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Islamic Republic of Pakistan
Feasibility Study on the Irrigation Water Resources
Development with Delay Action Dams Project
MAIN REPORT
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IRRIGATION AND POWER
DEPARTMENT
GOVERNMENT OF BALOCHISTAN

JAPAN INTERNATIONAL
COOPERATION AGENCY
JAPAN

FEASIBILITY STUDY
ON
THE IRRIGATION WATER RESOURCES DEVELOPMENT
WITH
DELAY ACTION DAMS PROJECT
IN
BALOCHISTAN
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

MAIN REPORT

JUNE 1997

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DEPARTMENT
GOVERNMENT OF BALOCHISTAN

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a Feasibility Study on the Irrigation Water Resources Development with Delay Action Dams Project in Balochistan and entrusted the study to the Japan International Cooperation Agency (JICA).

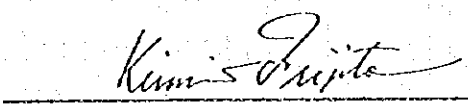
JICA sent to a study team headed by Mr. Katsuhiko Kimura, to the Islamic Republic of Pakistan, 2 times between March, 1996 and June, 1997.

The team held discussions with the officials concerned of the Government of the Islamic Republic of Pakistan, and conducted field survey at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

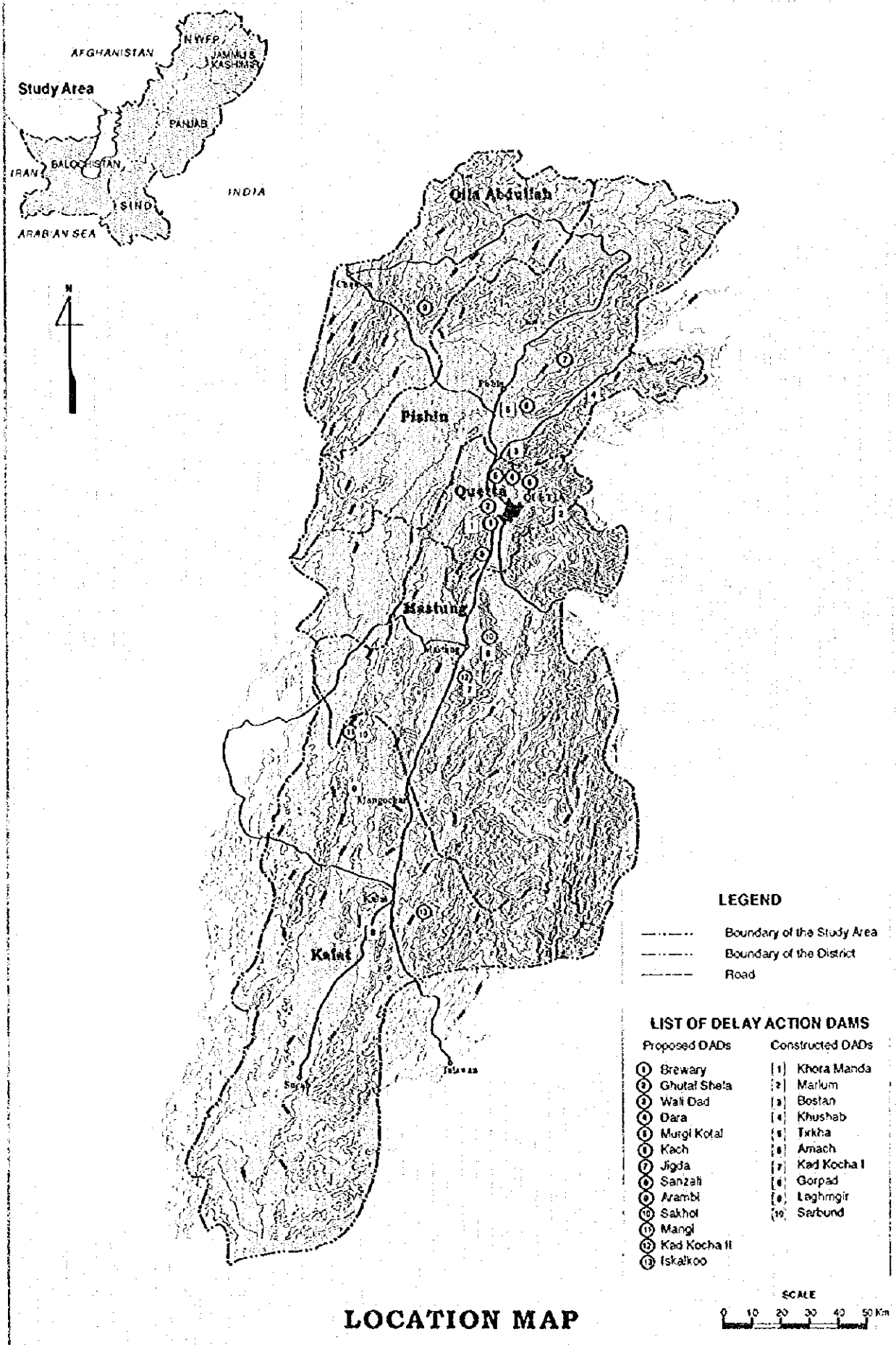
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

