is advantageous from a construction point because uniform material is utilized.

The review of the existing delay action dams indicates that most dams have been constructed as a homogeneous fill type dam with their sandy, soil materials mixture ratio of 3:2. Heavily weathered materials or talus deposits around the dam abutment were utilized for soil materials. Embankment materials were excavated and transported by bulldozers. In this connection, borrow sites of most of the dams were located within 150 m distance from the dam sites.

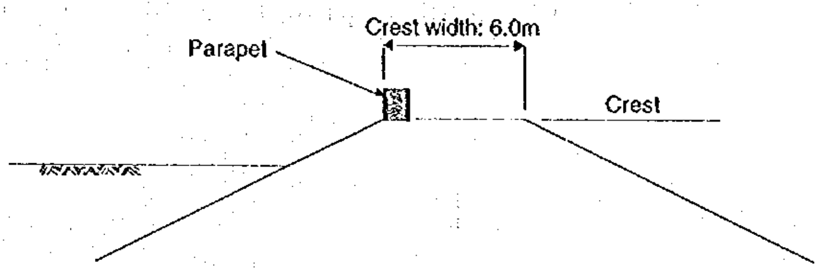
River deposits at up-downstream of the dam sites were utilized for sand-gravel materials. Well grained materials were available for embankment, which were accumulated at gentle slope sites on an alluvial fan. Besides, river deposits accumulated at steep slope site of the river were not always recommended to be utilized for the embankment due to high coarse particle content. Excessive pore space in coarse materials causes piping even though sufficient compaction is performed. Coarse materials are gathered locally when materials are moved by bulldozers in a long distance.

In due consideration of the above, it is proposed to prepare a stockyard for performing grain adjustment (mixing) of soil and gravel-sand. In addition, there are methods available to add water to increase moisture content of dehydrated materials, which are required for in the most materials near the dam sites in the Study Area. Alternatives of soil (impervious layer) and sand-gravel (pervious layer) resulting from poor grain adjustment induce piping due to the concentration of the seepage line along sand-gravel layers.

Soil tests should be conducted to examine the dam stability, especially for the dams of more than 15 m height. In addition, ground exploration for permeability and aquifer depth is required to practicably examine the seepage rate through the dam and reservoir foundation, as well as the stability of the embankment. Soil test equipment is given in section 6.10. As to ground exploration, drilling rigs owned by the Irrigation Department are available.

2) Freeboard of embankment

Free board of 3.06 m (10 feet) height from spillway crest has been adopted for most of the existing delay action dams. Siltation in the reservoir reduces flood control capacity of the reservoir and consequently causes overflow over the dam crest. Thus, allowance against siltation shall be added during decision about the crest elevation. Allowable height of at least 3.0 m from siltation surface will be allocated in view of the experience gained from, Murgi Kotal, Kach and Wali Dad dams in Quetta District. Parapet can also be used to secure an allowable height to prevent overflow caused by silt development in the reservoir. Proposed freeboard is discussed in the Planning and Design Guideline for Delay Action Dams.



3) Shear strength and permeability of the materials (Fill dam)

Materials for the existing delay action dams principally consists of sand and gravel. The shear strength of the sand and gravel materials depend on the hardness, grain shape, gradation, dry density and the stress conditions. In general, hard and well graded material having high dry density has high shear strength. The permeability depends on the gradation, particularly on the fine grain content. Impermeability of less than 1×10^{-5} cm/sec can be obtained with fine particle content (0.074 mm) of more than 8 %. Permeability of mixed materials of soil and sand-gravel with water content of a little larger than optimum water content (Wopt) is minimum. Hydraulic conductivity does not substantially increase even when the water content becomes larger than the above value. On the other hand, when the water content becomes smaller than the Wopt, the hydraulic conductivity greatly increases. Hydraulic conductivity becomes larger when coarse grain content (4.76 mm or larger) is more than 30 - 50 % in the materials. Well grained material improves workability, resulting in high dry density. The more a material contains coarse grains and the larger is the dry density, the less is deformation after construction.

Since embankment materials of the delay action dams consist of sand-gravel materials obtained from around the dam site, the permeability relationship between the fine particle content, and water content during compaction shall be examined. Furthermore, larger materials exceeding compacted larger thickness shall be removed before the compaction. Sedimentary rocks (shale, sandstone of Pleistocene period, etc.) shall be carefully utilized for embankment construction.

4) Seismic inertia force

a) General

Mechanical properties of soil, e.g. shear strength and deformation modules generally vary under static and dynamic stresses. It is important to examine the mechanical properties of soil during dynamic load stressed. Since sand-gravel materials are mostly used for the embankment of the delay action dams, reduction of the shear strength becomes an issue of the dam stability during earthquakes. In addition, increase of pore pressure together with liquefaction caused by excessive shear force duration may occur in the unconsolidated and saturated dam foundation.

As mentioned above, examination of stability of the dam embankment, and also the liquefaction of the dam foundation during earthquake are essential for the dams which storage water for longer period.

b) Seismic coefficient and stability analysis

Seismic coefficient is determined in accordance with statistical analysis of historical earthquakes in and around the project area. It is defined as the maximum earthquake that could probably occur within 100 year in the future according to the dam manual in Japan. Seismic coefficient is estimated for different dam types (gravity dam, zone type fill dam, homogeneous type dam) and foundations (rock, unconsolidated rock, sand-gravel, soil, etc.). Regarding dam type, a safety allowance of 1.2 is assumed for homogeneous type dam based on those of 1.0 for gravity and zone type fill dams. Similarly a safety allowance of 1.2 is assumed for unconsolidated rock foundation, 1.4 for sand-gravel, soil foundation based on that of 1.0 for consolidated rock foundation.

The Quetta area has been the location of a number of large destructive earthquakes. Earthquakes have occurred near the Chaman fault and Quetta fault where the Eurasian plate and Indian plate are attached to each other. Distribution of earthquakes in Balochistan Province is shown in Fig. 5.3.1. The following are principle earthquake records which have occurred adjacent to Quetta:

Principle Earthquake Records (Quetta)

Date			Magnitude	Date			Magnitude
27th	August	1931	7.4	24th	June	1979	4.7
30th	May	1935	7.5	12th	December	1981	4.7
2nd	June	1935	6.0	22nd	February	1983	4.4
18th	February	1955	6.0	3rd	May	1985	4.2
1st	April	1969	4.8	10th	October	1986	4.6
18th	August	1969	4.8	26th	March	1988	4.6
22nd	February	1974	4.9	26th	February	1990	5.4
3rd	October	1975	4.8	14th	October	1990	4.7
13th	July	1977	5.1	30th	September	1991	4.5
11th	July	1978	4.4	4th	May	1992	4.9
24th	June	1979	4.7	26th	July	1993	4.1

Source: Meteorological Department, Quetta
Note: Magnitude is in Richter scale

Earthquake coefficient of 0.44 is given when magnitude is 7.5 assuming the hypocentral distance from epicenter of 50 km in horizontal and 30 km in vertical direction. Besides, earthquake coefficient of 0.11 is given when magnitude is 7.0. It is recommended that the earthquake coefficient of 0.44 should be applied for the dam stability analysis to mitigate seismic risk for further 100 years. On the other hand, it is also suggested to reduce the coefficient for the analysis for the reasons that the project life of the delay action dams is 30 years, and damages occurred due to by dam collapse is expected to be less than those of storage dams because the reservoir is ordinarily empty.

The following are the earthquake coefficients applied for the stability analysis for the dams located in the study area:

Dam name	Dam type	Foundation	Dam height	Coefficient of earthquake
Brewery dam	Gravity dam	Limestone rock	33.0 m	0.45
Bostan dam	Earth dam	River deposits	16.0 m	0.20
Kach dam	Earth dam	Shale, sandstone	26.2 m	0.1-0.2

Note: Coefficient of 0.1 to 0.2 is assumed because Kach dam is located at "Zone-1" area in Pakistan according to the report of "Pre-feasibility Study for Rehabilitation of Kach Dam, NESPAK, 1987

c) Study for liquefaction

The factors concerning the liquefaction are as follows:

(i) Saturated sandy foundation is generally considered to be easily liquefied as compared to foundation which contains a few silt and clay.

(ii) Liquefaction generally occurs in comparatively unconsolidated foundation in which N value (Standard penetration test) is N < 2z (z: depth in meter). In most cases, relative density is 0.75 - 0.80 or less.

(iii) Liquefaction dose not easily occur when confined pressure is large, and there is not a liquefaction at depth of 15 - 20 m or lower.

(iv) When uniformity coefficient is 5 - 10 or smaller, particularly easily liquefied. Relatively coarse sandy materials are subject to liquefaction.
(Example: 0.074 mm<D_{50}<2.0 mm, or 0.2 mm<D_{60}<2.0 mm)

There is hardly any occurrence of liquefaction in the delay action dams because the stored water of the dam is drained or infiltrated rapidly within 1 to 2 months. Accordingly probability of earthquake occurrence is quite small during the dam embankment and its foundation being saturated. However, where storage condition is maintained for 3 to 6 months due to poor infiltration of the dam foundation, as observed in Khushab and Tirkha (Pishin district) dams, fundamental countermeasures should be taken.

d) Stability analysis of the embankment

(i) Fill type dam

Slope gradients of 1:2.0 (upstream slope) and 1:3.0 (downstream slope) are empirically applied for most of the delay action dams of their dam height of lower than 15 m. Impounding duration of the delay action dam is considerably short, and also excessive pore pressure is not observed because of high permeability of the embankment material. Due to this fact, stability of the delay action dam is more tolerant than the storage dam because of less internal/external force acting on the dam body. Dam stability against sliding shall be examined in accordance with standard requirements for the dams of more than 15 m height, and those having longer storage duration.

Analysis method for the sliding failure is broadly categorized in sliding surface method and stress analysis. The circle arc method is employed for the fill type dam. However, the sliding wedge method is adopted in case that the estimated sliding line passing through the weakest portion of the dam embankment and also foundation is not circular. In addition, safety against surface sliding is also estimated. Planning and Design Guideline for Delay Action Dams explains application of mechanical properties of fill materials for stability analysis.

5) Cut-off trench

Cut-off trench was not constructed in most of the delay action dam in the Study Area. Embankment were constructed after excavation of the unconsolidated river deposits. Since the delay action dams have been constructed aiming at the groundwater recharge through the dam foundation, it may be rather effective not to install cut-off trench to accelerate groundwater recharge. However, 25 % reduction of the seepage was observed associated with installation of the cut-off trench of which 50 % thick replacement of the entire dam foundation depth, in general. It is recommended to install a cut-off trench along the dam axis where maximum embankment load is placed so as to obtain sufficient bearing strength of the foundation.

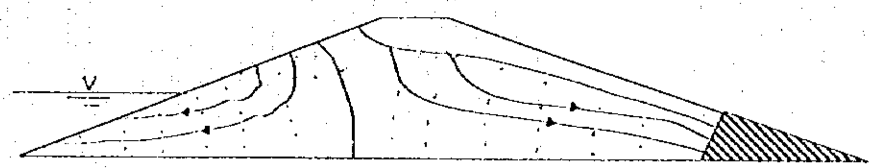
6) Slope protection

Up and downstream slopes of the existing delay action dams have been protected with stone riprap with their thickness of 0.45 m (1.5 feet) and 0.225 m (0.75 feet), respectively. It was observed on the dam recently constructed that the riprap protection on the downstream slope was not placed. Downstream slope must be protected from gully erosion with proper compaction. Riprap material of 30 - 50 cm diameter should be properly placed for slope protection together with filter layer.

7) Drains

It may be rare phenomenon that the seepage of the embankment spouts out from the downstream slope because uniform seepage flow is not rapidly developed in the embankment due to short storage period of the reservoir. However, in the case that the siltation prevent anticipated percolation rate of the reservoir foundation, proper drainage should be provided to lower seepage surface in the embankment with installation of the drain at the toe of the downstream slope (refer to Annex I).

Rapid drawndown of the water level implies seepage flowing towards the reservoir side due to reduction of the upstream water pressure. Consequently, drains should be installed at the reservoir side in the dam embankment in case that the upstream slope is comparatively steep.



Flow net during rapid drawndown

(2) Design of spillway

1) Design flood discharge

Design flood discharge of the delay action dams was estimated as explained in Planning and Design Guideline of the Delay Action Dams. Thirty year flood, which statistically occurs once in 30 years was applied for spillway corresponding to the project life of the delay action dams.

Delay action dams will not be demolished even after 30 years, and siltation during the period causes remarkable reduction in the flood control capacity of the reservoir (routing). Accordingly, floods were used to flow down not through spillway but overflow the dam body, consequently inducing collapse of the dam embankment.

In this regard, it is proposed that the design flood of 100 year discharge is considered for a gravity dam, and for fill type dam.

2) Design of spillway (existing dams)

Spillways were constructed applying favorable geographical conditions, at where the dam embankment and spillway canal were isolated by natural undulations. Required section of the spillway canal was secured on the rock foundations with blasting at most of the dam sites. Canal protection was not constructed for rock base canal. On the other hand, stone riprap protections were constructed to prevent erosion on the wholly or partly canal surface of soil base canal. Embankment and spillway were isolated with the retaining wall composed of concrete or stone masonry, where spillway canal was not able to be constructed separately from the embankment due to steep abutment, etc.

For the dams located at hilly sites, talus deposits or piedomont deposits were widely excavated to secure canal section, and riprap protection and cut-off walls (depth: 0.9 m) were embedded with intervals of 20 - 30 m to control canal erosion and scouring.

Regarding spillway inlet type, chute type inlets were selected in most of the delay action dams. Side inflow type spillway is also alternatively planned in the case that excessive excavation on the dam abutment is required to secure flow section of the spillway canal.

Overflow crest was not installed at inlet portion of the spillway, so that discharge coefficient was theoretically estimated at ranging from 1.5 to 1.7 (critical flow). However, total head (including velocity approach head) of the spillway of the existing dams were estimated by discharge coefficient of 1.89 in SI dimension, that actual total head above crest might be higher compared with estimated total head. Chute canals have been constructed with gentle slope along with natural terrain, or in step form to dissipate flow energy. However these canals constructed on the soil foundation are susceptible to scouring by flood. Furthermore, guiding canal at the downstream of the spillways were not constructed. Flood water frequently might inundate downstream of the dam embankment.

3) Flow obstruction by siltation

Excessive siltations were observed at Murgi Kotal, Kach and Wali Dad dams in Quetta District. Siltations surface had risen up to the spillway crest elevation in each dam, and flood water overflowing these dam crests, caused dam collapse. Siltation cover in the reservoir area is flat, and floods have flowed down through concave portion in the reservoir over the dams crests not through spillway.

4) Improvement on spillway design

The following are recommended for the design of spillway:

a) Design flood of 100 year discharge is proposed for a gravity and fill type dam.

b) Spillway crest is installed to improve discharge coefficient, as required.

c) Adequate flood control capacity shall be secured in the reservoir even after excessive siltation is developed.

d) Spillway canal shall be protected to eliminate scouring, except in rock surface.

e) Guiding canal at the downstream of the spillways shall be constructed to attain smooth flow towards downstream, as required.

f) Gentle slope shall be given to a spillway canal to accelerate scouring of suspended sediment on the canal bed. Furthermore, protection for canal slopes and bed shall be provided to prevent scouring.

g) Side inflow inlet type should alternatively be studied to secure flow section of the spillway canal, if topographically imposed.

(3) Design for groundwater recharge devices

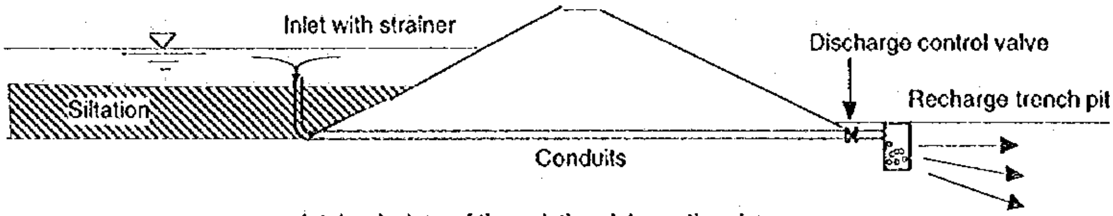
1) Upstream recharge (Recharge through dam foundation)

Delay action dams were constructed aiming at groundwater recharge mainly through the reservoir and dam foundation. Recharge ability depends on the permeability and thickness of the river deposits. No recharge device is required if high permeability is available.

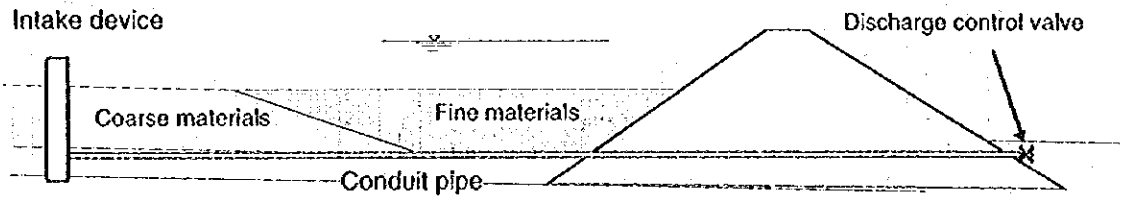
2) Downstream recharge (recharge through foundation downstream of the dam)

Downstream recharge is accelerated through intake devices comprising of conduits installed under the dam embankment and recharge trench or pond located downstream of the dam embankment. The following are typical devices installed at the existing dam sites:

- Inlet pipe: Steel percolated pipe (ø150 mm) with strainer
- Conduits: Steel pipe (ø150 mm)
- Recharge trench pit: Sprawl filling (3m x 3m x 3m)



Intake devices of the existing delay action dams



Inlet is located at upstream of reservoir at where coarse materials are deposited.

As described in Section 5.2 (3), seepage capacity through the dam and reservoir foundation is gradually decreased due to sediment accumulation in the reservoir. Downstream recharge through the river bed is, therefore, essentially . Impounded water in the reservoir is diverted to the downstream through the intake facilities. Groundwater recharge is, in principle, attained through the river bed. However, river bed gradient is not uniform, and therefore recharge through an infiltration pond is recommended to obtain sustainable and stable recharge effects, and easier activities such as removal of fine materials. Surface area of the infiltration pond is based on a transmissibility of aquifer.

5.4 Construction of Delay Action Dams

(1) General

River deposits (sand-gravel) accumulated upstream and downstream of the dam site and weathered materials (soil) on the abutment were generally utilized for the dam embankment. Materials were excavated and transported by bulldozers to the dam site, and compacted by roller. Embankment slopes of upstream and downstream were protected with stone riprap or sprawl with their thickness of 0.45 m (1.5 feet) and 0.225 m (0.75 feet), respectively. Riprap materials were transported by tractors from quarry sites. In the case that the riprap was not available near the dam site, its was transported from 20 to 30 km distance.

(2) Quality control of the embankment

Dry density control is most important for the embankment. The principle points with regard to density control are as follows:

- Due to quite low humidity, the field moisture content tend to be on the dry side of the optimum moisture content (Wopt). The moisture content of the embankment material shall be adjusted to be slightly on the wet side of the Wopt by means of water sprinkling, etc.

- Most of dams have been constructed as a homogeneous fill type dam with their sandy, soil materials mixture ratio of 3 : 2. However, mixture of these materials was not properly conducted. Mixing in a stockyard for grain adjustment would be more effective. Horizontal impervious layer composed of clay soil induces a seepage spouting out from the downstream slope of the embankment due to anisotropy of permeability, and consequently causes piping.

- Either of dry density or relative density control is applied for the quality control to ensure a uniformity of the embankment. Single compaction degree for the banking is determined in accordance with the result of field banking test. The shear strength and compaction degrees shall be periodically checked, also immediately after materials used for embankment are changed.

(3) Seepage flow through the dam embankment

Monitoring of the hydraulic conductivity shall be carried out during the dam construction. In case where piping is expected, e.g. foundation is impermeable, or the groundwater level is high, it is a general practice to install drains. Where dam height is around 15 m, a toe drain is installed. When dam height is around 25 m, horizontal drains covering the entire downstream dam foundation are planned. Vertical drains are established at the center of the dam body in the case of the dam height of over 25 m, which serve to rapidly lower the seepage line. Ample cross section for these drains is necessary. Considering fluctuations in hydraulic conductivity, a safety margin in cross section of 10 - 100 fold shall be allowed. Where the hydraulic conductivity of the drains is larger than those of the embankment materials, a filter shall be introduced to prevent wash out of fine graded materials.

Contact clay with 5 to 10 cm thick shall be placed on the boundary of the rock dam foundation and embankment in order to mitigate seepage flow along its boundary.

(4) Construction of spillway and intake facilities

Sufficient crest width, as well as smoothening of canal surface shall be obtained to safely release a maximum flow equivalent to the design flood discharge. Riprap protection shall be constructed for earth foundation canal. Energy dissipater is installed at the downstream of the spillway to dissipate hydraulic energy, as required.

Regarding intake facilities, cut-off wall shall be installed along conduits to prevent piping along the conduits. Conduits are deeply laid in the dam foundation to protect the conduits from eccentric load pressure in case where a cut-off trench of the dam embankment is installed.

5.5 Operation and Maintenance of Delay Action Dams

(1) General

According to the O&M of the delay action dams, the following are achieved in due consideration of rapid fluctuation of the water level in the reservoir:

The leakage and deformation depend on the embankment materials and quality control values on the fill type dams. Detailed monitoring plan be initially deliberated taking those phenomena into account. Monitoring devices, especially for leakage are required due to its difficulty to determine the leakage route.

It is vital for either regular or temporary inspection to be implemented in order to observe the conditions of the dam embankment and the natural ground around abutments. Furthermore, inspection for leakage, cracks, land slips and scour of spillway is carried out immediately after the flood or earthquake occurs. Monitoring after flood or earthquake is also necessary for certain period as was obvious from some examples where dam embankments had collapsed after a few days due to the development of piping or cracks.

(2) O&M for recharge capacity

Groundwater recharge is accelerated by upstream recharge through dam foundation and downstream recharge through intake devices as explained in the previous section. Silt accumulated near the dam embankment causes a remarkable reduction of the recharge rate through dam foundation. Fine materials shall, therefore, be removed by machinery to maintain recharge capacity of the dam, if vital from the economical point of view.

In cases of the downstream recharge, removal of fine materials in the infiltration trenches and ponds, replacement of filter materials are required to maintain recharge capability.

5.6 Related Structures to Delay Action Dams

(1) Erosion control plan

The principal purpose of constructing erosion control facilities is as follows:

i) to settle and store sediment

ii) to control erosion by means of controlling riverbed slope

iii) to decrease sediment production from hillside due to raising riverbed elevation

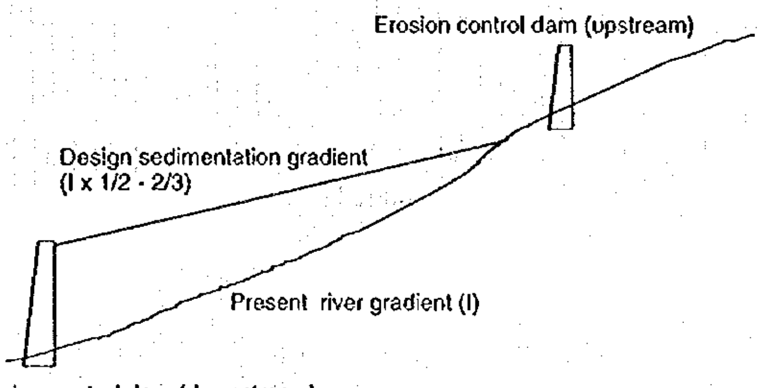
iv) to prevent the movement of riverbed deposits v) to reduce the peak discharge of debris flows

In some river basins within the Study Area, large quantities of soil flow downstream due to devastation of the catchment area, and it causes reduction of the function of delay action dam. Therefore, erosion control facilities should be proposed for reduction of sediment production and also settlement and storage of sediment. In addition, it is expected that such erosion control facilities would to contribute to groundwater recharge along with the dam itself.