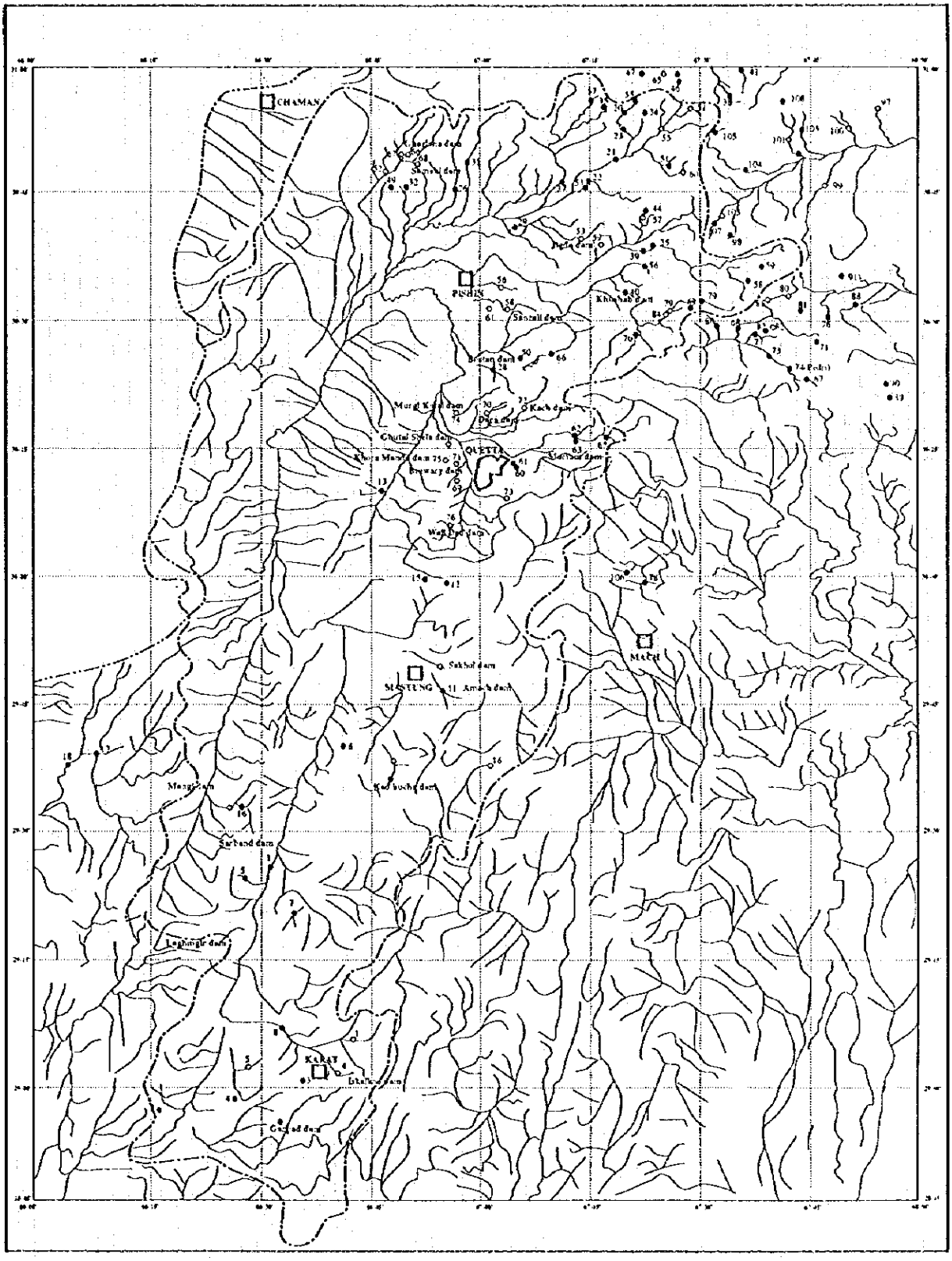
June, 1997



Kimio Fujita
President
Japan International Cooperation Agency



LOCATION MAP



Location Map of Dam sites

SUMMARY

In order to resolve the issue of sustainability of groundwater use, the Government of Pakistan requested technical cooperation for the study of the delay action dams (DADs) to the Government of Japan in June, 1994. In response to the request, the Government of Japan through JICA sent the preparatory study mission to Pakistan to confirm the scope of work (S/W) of the feasibility study on the Irrigation Water Resources Development with Delay Action Dams Project on December 22, 1995. Based on the S/W, the JICA Study Team had carried out the Study from April 1996 to March 1997. This is the Final Report compiling all the results of the Study and its conclusion.

(Background of the Study)

The Islamic Republic of Pakistan has an area of 796,000 sq.km, comprising of four provinces of Punjab, Sind, Northwest Frontier and Balochistan. The whole country has been classified as subtropical climatic region. Annual rainfall varies from more than 900 mm in the northern mountain areas to less than 250 mm in the south western region. Population of Pakistan was estimated at 128 million as of 1995 with population density at 161 person/sq.km, recording high growth rate of around 3 % par year. Though sectoral GDP in agriculture is ranked third at 24.8 % of all GDP following 48.7 % in service sector and 26.5 % in manufacture sector, it is the most important sector of Pakistan due to high rate (50 %) of work force absorption. Eighth Five Year Plan (EFYP) being implemented from 1993/94 is targeted to increase growth rate of agricultural production corresponding to the population growth, to ensure food security, self-sufficiency and large exportable surpluses. Emphasis was laid on integrated management of agriculture, irrigation and drainage, efficient land management and efficient water management.

Balochistan Province is located in west of the country, bounded on the north by Afghanistan and on the west by Iran. The Province covers a total area of 347,200 sq.km (about 43.6 % of the country), being divided into four regions that are the upper highlands, lower highlands, plains and deserts. Out of the total provincial land, cultivable land is only 4.8 %, forest is 3.0 %, and the remaining area is uncultivated or unreported. Rainfall is highly variable and unreliable. The average annual rainfall varies from less than 100 mm in the west to 400 mm in the northwest. Due to such scarcity of rainfall, irrigation is definitely necessary for stable agriculture. Population of this largest province in Pakistan is estimated at 7.4 million with high population growth rate comparing to the national growth. The population density is still very low at 16 persons per sq.km than the national average of 161. Quetta is the seat of the

Provincial Government and the largest urban center where rapid urbanization has taken place during the last two decades.

Ethnologically a large part of Balochistan can be characterized as tribal area. There are three major ethnic groups in the Province, namely, Baloch, Brahui and Pashtun, who have adhered to their own culture and custom. The literacy ratio in Balochistan was 20.9 % (29.3 % for men and 11.8 % for women) which is considerably low compared to the national average of 35.5 % (45.3 % for men and 24.7 % for women).