1) Design sediment volume and design discharge

In the Study Area, riverbed slope of small/medium scale river is generally steep over 1/20 and sediment volume stored by one unit of sediment control facility is limited. On the other hand, it is supposed to be expensive to increase storage capacity by constructing large scale facility. Therefore, it should be desirable to adopt 5 to 10 years sediment volume as a maximum design sediment volume.

It is necessary to estimate design sedimentation slope for calculation of sediment volume and the design sedimentation slope of 1/2 or 2/3 of present riverbed gradient is generally applied. In some cases, it was informed that riverbed slope was less gentle below 1/2 where small grain size sediment was produced. According to the results of grain size analysis at proposed dam sites in the Study Area, 90 % grain size of sediment was almost bigger than that of fine sand at each site, so that it is estimated that design sedimentation slope of 1/2 of present riverbed slope is applied for estimates.



It is suggested to estimate design sediment volume stored upstream of the sediment control facilities by following formula adopting the design sedimentation gradient mentioned above.

Design flood discharge of 100 year probability is adopted for structural design of the sediment control facilities in general. However, it is recommended to adopt 30 year probable discharge including 15 % sediment contents in flood in consideration of the economic aspects and experience of facility planning by the Irrigation Department of Balochistan.

2) Site selection

The site of erosion control facility should be determined under considering the following items:

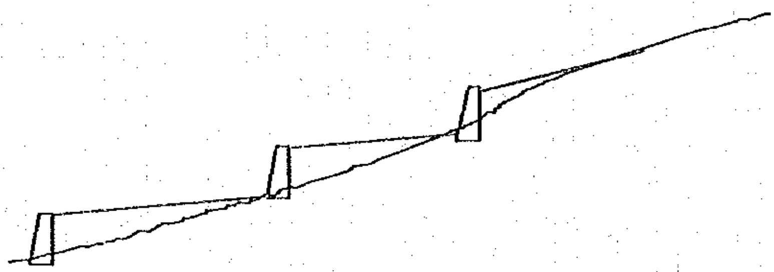
- It is desirable to select the site where valley is narrow, riverbed slope is gentle and large capacity for storage exists for the purpose of storage and control. In the meanwhile, the facilities be constructed crossing wider river bed to reduce specific discharge at where week foundation and abutments are exposed.

- The facilities are constructed downstream of the confluence of tributaries. However, in the case that devastation is proceeding in tributary worse than main river, it is important to give precedence to tributaries.

- When the facilities are constructed aiming at loosening riverbed slope, the site should be selected at downstream of collapse area.

- When the facilities is aiming at preventing landslide, the site should be selected at the downstream of landslide area.

- Plural and lower facilities are to be continuously constructed to secure structural stability.



Plan of multiple erosion control dams

3) Type selection

Concrete type, masonry and gabion structures are suitable for sediment control facilities (detention bund). Gravity dam, masonry structure are limited at where sufficient bearing capacity of foundation is attained. On the other hand, gabion type is preferable for weak foundation due to its flexibility. The following selection is applied according to dam height:

- 3 m height or lower: gabion type

- 3 m height or higher: Concrete or masonry structure (stability shall be examined)

4) Facility planning

a) Detention bund

There are many small scale bund comprising of gabion of 2 m height and 1 to 2 m width of crest in the Study Area. For the structural planning of the detention bund, it is recommend to adopt stair type slope at upstream slope to utilize the sediment weight contributing to stability of the structure. Furthermore, at least 1 m cut-off wall is installed at the both end of the structure to prevent scouring by floods. Filter cloth is also effective to prevent drawout of fine materials on the foundation.

b) Erosion control dam (concrete or masonry structure)

It is necessary to examine the structural stability in accordance with delay action dam.

(2) Land slide protection

Aiming at reduction of sedimentation in the reservoir, surface drainage ditch, bench cutting, slope protection by means of vegetation and retaining wall composed of concrete and stone masonry are proposed to prevent land slide in the catchment area. These countermeasures shall be applied in the reservoir area to prevent broadly slope collapse owing to rising groundwater level by ponding.

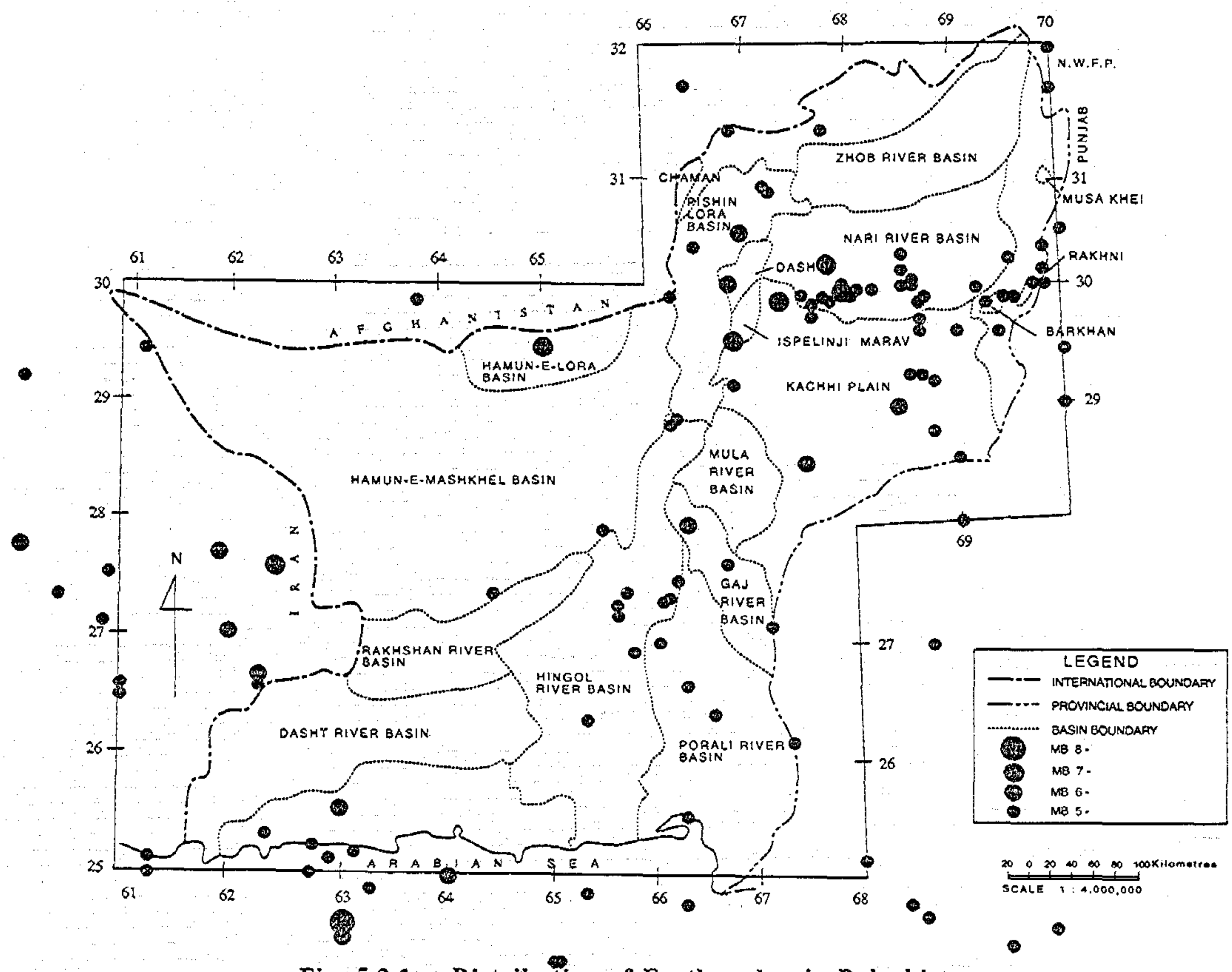
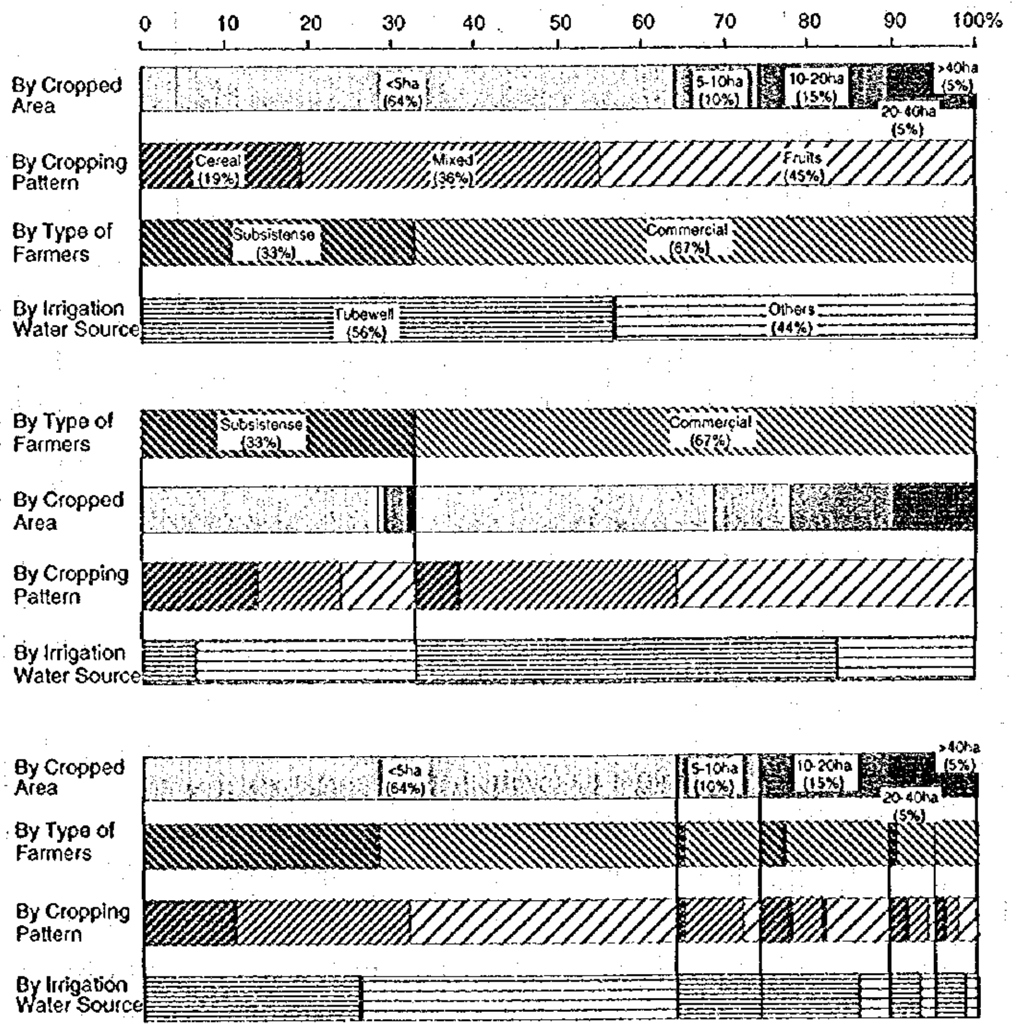


Fig. 5.3.1 Distribution of Earthquakes in Balochistan

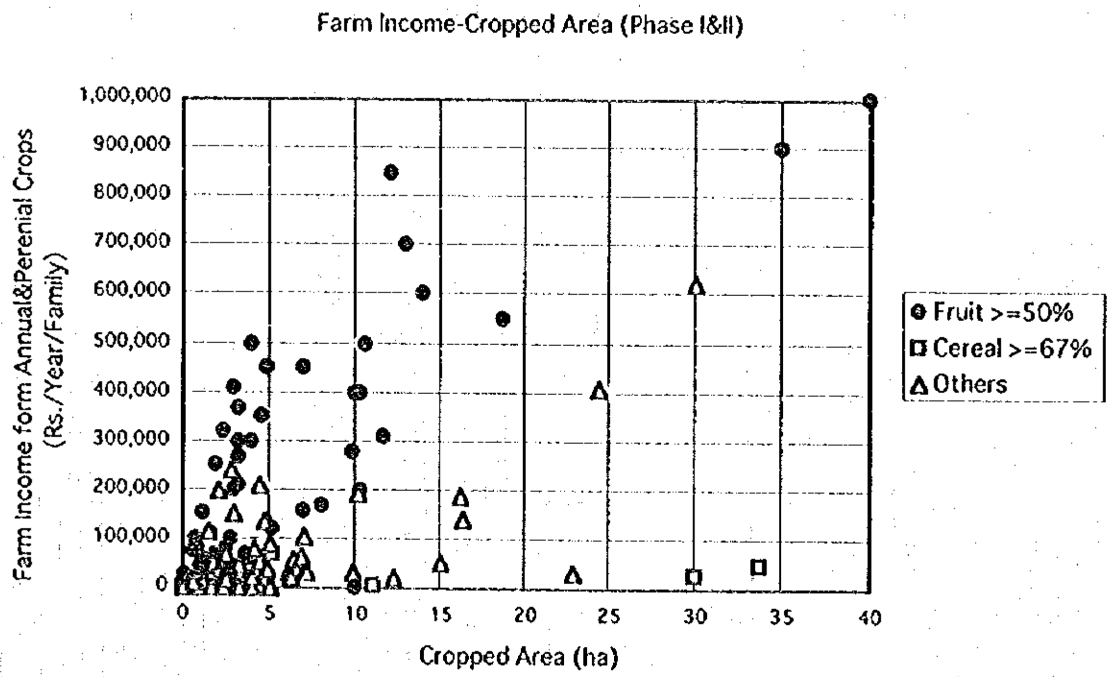
6. *DEVELOPMENT CONCEPT*

6.1 Farmers' Characteristics in the Study Area

Farmers in the Study Area are strongly motivatal in agriculture in general, while income difference among the farmers is conspicuous. According to the result of the farmers survey obtaining 131 effective replies conducted during this Study period, the farmers in the Study Area can be divided into 3 typical patterns by applying cropping manner, namely, food grain producers who cultivate wheat and barley at more than 67 %, mixed cultivators who mainly cultivate vegetables and grains and so on, and fruit growers who crop deciduous fruit trees at more than 50 % of their farm areas. As a whole, the fruit growers are prominent shearing 45 % of all replyers, while the food grain producers are minority shearing 19 % of all replyers in the Study Area. Principal water source in irrigation is tubewells sharing around 60 % of all kinds of irrigation water sources including springs and karezes.



A relation between agricultural income and owned farm area of farmers is shown in below figure by their cropping manners. Each farmers group by cropping manner also form an income group, the fruit growers indicate highest income, and the food grain producers indicate lowest income. The mixed cultivators take up their position in middle income level of the both farmers groups. History of agriculture change in the Study Area, shifting from grain harvesting to fruit producing through mixed cultivating with vegetables, can be supposed by the result and the fact that orchard area has been increased year by year.



Anther information was obtained through the farmers survey as showing figure in before page. There are two categories of agriculture, subsistence agriculture and marketing agriculture, in the Study Area. Subsistence farmers assuming with annual agricultural income less than Rs. 25,000 are at about 33%, while remaining majority perform marketing agriculture. The subsistence farmers own small farmland, of which 86 % have a farmland of less than 5 ha, being grain harvesting depending not tubewells but traditional water sources. Meanwhile, farmers in marketing agriculture own wider farm land, and perform fruit cropping positively. They have greatly relayed upon groundwater irrigation through tubewells. Reminding that the objective of the Study is to make groundwater use in the Study Area be sustainable, the target beneficiary of the Study should be the farmers in marketing agriculture who have extracted groundwater prominently as the substantial groundwater users for fruits harvesting. Providing that the farmers in marketing agriculture are put on target rather than subsistence farmers in the

Study, development strategy should be a plan seeking profitable agriculture rather than sufficiency of products.

Furthermore, the result of farmers survey shows the fact that small land owners also perform fruits harvesting actively, about 50 % of them are categorized in fruits growers. They have also used groundwater for fruit irrigation purpose by their own tubewells. This Study should consider small land owners as well as big land owners because they are the beneficiaries of groundwater. By these reasons, this Study is not aimed at large land owners only.

6.2 Constraints for Development in the Study Area

Major and critical constraints in the Study Area is shortage of water. Water use structure is going to precipitate as a real crisis in the Study Area, where no remedial steps have been taken against increase of water demand under the given condition of limited water resources.

In the Study Area, more than 90 % of water demand is supplied by groundwater. Present exploitation of groundwater is far exceeds the recharge in natural condition. Such over-exploitation causes worst symptoms such as lowering of groundwater table, which might cause serious harm for sustainable use of groundwater. Two remedial measures can be taken for the critical deteriorating situation in groundwater use. One is to enhance recharge by artificial expedients, another is to increase efficiency of groundwater utilization. Delay action dam (subject of this Study) is a core attempt in the former direction.

Besides this critical constraint on water in the field of natural condition, some sociological and agricultural constraints were recognized, which directly influence success of the development, or indirectly reduces the benefits of investment in groundwater development. These constraints in the Study Area for development are enumerated as follows:

1) Scarcity of irrigation water

   Annual rainfall in the Study Area is very low and variable from year to year. The continuous lowering of the water table due to increased pumping of ground water with tubewells is a particular concern in terms of long term sustainability of the irrigated agriculture. In addition over-irrigation is sometimes found in the Study Area due to lack of scientific information and advice. Unreliable electricity supply for pumping with the application of fixed charge tends to enlarge excessive pumping.

2) Inadequate supply of agricultural inputs

At present the Agricultural Sector is furnishing far less than the required seed for the major agronomic crops and the required fruit seedlings. The use of fertilizer in the area is low which is attributed to its non-availability at the proper time and place particularly in remote areas due to lack of access. Efforts will be also made to introduce integrated pest management technology and monitor the quality and residual effects of chemicals now in use. Although use of agricultural machinery has increased, often the equipment used is not suited to the conditions of the soil and there is little knowledge on the part of operators about proper land preparation techniques and equipment care and maintenance.

3) Lack of agricultural supporting system

The Extension Service of the province is understaffed and needs to be strengthened. In many districts, facilities and transport are not adequate as well as inputs to effectively carry out basic extension functions. There are constraints of the system of inter-disciplinary collaborative problem-solving research is minimal and the research-extension linkages for a two-way flow of information are not operating very effectively. There is an overall shortage of technical manpower in the Agriculture Department and a number of budgeted posts have remained unfilled.

4) Poor establishment of cooperatives

Though there are around 400 agricultural cooperatives in the Study Area, average number of member ship per cooperative is only 23 that is very small compared to total number of farm households, and share capital and working capital are also very limited. Formerly there have been traditional groups of water users in several irrigated areas. In these areas tribal custom is still so prevailing that the top position of such a group is usually occupied by the person who constructed the irrigation facilities, his successor or the big land owner.

5) Week agricultural credit system

Despite the availability of the institutional credit at reasonable terms, most credit needs are met informally by borrowings from family or individuals of the same tribal group or from money lenders. Such credits system have not been utilized efficiently due to people's sense of dislike for a debt as a traditional notion.

6) Uneven Land Holding

Though large scale farmers with more than 20 ha farms is minor in number, they occupy some 42 % of the total farm area. Uneven land holding is recognized in the Study Area. There is a virtue of tribal custom in the Study Area, on which the large scale farmers look after the small farmers as masters of their tribe. This results into an uneven distribution of wealth.

7) Unregulated marketing system

A large amount of fruits is exported to other provinces at harvest time. After several months of storage there, the fruits are re-imported to Balochistan during the season when higher price is expected which is due to lack of capacity of cold storage capacity in Balochistan. Furthermore, most farmers make contract with pre-harvest contractors at the blooming time of fruits. The pre-harvest contractors manage the orchards at their own expenses till harvest time and market the fruits.

8) Undesirable influence of traditional tribal system

In the villages of the Study Area, traditional tribal custom still remain so deeply in their communities that a few people in ruling class have big powers and control the communities.

9) Extreme low level of literacy rate

Literacy rate, especially in rural areas, is very low and educational conditions are poor. It will take the great efforts and long periods to resolve such a situation. The low literacy will hamper to beneficiary's execution of groundwater use control, and enhancement of sense of saving water.

10) Low status of women

The status of women in the society is very low and their living situation is very poor. Despite her hard work in daily life, women have not been justly recognized for their great contribution to the community.

11) Delay of social infrastructure services

The population growth rate in the Study Area is considerably high in comparison with the national average. The preparation of rural infrastructure still lag behind due to the low population density and very scattered dwelling.

Moreover, institutional draw backs such as lack of cooperation between various agencies are still major constraints for development, despite the endeavor by P & D Department of GOB to renovate.

6.3 Regional Development Policy

Basic regional development policy is to enhance sustainability in the Study Area of space for living, producing and resting. In this Project, the sustainability shall be directly and indirectly sought by means of construction of delay action dams.

Clearly contribution of the delay action dam scheme in the present circumstance is recognized for improving domestic water supply conditions. Delay action dams increase groundwater availability to be used for domestic water purposes by enhancing groundwater recharge. Furthermore, the dams may improve the groundwater basin in quality of water by improving hydrological cycle of groundwater. Contribution of the delay action dam scheme aim at creating condition for improving agricultural productivity by increasing the supply of irrigation water and livestock production through by making water available all the year round. Additional increase of agricultural production is expected if farmers organization and extension services are strengthened. Furthermore, recreation spaces will be created by making water-front appearance through construction of delay action dams. Providing watershed conservation together with delay action dam construction would further enhance, establishment of spaces for living, producing and resting.

On the basis of present situation mentioned above, following items will be taken into consideration for preparation of the development plan:

1) It shall be recommended to execute the regulation of unorganized and limitless use of groundwater, and to promote efficient use of groundwater through the rational water management.

2) It is so difficult to introduce immediately the planning concept based on the modern social structure. Planning shall be done taking into consideration of the traditional tribal customs.

3) On the basis of the current education level in the Study Area, the agricultural development plan shall be prepared to be accepted easily by the beneficial farmers.

4) Operation and maintenance plan of the Project facilities shall be prepared not to force the beneficiaries to work with highly advanced and complex specification.

5) The development plan shall not force the women to much harder works.

6) The participation of the beneficiaries in the Project shall be promoted in order that they confirm the project as one being implemented for themselves.

7) The necessary recommendation shall be made to promote the rapid construction of the rural infrastructure concerning closely with the Project.

8) Administrative structure shall be strengthen to be effective without wasteness, under the appropriate development plan harmonized with severe natural condition, and adequate recommendation in consideration with peculiar social situation in the area. Especially, the institution which can enhance water management accompanied with groundwater use control effectively, shall be proposed in the Study.

6.4 Agricultural Development Strategy

Agricultural development strategy in the entire-study-area is to promote sustainable agriculture and livestock with due consideration for the present natural conditions. Proposed delay action dam will contribute to make present irrigation practice sustainable against extending irrigable area with newly developed groundwater. Along with this, agriculture including present cropping pattern needs to be improved by promoting agricultural extension, strengthening framers organization and elevating availability of agricultural credits, so as to make effective use of limited water.

In search for better cropping pattern, irrigation water requirement, profitability, marketability, required labor force, and suitability of soil and climate etc. should be considered. In case profitability is the only goal, orchard cropping is much profitable rather than others, as far as available water is limited. According to the farm economic survey in the Study Area, farmers cultivating mono-serial are in lowest income group, farmers with vegetable cultivation are ranked middle, and orchard farmers are at the top. It is, therefore, proposed to shift mono-cereal to a pattern including vegetables, and to shift the pattern with vegetable cultivation to a pattern introducing fruits. However, too much of a shift toward orchard cultivation is not realistic, and not sound in agriculture, even though highest income could be expected. A time lag between planting and growing of trees for harvesting fruits need to be considered in farm economy. To set the cropping pattern, marketability, availability of labor force, soil suitability, farmers intention besides profitably have to be considered. Considering these factors for cropping pattern, a trial study was done to obtain recommendable cropping pattern in each district in the Study Area as follows:

	Quetta	Pishin/Qila Abdullha	Mastung/Kalat
Orchard	40-50 %	25-35 %	10-20 %
	(42%)	(23%)	(11%)
Vegetables	20-30 %	20-30 %	30-40 %
	(25%)	(21%)	(27%)
Cereals	20 30 %	35-45 %	35-45 %
	(29%)	(54%)	(52%)
Fodders	5 -10 %	5 -10 %	10-15 %
	(4%)	(2%)	(10%)

Comparing the present cropping with the above, Quetta and Pishin have already attained the recommended pattern, Mastung and Kalat are still behind the target. Referring these result, an improved cropping pattern will be proposed to allocate limited water resources more effectively without not increasing present irrigation water requirement.