Agriculture is the dominant sector of the Province contributing 54 % to the GDP and directly employing 62 % of the population. The majority of farmers are engaged in farming practices. About 48 % of 1,660 thousand hectares, which is the total cultivated land, is under irrigation, while about 52 % is under rainfed farming. In irrigated uplands, deciduous fruits and vegetables production prevails in summer. Rice maize, millet, tobacco and cumin are also some of the main summer crops. Wheat, barley, legumes, rape, mustard and some winter vegetables are mainly planted in winter. While in rainfed areas, wheat, barley, beans, melons and some other cash crops are mainly planted though their yields per hectare are very low fluctuating year by year due to the unreliable rainfall. About 60 % of the area is rangelands with poor and deteriorating natural vegetation. However these rangelands are important for grazing by nomadic and semi-nomadic people. According to the livestock population census of 1986, there are 11.1 million heads of sheep, 7.3 million heads of goats, and 1.1 million heads of cattle in the Province. The heads of sheep and goat share 47 % and 25 % of the total heads of country, respectively.

Irrigation Department of Balochistan Government has constructed delay action dams against over-exploitation by tube-wells since 1971. As of 1996, 110 number of delay action dam were completed.

(The Study Area)

The Study Area is bounded within five (5) districts of Quetta, Pishin, Qila Abdullah, Mastung and Kalat, which almost constitute the Pishin Lora Basin being under most severe situation on groundwater utilization. The Study covers thirteen (13) sites consisting of fourteen (14) proposed delay action dams and their benefited areas within the same districts.

In Balochistan Province, irrigation water supply which shears major portion in quantity of water demands greatly depends upon groundwater abstraction. Excessive groundwater exploitation for irrigation by tubewells corresponding with rapid expansion of orchard has brought about lowering of groundwater level in recent years, which is an alarming situation for sustainable groundwater resources utilization.

Sixty-four (64) number of delay action dam have been constructed in the Study Area. Significant stabilization of groundwater level due to the construction of these dams has been noticed in some portions in the Study Area, while groundwater level is still declining in the most part of the Study Area.

About 80 % of the interviewed farmers in the expected beneficial area of the proposed delay action dams (DADs) desire construction of DAD, or understand its significance, and 81 % of the farmers answered they had no objection to participate in planning, construction, or maintaining of delay action dam scheme. Around 80 % of the farmers desire the fruits cropping in their future farming. Vegetables and common upland crops follow fruit crops.

Through groundwater study on sub-basin basis, the fact that groundwater exploitation exceeds the natural recharge was recognized in all 11 sub-basins in the Pishin Lora Basin. According to the result of the study, deficit of groundwater recharge causing water stage lowering has been estimated at from 15 % to 50 % by sub-basin.

Major and fatal constraints in the Study Area is shortage of water. Water use structure is going to result into real crisis in the Study Area, where no substantial remedies have been taken against increase of water demand under the condition having only limited water resources.

With regard to the agriculture in the Study Area, apples being typical of orchard has been a prominent crop which is the most profitable agricultural product. However, constraints in agriculture, namely, insufficient agricultural extension services, poor establishment of cooperatives, week agricultural credit system, lack of storage facilities, and unregulated

marketing system were observed. There is no significant relationship between better quality and higher value in agricultural products in the Study Area. Quality of production should be improved as well as productivities of crops.

Though big farmers with more than 20 ha farms is minor in number, they occupy around 42 % of the total farm area. Uneven land holding is recognized in the Study Area. It is customary in the Study Area, that the big farmers look after the small farmers as masters of their tribe. However, it can be stated that such conditions result in uneven distribution of wealth.

Livestock raising is an important activity and the Province is rich in livestock resources. It maintains 11.1 million heads of sheep and 7.3 million goats and these figures represent 48 % and 24 % of the national sheep and goat population, respectively. Natural vegetation is commonly 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 degradation.

In the village communities of the Study Area, traditional tribal customs are so deeply ingrained that a few feudal lords have all the powers to control the communities.