Further, extension services for farming technology is required. In the farm economic survey in the Study Area, big difference in income was found in each farmers group categorized by cropping pattern, which seems to be due to knowledge of farmers' agricultural technology. Even among the farmers practicing fruits cropping, there is a variation in their income by their agricultural skills, application of chemicals, and so on. Vegetable farmers group is also showing same variation. These evidences show that introduction of improved technology through extension services and strengthening of agricultural credit to enable the farmers to use agricultural materials and hire labor is essential.

There is little relationship between better quality and higher value in agricultural products in the Study Area, and it is almost true about the whole country. However, if this relationship is recognized more widely in the area, it is possible to get the same return with reduced cultivated area, which will contribute to save water in the area.

Livestock production is also one of the important agricultural activities in the area. Fodder crops should be incorporated properly in the cropping pattern to enhance livestock production of the area. Besides fodder crops from cultivated fields, natural vegetation is also used as animal feed resource. Due to sparse density of the vegetation, the land tends to be overgrazed which may cause deterioration of the grazing land and severe soil erosion. To encounter the land degradation, range land management will be necessary measures along with watershed management. In the Study Area, around 8 % of crop intensity has been shared for fodder cultivation. According to the analysis for feed balance, 50 % of required fodder of animals in the Study Area, has been obtained by grazing. In comparison with allowable quantity of grazing to be sustainable, fodder production is recommended to increase to maintain the same head number of livestock in the area.

In pursuance of EFYP, the Government of Balochistan have directed their extension efforts towards increasing milk and carpet wool production, increasing per animal productivity by raising body weight, introducing new fodder varieties, and substantially reducing number of sheep and goat. Following this concept, promotion of livestock having no mal-effect in natural environment is recommended by means of restraint of number of sheep and goat, and increasing cropping area for fodder with introduction of new varieties.

As mentioned in Section 3.7.4, the existing agricultural cooperatives are insufficient for development of agricultural production. A very small number of farmers joins cooperatives, as most of the cooperatives are lacking financial and human resources. In addition, the traditional tribal structure of rural communities, that are ruled by the village chief and a few elders, are not appropriate for cooperative activities. Furthermore the contractors or wholesalers have the strong powers in the marketing of the agricultural products, especially of fruits.

To strengthen agricultural cooperatives, these will have to be expanded to increase its members. A federation of cooperatives has to be established at district or division level to enhance the powers of the unit cooperatives. The provincial government should induce farmers to join the new or improved village cooperatives and make village cooperatives organize the federation. The active and powerful federated cooperatives must be able to lift up the socio-economical standing of rural farmers.

The traditional irrigators' associations mainly for the maintenance of karezes have recently been weakened due to the development of tubewell irrigation. However most of tubewells are installed privately and none of the modern water user's association for the use of groundwater are found in the Study Area. The use of groundwater for irrigation should be strictly regulated to prevent the decline of the groundwater level, and along with the construction of delay action dams, efficient water use on farm should be adopted. Otherwise, no matters how many delay action dams were constructed, the raising of groundwater level would not be realized due to continuous excessive consumption of groundwater. It is, therefore, essential that farmers recognize the critical situation of groundwater resources, and act to improve the current inadequate irrigation farming by themselves. The provincial government should also make farmers establish the modern water users' association by irrigated farm area to achieve the scheduled and reasonable use of groundwater.

6.5 Irrigation and Drainage Development Strategy

Surface irrigation methods have been widely practiced in the Study Area. Rapid lowering of groundwater table in the basins seems to be caused by low irrigation efficiency which is 40 to 50%. This calls for introduction of modern irrigation methods such as drip irrigation which has been successfully attempted by the Agricultural Department. Electricity consumption will also be saved by improvement of irrigation method. However, it should be kept in mind that major water loss during irrigation returns to underground. The high investment on drip irrigation may, therefore, be not justified in all cases as the net water saving may be small.

In a conclusion for this matter, surface irrigation method may be changed to new irrigation method where hard-soil with low permeability is encountered, and where available electricity is limited, or groundwater stage is to be quickly stabilized.

Regulation pond constructed with tubewell is recommended for wider acceptance. Many existing regulation ponds in the Study Area with night time irrigation capacity are effectively used both for irrigation and domestic water supply. Some farmers have experimentally introduced drip irrigation in the Study Area, but this has not worked very successfully due to lack of knowledge of farmers. For the introduction of new irrigation method such as drip irrigation, farmers' understanding about its necessity and the technology is necessary.

Drainage can be categorized into surface drainage, flood water drainage, and groundwater drainage the best one is a major countermeasure against saline harm. Since there is no problem of surface drainage in the Study Areas, no such facilities are proposed. Some flood way should be provided against flood flow. Drainage module at 52 liter/sec/ha for 5 year return period's rainfall of 20.9 mm/hr is expected. Construction of drainage channel against flood is recommended where there is no suitable natural drainage channel.

Generally speaking, groundwater drainage is necessary corresponding to irrigation practice in order to mitigate saline harm and water-logging where groundwater level is considerably high. However, no groundwater drainage is required in the Study Areas because groundwater table is low due to over exploitation, that no saline harm has been found in the Study Area.

6.6 Groundwater Development

6.6.1 Groundwater Development by DAD

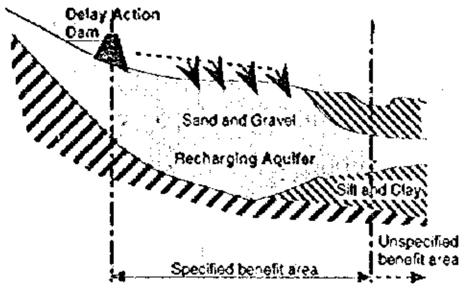
Groundwater use in the Study Area is under critical situation due to extreme over-exploitation. Delay action dam is an effective measures to enhance recharge of groundwater if it would be planned adequately at the suitable site, and designed satisfactorily. More delay Action dams are proposed to be constructed in the Balochistan Province, especially in the Study Area.

Irrigation area is not expected to be increased due to limited water availability even if proposed delay action dams are constructed. The present irrigated area is also not sustainable if the groundwater basin is continued to be exploited indiscriminately by the ever increasing number of tubewells. Certain new additional water source is therefore required to make the present irrigation water use sustainable. Recharged water by the delay action dam may be enough to prevent the lowering of groundwater level. Delay action dams may be spread over a wider area within basin against isolated specified beneficial area for continuity of groundwater. While agricultural land located downstream of proposed delay action dam in close proximitly is more convenient for use of recharged groundwater rather than remote lands in the same basin, benefit of groundwater availability after construction of delay action dam for other areas with in the same basin can not be neglected.

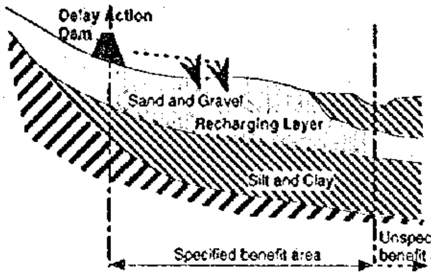
Delay action dam scheme should not be considered as dam construction activity only, but should be dealt with along with a comprehensive package program consisting of necessary components so as to obtain sustainable effects in harmony of those components, in which delay action dam construction is a keystone. The components are watershed conservation, improvement in irrigation practice, groundwater use control and innovation of agricultural structures. While each component is significant within the delay action dam packaged scheme, it can be expected to contribute independently as designated in the five year development plan of Balochistan Province as shown in Fig. 6.7.1.

6.6.2 DAD Patterns by Shape of Aquifer

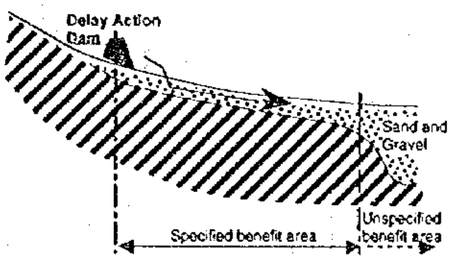
Mechanism of groundwater recharge by delay action dam depends upon shape of dam site and characteristic of aquifer extending downstream. Effective recharge could be fulfilled through the recharging devices meeting with characteristic of aquifer. As mentioned in Chapter 4, each proposed delay action dam has different form of aquifer being different in availability of groundwater and using method of groundwater exploitation. Aquifers concerned with proposed delay action dams may be categorized in a broad way into 3 patterns as shown below.



Type I : to recharge to an aquifer for tube-well use



Type II : to recharge to an layer for shallow-well and kareaze use



Type III : to infiltrate to an layer for kareaze use

As to these categories, Type I has a clod of thick unconfined aquifer extending downstream where many number of tubewells were dug. Six proposed delay action dams, namely, Brewary, Wali Dad, Dara, Murgi Kotal, and Kad Kocha are in this category. Type II has cramped and shallow aquifer than Type I, in which shallow-wells and karezes are available. Three proposed delay action dams, namely, Sakhol, Samaki, and Ghutai Shela are in this category. Type III is under poor condition in groundwater use because of no aquifer downstream. In this Type, only irregular karezes are available collecting sub-surface water flowing through riverbed layer. Five proposed delay action dams, namely, Kach, Jigda, Sanzali, Ghazlona, and Iskalkoo are in this category.

Delay action dams to be constructed at the sites for the Type I aquifer shall contribute to recover groundwater use by existing tubewells, and Type II aquifer will help karezes and shallow-wells. For the Type III, sub-surface water use by existing karezes may be improved as a specified beneficiary. Beside this effect, recharging outcome can be expected on the aquifer located far downstream as a unspecified benefit.

At present, delay action dam site selection by the Irrigation Department, is done by topographical condition for economical dam construction. Rechargebility of the site seems to be of secondary importance. Some dam sites were approved for construction, for flood mitigation with small rechargebility characteristics. Selection of dam sites of proposed delay action dams of the Study follows the PC-I prepared by the Irrigation Department. In this Study, only minor modification on dam sites will be done, and the suitability of dam site will be determined by project evaluation.

6.6.3 Rechargeable Quantity of Groundwater

Groundwater recharge contributed by delay action dam is categorized into two types. One is a recharge from reservoir bed and another is downstream recharge in the fan for the later water is supplied through conduit installed under the dam body. Each recharge volume of water is subject to hydrogeologic characteristic of related groundwater layer, scale of reservoir, dam facilities, rainfall pattern, and reservoir stage. In order to estimate recharge volume, a dam operation study is required to be conducted.

The dam operation study was done to calculate reservoir stage monthly, by input of runoff into reservoir from catchment, and outputs of evaporation from reservoir water surface, recharge from reservoir bed, and releasing water for downstream recharge. Runoff from catchment is neglected when reservoir is full of water. And no evaporation and recharge occurs when reservoir is empty of water. Runoff from catchment was estimated by actual rainfall multiplied by runoff factor which vary from 8 % in summer to 15 % in winter. Evaporation calculated by Penman method was used in the dam operation study.

Recharge from reservoir bed was estimated in consideration with characteristics of dam foundation layer for permeability and stage of reservoir using results of seepage analysis. For this estimation of the seepage from reservoir bed, the effect of siltation was considered which decreases permeability of reservoir bed corresponding to increase of siltation in the reservoir. Recharge on downstream area was estimated in consideration with the area spread and its characteristic of permeability. Such downstream recharge was also calculated by estimated discharge of pipe which was related to condition of reservoir stage.

Dam operation study was conducted using conditions as shown in Table 6.6.1. Recharge volume of water was calculated through the study simultaneously obtained reservoir stage time to time. Annual expected recharge volume of water is as follows:

Annual Recharge Volume

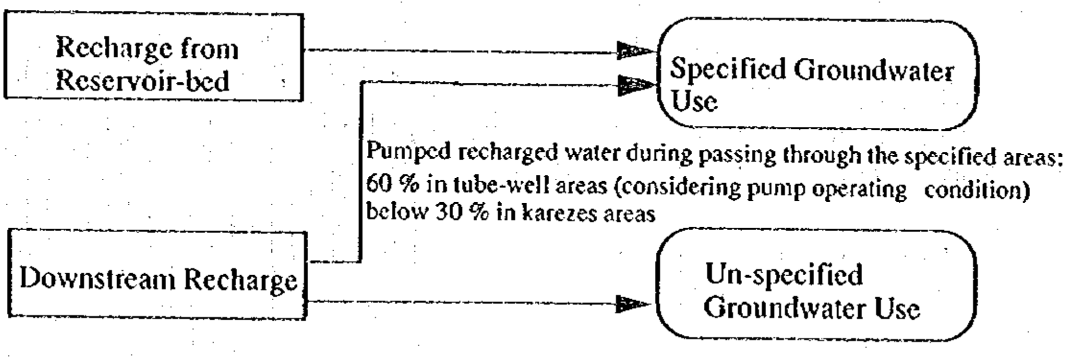
(1,000m3/Year)

	DAD	Recharge Volume		DAD	Recharge Volume
1	Breway	510.2	8	Sanzali	213.3
2	Ghutai Shela	31.4	9-1	Ghazlona	140.7
3	Wali Dad	137.9	9-2	Samaki	57.8
4	Dara	389.5	10	Sakhol	206.1
5	Murgi Kotal	394.5	11	Mangi	1,091.3
6	Kach	1,147.0	12	Kad Kocha II	508.9
7	Jigda	528.0	13	Iskalkoo	109.3

6.6.4 Groundwater Use Plan

Delay action dams are further categorized into specified water use and unspecified water use. The specified water use is using recharged groundwater for specified beneficial area located downstream of the delay action dam in short distance. Unspecified water use is an utilization of water in the concerned groundwater basin, by any beneficiary or for any purposes of agricultural use and drinking use. In this Study, quantity of recharged groundwater for the specified water use is estimated considering the physical possibility to reach the specified area. Remaining recharged water consisting of the downstream recharge other than used for specified water use, and recharge water from reservoir bed, is appropriated for unspecified water use.

The division of downstream recharge into specified water use and unspecified water use is though difficult yet, it may be simplified. The recharged groundwater by delay action dam is supposed to flow toward direct benefit areas, and diffuse widely to other areas. Pumped water by existing wells in the specified benefit areas within the total recharged water flowing toward these areas is defined as a quantity of recharged groundwater on specified benefit. Recharged water diffused out of the specified benefit areas, and recharged water passing through the specified benefit areas without being pumped even flowing toward the areas, are defined as the recharged water for unspecified benefit. Even the usable recharged water flowing toward the specified areas will not be availed in the areas if wells are not operated. Following this situation, pump operating duration can be regarded as the availability ratio for specified beneficial use. For the karezes use, the availability ratio for specified beneficial use may be bounded out by aerial ratio of affected range of karezes. The understanding for definition of the groundwater use is schematically shown below.



Definition of the Groundwater use

Based upon these considerations, available quantity of recharged water for specified groundwater use and unspecified groundwater use were estimated as follows:

Available Quantity of Recharged Water

(1,000m3/year)

	DAD	Specify	Unspecified		DAD	Specify	Unspecified
1	Brewary	306.1	204.1	8	Sanzali	34.0	179.3
2	Ghutai Shela	15.0	16.4	9-1	Ghazlona	41.4	99.3
3	Wali Dad	82.7	55.2	9-2	Samaki	17.0	40.8
4	Dara	233.7	155.8	10	Sakhol	98.4	107.7
5	Murgi Kotal	188.6	206.3	11	Mangi	654.8	436.5
6	Kach	407.4	739.6	12	Kad Kocha II	305.3	203.6
7	Jigda	84.1	444.0	13	Iskalkoo	32.1	77.2

6.7 Development Components

In pursuance of the integrated development concept in which delay action dam construction is a keystone, the other components are watershed conservation, improvement in irrigation practice, groundwater use control and innovation of agricultural structures. While each component is significant within the delay action dam packaged scheme, it can also be expected to contribute independently as designated in the five year development plan of Balochistan Province as shown in Fig. 6.7.1.

Watershed conservation is the most important matter in the Study Areas even in the relation with groundwater recharge. Artificial intervention in watershed such as tree felling or grazing seems to have caused essential watershed destruction. The first and the foremost important issue is the regulation of artificial activities in watershed. As application of the regulation is an individual concern, participatory approach is the shortest and most effective route. Although watershed management with participatory approach is not the subject of this Study yet, the Study Team would seek to joint with other watershed management program to emphasize it importance for water conservation.

Watershed conservation component in the Study shall be specified within the watershed concerned in proposed delay action dam schemes. Furthermore, the elements of watershed conservation shall be specified, which contribute to water feeding or environmental improvement and to make dam life long by means of reducing siltation. Facilities in the component are vegetation cover and construction of check dams. Range management in the area downstream of the proposed delay action dams seems to be a possible to intervention.

Most essential constraint on irrigation in the Study Areas are shortage of groundwater resources. This project shall seek to mitigate this constraint in particular, and no other remarkable constraints are recognized in irrigation field. As present irrigation practice can mostly be adopted in future, no remarkable development components are necessary to propose as long as water availability is enhanced. No drilling of tubewells are proposed from now on with the exception of replacement of existing wells. Karezes which can still function and can possibly be maintained in future by their beneficiaries organization, are proposed to be rehabilitated within this Project.

Flood control by delay action dams will be conspicuous. Such benefit consists of reduction in flood damages of agriculture and infrastructure. Only some additional facilities for catching runoff from adjacent catchment and diverting to beneficial area are proposed.

Constraints in agriculture in the Study Areas are, insufficient agricultural extension services, poor establishment of cooperatives, week agricultural credit system, lack of storage facilities for agricultural production, and unregulated marketing system. As some constraints have deep global roots, countermeasures should be taken on global scale such as district level, division level or provincial level, against handling these in development plan of each delay action dam program.

The agricultural component of delay action dam scheme is limited the karez level to strengthening of farmer's organizations considering tribal custom and its system with respect. The existing farmer's organizations are expected to be strengthened to maintain and operate the delay action dam facilities, to interact with agriculture extension, and to be a global regulatory body for groundwater use control.

6.8 Groundwater Management

6.8.1 Operation and Maintenance

Laborious operational work as well as maintenance work are not frequently required for the dam embankments and appurtenant structures proposed in the Study. However, periodical O&M works, and consecutive beneficiaries' activities enumerated below may be encouraged. Proper O&M plan with participation of the beneficiaries, the Irrigation Department and other governmental agencies relevant to the project is conceived during the project implementation.

O&M Activities and Responsible Agencies

O&M activities	Description	Responsible agencies
(Dam and reservoir)		
Dam embankment	1)	Irrigation Department
Reservoir	Dredging	Irrigation Department, beneficiaries
Catchment area	Vegetation control, etc.	Relevant agency, beneficiaries
(Transmission structures)		
Recharge control valves	Operation, as required	Irrigation Department
Maintenance of karez, pond	Periodical cleaning works	Farmers association
Maintenance of tube wells	Operation and repair works	Owners
(Technical transfer)		
Agricultural extension service	Ordinary	Agricultural Department
Technical support for irrigation	Ordinary	Irrigation, Agricultural Department
(Others)		
O&M for other facilities	Emergency repair	Irrigation Department

Notes: 1): details in "Planning and Design Guideline for Delay Action Dams"

It is not practicable for the delay action dam project to collect water fee according to its characteristic as a public service, and no cost recovery for the investment can be imposed on any beneficiary due to difficulty of specifying beneficiaries clearly. However, beneficiaries participation is inevitable to accelerate watershed management and to encourage O&M activities on water transmission lines.

6.8.2 Water Management Plan

1) Importance of groundwater management

Although the Government of Balochistan has established the ordinances on irrigation development including groundwater management as mentioned in Section 3.10, appropriate enforcement of the ordinances for the control of groundwater extraction is difficult due to the following reasons.

- Publicity media to the populace and monitoring system on groundwater crisis are poor in the province, and public participation to recover from the crisis is very weak.
- Appropriate implementation of the basin wide water management decisions is difficult due to the lack of a master plan on provincial basin wide groundwater resources development in the province.
- Coordinating function of the authorities on groundwater management is not strong to build up public consensus on equity concept of water right.
- Groundwater extraction right belongs to the owner of the land in the Islamic traditions, and it is not adaptable concept that groundwater is collective resources for public.

In this situation, various groundwater development studies have been conducted by related agencies, and it is said that the solution of the problem can not be achieved by only irrigation, because the depending groundwater in the basin is collective property of the basin populace including other competing water users.

Balochistan Groundwater Resources Reassessment, 1996, ADB, one of the prominent reports is recommending policy measures to be newly introduced as follows:

- The prime concern of any policy document which is created to assist in optimizing use of water resources should be that there is equitable distribution to all consumers.
- Water can no longer be provided free of charge. However, a working and extensive distribution system has to put in place before a charge is made.
- A water awareness campaign has to be established using all facets of the media, wastage of water has to be considered a crime against the community.
- An Integrated Valley Development Authority (IVDA) has to be established to control all aspects of supply and demand. Local representation also necessary.
- In areas where there is a deficit, existing or potential, the IVDA would be responsible for decisions about allocation of the resources between competing priorities.

There are two mutually supporting measures on the efforts to mitigate the critical groundwater problems. One is generation of additional water resources including delay action dams program, and another is water saving by means of efficient groundwater utilization on equitable basis.

In places where the excessive groundwater is under extraction, groundwater table is continuously going down (about 1 to 2 m/year) heading toward a running out of water, the on-going delay action dams project is not the ultimate selection due to its limited magnitude.

Consequently, strong institutional measures on the groundwater control are inevitable to recover groundwater resources for sustainable basin wise regional development, until a gigantic trans-basins water transfer project is realized.

Conventional approach by the line ministries with vertical administration completely lacks coordination. The institutions with dictatorial approach are not always accepted by the communities. An organizational revision and strengthening of coordinating functions at provincial and basin level will be needed to obtain a comprehensive and participatory response from relevant communities.

Water resources development plan including equity will be studied based on the evaluation of available resources in each basin. Education and mobilization of communities will be necessary to comprehend that the groundwater resources are scarce and fragile. Through communications with the government agencies, they will understand the necessity of collaboration on the establishment of groundwater management program which is equitable and sustainable. The established program participated by the communities will be vital for the enforcement of the ordinance on water management.

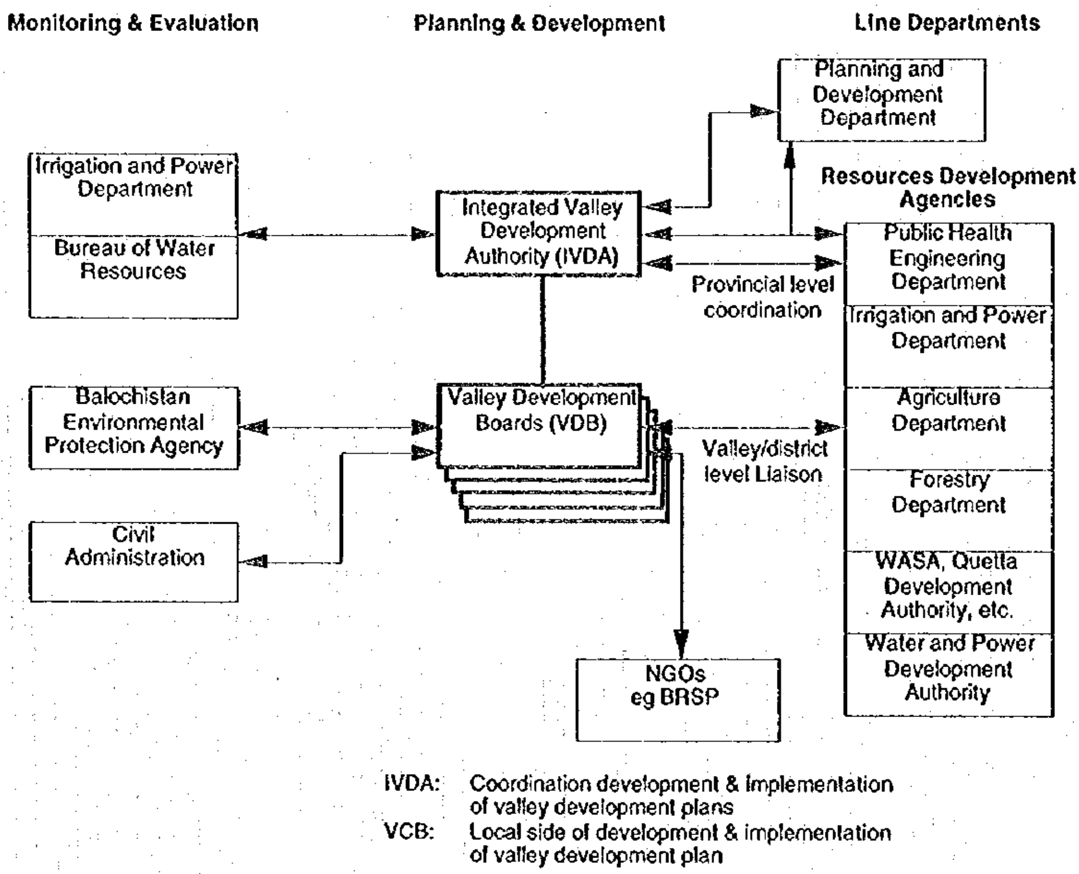
Water conservation plan for sustainable groundwater use will be elaborated together with operation of the groundwater recharge scheme taking account of excessive groundwater abstraction in the Study Area. To achieve water conservation strategy given above, monitoring on the groundwater level and restriction on additional tubewell installation, as well as restriction of groundwater use by existing tube wells, are expected to be realized by the following institutional reforms.

2) Institutional reforms

The objectives of this Study are to carry out a feasibility study on the irrigation water resources development with delay action dams project, and contribute to improvement of the quality of life in rural community in Balochistan. To realize this objective, an institutional reforms on the groundwater management are considered in this Study, because the sustainable agriculture in Balochistan is surely dependent on the sustainable groundwater resources which will be promised by the judicial operation of groundwater management.

It is recommended to establish responsible agency (e.g., IVDA) aiming at proper surface and subsurface water management in whole of Balochistan Province. The agency is responsible for monitoring of groundwater shortage, encouragement of water conservation, planning of sustainable groundwater use program, legislation of groundwater exploitation, restriction of groundwater use, monitoring groundwater quality, coordination of related agencies concerned with the groundwater development. Institutional chart is proposed below which coincides with a proposal presented in the Groundwater Re-assessment Project by ADB in 1995.

The proposed agency of IVDA will establish sub-agencies of Valley Development Board (VDB) in each district chaired by the Deputy Commissioner (head of district), and the VDBs will be responsible for all basin policy and planning decisions, and representatives from all sections of the community will sit on the Board. The aim of the Boards should be to provide a clean water supply to all members of the community located within the basin and make decisions about alternative uses for other water using commercial and public service activities as and where appropriate. The IVDA and VDBs should also be responsible for resolving conflicts or potential conflicts between the water resource demands of different sectors of the community. Planning should aim to identify and resolve, any potential conflicts before they arise. Both inter basin and intra basin conflicts must be identify and resolved, by mutual agreement between the authorities, the boards and especially the regional and local communities. The organization structure is figured as follows:



Recommended Integrated Valley Planning and Development Organization

6.9 Environmental Conservation Strategy

Environmental conservation in the Study Area should be based on "Balochistan Conservation Strategy (BCS)". Although BCS has not been announced officially yet (as of December 1996), BCS Unit organized in the Urban Planning & Development Department is planning the process, institutional arrangement and completing the documents so as to establish the substantial and realistic strategy.

The BCS, which based on "National Conservation Strategy (NCS)" published as environmental conservation policy and measures on national level in 1992, will be established on provincial level to achieve the rehabilitation of natural environment and the improvement of human environment in Balochistan. In the concept paper for BCS prepared by BCS Unit, it is inclined a basic policy as well as major environmental problems of Balochistan, urban environmental problems, potential industrial pollution and legal and institutional issues are recognized. Corresponding with the concept, outline of environmental conservation plan in the Study Area should be considered as follows:

1) In order to resolve the water issues of natural environment and to ensure the sustainable use of groundwater resource, a comprehensive package programme to avid or slow down the decline of groundwater level should be implemented.

2) In order to improve the vegetation of natural environment and to ensure the sustainable use of fuel and feed resources, a comprehensive rehabilitation package programme to mitigate or control the degradation of rangeland should be implemented.

3) In order to conserve topographical and geological condition of natural environment and to improve the social, life and health issues of human environment, watershed management project such as soil erosion and loss control to reduce flood damages caused by flush flood should be tackled.

4) In order to protect soil fertility and water quality of natural environment and the health issues of human environment, education and training programme to introduce the appropriate use and maintenance of persistent pesticide and/or nitrogen fertilizer should be touched by skilled staffs and farmers.

5) In order to protect and preserve the total bio-diversity of the fauna and flora, habitat and ecosystem issues of biotic environment, legal and institutional arrangement to control the decline in bio-diversity should be considered.

In the concept paper it is stressed that institutional setting for BCS is not through the conventional department approach but through the consultation and collaboration of adequate inter-sectional or between public and private institutions, NGO's and communities.

Although BCS has not established, some organizations such as international agencies, banks, donor countries and NGO's have already prepared a conservation project or programme for Balochistan, consulting NCS. Out of above-mentioned plan, items of number 1 to number 4 have just been practiced in "Integrated Area Development Programme (IADP)" by Food and Agriculture Organization (FAO), and number 5 has been attempted in "Balochistan Natural Resources Management Project (BNRMP)" financed by World Bank. These programme and project have contributed to the environmental conservation considerably in the Study Area. As referred to Section 2.5, IADP comprises five on-going projects which aim at conservation of natural resources and the improvement of human environment. The programme has been emphasized the role as comprehensive package programme mentioned in number 2. BNRMP includes institutional arrangement related to environmental conservation and attempts to protect the bio-diversity including improvement of Hazarganji - Chiltan National Park.

In this Study it is necessary to establish effective plans in order to attain improvement of environmental situation and to avoid negative impacts caused by the construction of dams. Delay action dam construction can be recognized as a component for a comprehensive package programme mentioned in number 1 of the outline of environmental conservation plan. Number 3 coincides with the major objectives of the DAD projects. Above-mentioned items of number 2 and number 4 should be practiced through the proposed Integrated Valley Development Authority (IVDA) which is new agency recommended as an institutional reforms of the operation and maintenance plan established in the Study, being involved as environmental conservation component for the DAD projects. Therefore, environmental conservation component for the DAD projects established in the study corresponds with the outline of environmental conservation plan, and contributes environmental conservation in the Study Area.

As a result of the above consideration, environmental conservation plan for the DAD projects can be summarized as follows:

1) It is expected that effective groundwater recharge by means of DAD mitigates serious decline of groundwater level. It implies that groundwater resources availability is enhanced. In order to ensure the availability of water, proposed IVDA should execute adequate water management, and attain the sustainable use of groundwater resource.

2) DAD mitigates and controls serious flood damages. Soil-saving facilities such as detention bund, check dam and counter trench should be considered in order to reduce soil loss. This plan is necessary for protection of topographical and geological condition of natural environment and improvement the social life and health issues of human environment.

3) In order to reduce soil erosion and loss, proposed IVDA should consider comprehensive rehabilitation programme for the rangeland, recognizing the approach, progress, results and work plan of "Integrated Range and Livestock Development Project" executed by FAO. This plan is important for conservation of the vegetation of natural environment and establishment of the sustainable use of fuel and feed resources.

4) In order to reduce the deterioration of soil and water quality, proposed IVDA should strengthen education and training programmes to introduce the appropriate use and maintenance of persistent pesticide and/or nitrogen fertilizer to the concerned staffs and farmers, referring the approach, progress, results and work plan of "Outreach and Transfer of Fruit Technology in Balochistan" executed by FAO. This plan is important for conservation of the vegetation of natural environment and establishment of the sustainable use of fuel and feed resources.

5) Proposed IVDA should appreciate the progress, results and work plans of "Balochistan Natural Resources Management Project" executed by World Bank in order to avoid negative impacts of the construction or rehabilitation of DAD against the total bio-diversity of the fauna and flora, habitat and ecosystem issues of biotic environment.

6.10 Implementation Program for Delay Action Dam Schemes

The Irrigation Department, Balochistan is responsible for the implementation program of the delay action dams. To properly implement the program, the following are to be settled according to the present constraints during the project implementation.

1) Effect of the delay action dams is not accurately evaluated, and technical criteria for the dam planning and design is not available.

2) Study on the dams structure and recharge method is insufficient due to a enough shortage of budget. Limited number of the dam construction is not to meet water requirement, and the dam construction is not properly achieved in line with the specification.

3) Construction machinery and equipment owned by the Irrigation Department and contractor are insufficient to properly achieve the construction works.

4) Because of a lack of the construction engineer, proper construction supervisory work is not attained during the construction period.

5) Budget for the operation and maintenance works for the completed dams is not enough to ensure the dam operation.

6) Monitoring plan regarding groundwater recharge through the dam is not yet established, and no effort is made to accumulate data and materials in terms of dam planning, designing and construction method.

In above constraints, 1), 4) and 6) are able to be improved referring to the technical guideline prepared in the Study. For the matter of 6), data accumulated through continuous groundwater level observation in and around typical existing delay action dams should be examined and reflected in planning, designing and constructing for further delay action dam schemes. These task should be conducted by the Bureau of Water Resources. As to 3), it is suggested that the

Irrigation Department should elaborate the construction plan as well as optimization of the construction schedule by means of appropriating construction machinery together with technical and financial assistance of the foreign donors.

As explained in paragraph 2.4, most of construction machinery possessed by the Irrigation Department has been worn out. In addition, the contractors have insufficient machinery, so that proper construction can not be performed due to deterioration of their working capacities. With respect to this, it is recommended to procure the construction machinery and equipment for earth, transportation, concrete and other temporary works aiming at improving construction plan and quality control, etc. The concept on the machinery selection and required number is given below in due consideration of the experimental construction of the delay action dams, and proposal given in PC-1. Reference is also made to the long-term budget allocation prescribed in the Eighth Five Year Plan (1993-1998) of the Balochistan Government.

(Number of machinery and equipment)

Several alternatives in terms of specification and combination of the construction machinery and equipment are proposed depending on the construction period of the each dam, especially in the case that multiple dams are simultaneously constructed.

According to PC-1, amount of Rs. 400 million is estimated for the proposed 66 delay action dams, and amount of Rs. 305 million is allocated for the delay action dams in the Eighth Five Year Plan. In relation to the above, 50 dams in five years, say 10 dams per annum can be constructed from the financial point of view. Meanwhile average embankment volume is estimated at 110 thousand m^3 a dam, total 550 thousand m^3 embankment is completed per annum. Specification and combination of the construction machinery and equipment should be determined with respect to these assumptions.

(Specification of machinery and equipment)

1) River deposits are mostly utilized for the embankment of the fill dams. The materials are excavated and hauled by the bulldozer to economize construction cost. When the embankment volume is larger, hauling distance becomes longer, and consequently material loss during hauling is not negligible. Furthermore relatively large size of materials are accumulated in the embankment. To uniform the embankment materials, dump trucks are proposed to haul the materials. Dump trucks are available for the material hauling from the borrow area located far from the dam site and for those produced from spillway excavation.

2) Field moisture content of the embankment materials is mostly on the dry side of the optimum moisture content, so that moisture content shall be adjusted by means of water sprinkling, etc. Mixing of pervious and impervious materials is required for the dams which has impervious zone in the embankment. For these works, earth moving machinery for material loading and hauling are required.

3) Tamping roller and vibratory roller are required for the materials of clay and sand-gravel, respectively. Contact clay must be constructed on the boundary between foundation of dam abutments and embankment to mitigate seepage

through the boundary, thus hand-tamper is used for the compaction of the contact clay.

4) Existing road located in the dam and required area should be replaced during the dam construction. Motor grader is suitable for spreading and surface smoothing of the pavement and sub-grade of the roads.

5) Cargo trucks are required for material and equipment transportation. Truck with optional crane is also useful for loading works. Mixer truck and dump truck are required for concrete hauling.

6) Concrete plant is inevitable for the gravity dam , spillway and stone masonry works. Plant capacity is determined in conformity with concrete placing plan.

7) Water supply facilities is necessary for moisture adjustment of the earth materials, concrete mixing, etc. In the case that the surface water is not available, groundwater shall be pumped up by the tubewell, as well. Generation facilities are also required for water supply facilities and other purposed.

Soil Tests for Dam Embankment

Items	Test Items	Objectives
Physical properties	Specific gravity	Basic data to analyze soil test results
	Water content	Soil properties (compression, strength)
	Grain size analysis	Uniformity coefficient, permeability, average grain size
	Liquid limit, plastic limit	Classification of soil
Dynamic properties	Compaction test	Utilization to compaction criteria
	Permeability test	Permeability to determine compaction criteria
	Unconfined compression test	Bearing capacity of dam foundation
	Triaxial compression test	Dam stability analysis
	Direct shearing test	- ditto -

Table 6.6.1 Estimated Rechargeable Water

Expected Recharge Water of Proposed Delay Action Dam Sites

Name	H.W Depth (m)	Length of G.layer (m)	Permiability of Reservoir (cm/s)	Seepage (m3/day)	Flowing width (m)	Flow reach (m)	Permiability of riverbed (cm/s)	Rechargeble water (A) (m3/day)	Transmissibility (m2/day)	Width of Aquifer (m)	i	Rechargeble water (B) (m3/day)	Rechargeble water (m3/day)	Seepage Max (10^3m3/M)	Re water downstream (10^3m3/M)
1 Brewary	12.00	6.0	2.50E-03	35.3	3.0	500	2.50E-03	3,240.0	90.0	1,200.0	0.2440	26,352.0	3,240.0	1.06	97.20
2 Ghutai Shela	4.40	30.0	9.50E-03	189.4	3.0	1,000	9.50E-03	24,624.0	45.0	1,000.0	0.1070	4,815.0	4,815.0	5.68	144.45
3 Wali Dad	40.00	50.0	1.26E-04	107.6	3.0	4,000	1.00E-03	10,368.0	60.0	2,600.0	0.0450	7,020.0	7,020.0	3.23	210.60
4 Dara	40.00	70.0	1.49E-03	642.3	3.0	4,000	1.50E-03	15,552.0	80.0	2,800.0	0.0440	9,856.0	9,856.0	19.27	295.68
5 Margi Kotal	10.50	60.0	7.82E-04	193.1	3.0	3,000	1.00E-03	7,776.0	95.0	3,000.0	0.0360	10,260.0	7,776.0	5.79	233.28
6 Kach	1.00	100.0	3.50E-07	0.0	3.0	2,000	1.00E-03	5,184.0	80.0	2,000.0	0.0594	9,504.0	5,184.0	0.00	155.52
7 Jigda	9.40	60.0	1.15E-03	213.1	3.0	5,000	1.15E-03	14,904.0	165.0	4,000.0	0.0274	18,084.0	14,904.0	6.39	447.12
8 Sanzali	2.40	50.0	1.54E-04	0.0	3.0	1,000	1.00E-03	2,592.0	75.0	800.0	0.1710	10,260.0	2,592.0	0.00	77.76
9 Aranbi (Ghazlona)	17.00	50.0	2.07E-04	111.5	3.0	1,000	1.00E-03	2,592.0	45.0	300.0	0.0490	661.5	661.5	3.35	19.85
(Samaki)	17.00	50.0	2.07E-04	111.5	3.0	500	1.00E-03	1,296.0	45.0	300.0	0.0980	1,323.0	1,296.0	3.35	38.88
10 Sakhol	40.00	400.0	3.06E-04	1421.8	3.0	5,000	1.00E-03	12,960.0	10.0	4,000.0	0.0244	976.0	976.0	42.65	29.28
11 Mangi	27.00	400.0	1.06E-04	726.8	3.0	5,000	1.00E-03	12,960.0	200.0	4,500.0	0.0158	14,220.0	12,960.0	21.81	388.80
12 Kad Kacha II	40.00	550.0	3.18E-05	549.9	3.0	5,000	1.00E-03	12,960.0	90.0	3,800.0	0.0410	14,022.0	12,960.0	16.50	388.80
13 Islalkoo	6.40	30.0	1.03E-04	41.4	3.0	1,000	1.00E-03	2,592.0	80.0	800.0	0.1070	6,848.0	2,592.0	1.24	77.76

Rechargeable Water of Proposed Delay Action Dam Sites

Name	Catchment Area (km2)	Average Rainfall (mm)	Design Capacity (10^3m3)	Reservoir Depth (m)	Max Seepage Reservoibe (10^3m3/M)	Max Release Water (10^3m3/M)	Annual Rechargeable Wate (mm)	Annual Rechargeable Wate (1000m3)	Seepage Recharge (10^3m3)	Flowing toward specified area (10^3m3) Sepecified	Flowing toward specified area (10^3m3) Unspecified	Flowing toward other areas Unspecified	Annual Rechargeable Water (10^3m3) Sepecified	Annual Rechargeable Water (10^3m3) Unspecified	Remarks
1 Brewary	25.90	230.1	360.0	11.5 / 4.2	1.06	97.20	19.70	510.20	10.2	60% 306.1	40% 204.1	0% 0.0	306.1	204.1	
2 Ghutai Shela	1.80	208.8	42.0	5.6 / 1.3	5.68	144.45	17.43	31.37	0.6	60% 15.0	40% 10.0	20% 6.4	15.0	16.4	
3 Wali Dad	5.40	230.1	90.0	7.5 / 6.0	3.23	210.60	25.54	137.90	2.8	60% 82.7	40% 55.2	0% 0.0	82.7	55.2	
4 Dara	16.60	230.1	240.0	14.3 / 2.7	19.27	295.68	23.46	389.45	7.8	60% 233.7	40% 155.8	0% 0.0	233.7	155.8	
5 Margi Kotal	19.70	208.8	260.0	16.8 / 2.2	5.79	233.28	20.04	394.86	7.9	60% 188.6	40% 125.7	20% 80.6	188.6	206.3	
6 Kach	59.30	230.1	1,200.0	20.8 / 7.2	0.00	155.52	19.34	1,146.96	22.9	60% 407.4	40% 271.6	40% 468.0	407.4	739.6	
7 Jigda	20.80	238.5	290.0	14.7 / 3.8	6.39	447.12	25.39	528.03	10.6	20% 84.1	80% 336.2	20% 107.7	84.1	444.0	
8 Sanzali	10.40	238.5	160.0	9.2 / 2.0	0.00	77.76	20.51	213.28	4.3	20% 34.0	80% 135.8	20% 43.5	34.0	179.3	
9 Aranbi (Ghazlona)	9.10	238.5	140.0	7.7 / 2.7	3.35	19.85	15.46	140.69	2.8	60% 41.4	40% 27.6	50% 71.8	41.4	99.3	
(Samaki)	2.50	238.5	50.0	11.3 / 2.7	3.35	38.88	23.12	57.81	1.2	60% 17.0	40% 11.3	50% 29.5	17.0	40.8	
10 Sakhol	22.30	151.1	210.0	6.4 / 1.4	42.65	29.28	9.24	206.10	4.1	60% 98.4	40% 65.6	20% 42.0	98.4	107.7	
11 Mangi	(39.4) 74.20	162.3	420.0	6.7 / 1.7	21.81	388.80	14.71	1,091.27	21.8	60% 654.8	40% 436.5	0% 0.0	654.8	436.5	
12 Kad Kacha II	(15.2) 36.20	151.1	140.0	6.3 / 1.3	16.50	388.80	14.06	508.90	10.2	60% 305.3	40% 203.6	0% 0.0	305.3	203.6	
13 Islalkoo	5.80	190.8	80.0	8.4 / 2.6	1.24	77.76	18.84	109.29	2.2	60% 32.1	40% 21.4	50% 55.7	32.1	77.2	

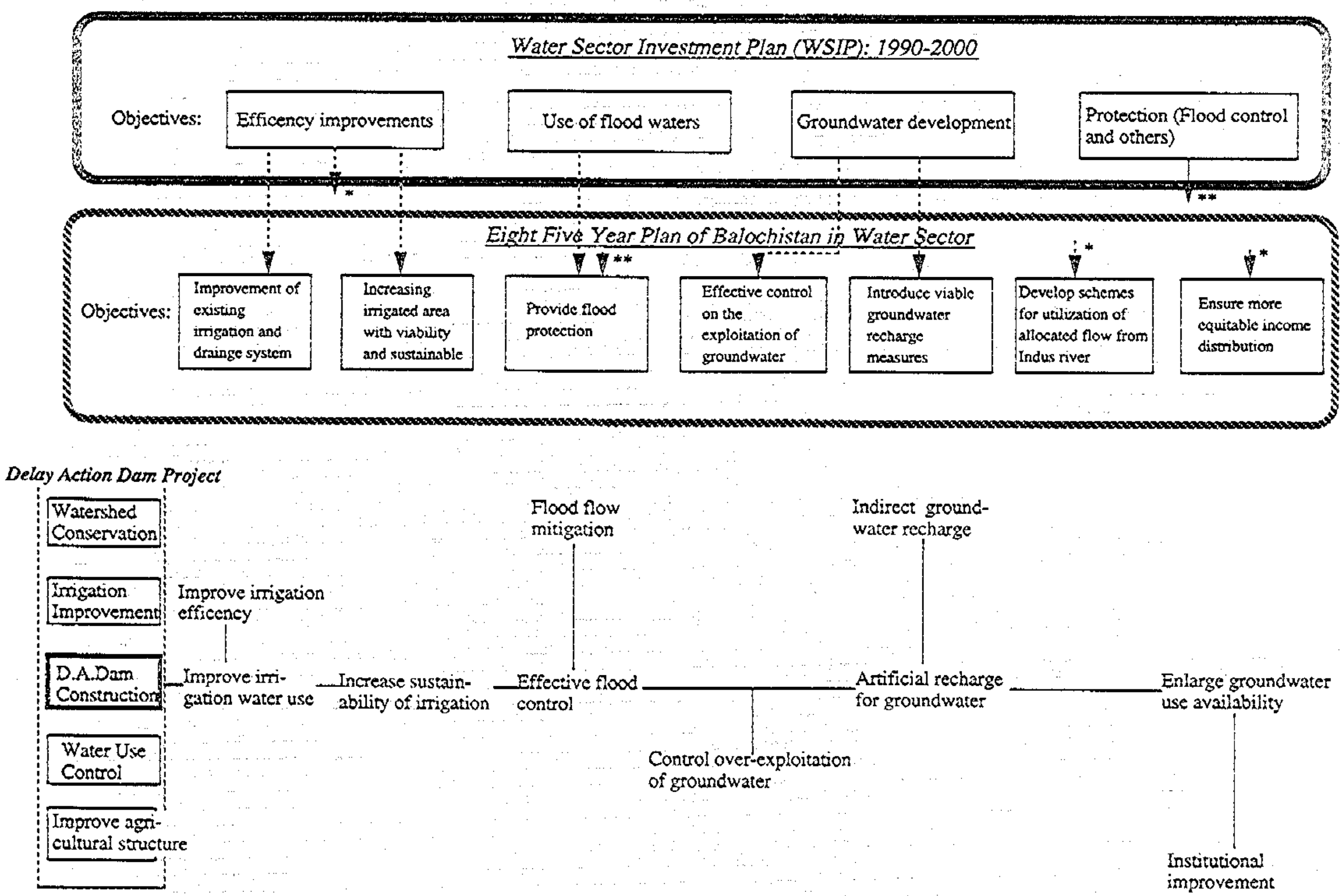


Fig.6.7.1 Position of Delay Action Dam Project on the Developent Plan of the Balochistan Province