Literacy rate especially for women is very low and educational opportunities are inferior. It will take a great effort and time to improve the situation. The low literacy will hamper to beneficiary's execution of groundwater use control, and enhancement of sense of saving water. The status of women in the society is severely low and their living conditions are very poor. Despite their hard work in daily life, women have not been properly recognized for their great contribution to the community.

The average urban and rural population growth rate of 4.5 % and 3.2 % respectively in the Study Area has been recorded which is higher than the national average and is quite conspicuous. Concentration of population in urban area has strained and hindered the infrastructure development where as the rural infrastructure still lag behind due to the low population density and very scattered dwellings.

Further, the institutional weaknesses such as lack of coordination between different agencies are still major constraints for development, despite the endeavor of P & D Department of Government of Balochistan to renovate.

(Issues on Existing DAD)

Delay action dam is considered as an effective facility by the fact that some evidences of recharge was found due to the existing delay action dams in the Study Area. At the same time, some points to be improved in the fields of planning, designing, construction, and maintenance were identified.

During appraisal investigation of existing dam sites, an irrational imbalance between quantity of available water from study of hydrology and designed capacity of reservoir is conspicuous which indicates short coming in planning of the delay action dam. Capacity of reservoir of some existing delay action dams is too large showing poor economy in comparison with scale of catchment area or expected runoff. Guideline for determination of adequate capacity of reservoir is urgently required. The problems of recharge effect and over-topping by flood due to siltation in the reservoir are also required to be solved urgently.

Suitable dam designing by conducting stability analysis has not been carried out. This as well as other design parameters including calculation of design flood discharge, determination of height of free-board etc. need to be improved.

Construction methods such as poor compaction of earth filling should be improved, and necessary activities on operation and maintenance such as dredging siltation within the reservoir, or taking protection against gully erosion in the surface of dam body should be introduced.

In order to improve planning, design, construction, and operation and maintenance of delay action dam scheme, a guideline for delay action dams has been prepared in the Study. Major points of the guideline for delay action dam are as follows:

- Delay action dam is a most effective and economical measures for enhancement of groundwater recharge in the Study Area.

- Most important factors for the planning of delay action dam are selection of site, stability of dam foundation, seepage and recharge ability, flood regulation function, and construction method etc.

- As countermeasures against the up-lift force, drain installation at toe of the downstream of dam embankment can be proposed. To prevent piping and boiling, relief wells are proposed to be installed at the downstream of dam embankment where needed.

- From the viewpoint of the enhancement of groundwater recharge, a narrower valley is not recommended for the delay action dam construction, but a widely open alluvial fan is preferable even if a larger dam crest length is required.

- Accurate estimation of silt production of delay action dam catchment area is indispensable to confirm dam stability, and maintain groundwater recharge capability.

- From the review of some existing delay action dams, it is found that over-topping by flood is a most perilous event for dam safety. Such over-topping was caused by not only having insufficient flood storage capacity decreased by siltation, but also by having insufficient capacity of spillway. Due to lack of hydrological data the capacity of spillway is recommended to be against 100 year return period flood, which is a safety side decision. The shape of spillway is also recommended to be modified. Siltation capacity for delay action dam reservoir is proposed to be provided separately for 30 years siltation.

- Groundwater recharge of delay action dam through reservoir bed is always reduced by siltation year after year. Downstream recharge through conduit installed in the dam foundation is recommended together with such upstream recharge from reservoir bed.

- Due to dry weather of the Study Area, field moisture content is mostly on the dry side of the optimum moisture content during construction. Adequate moisture control of soil material for the dam embankment should be taken during dam construction. Rapid draw down of water stage in reservoir also infringe upon safety of dam body. Measures against such phenomena should be considered. Cheaper construction with proper safety factor is preferred.

(Development Strategy)

The farmers in the Study Area can be divided into three typical patterns by applying cropping types, namely, food grain producers, 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. The commercial farmers have extracted groundwater prominently as the substantial groundwater users for fruits harvesting rather than the subsistence farmers. The objective of the Study is to formulate a development strategy which should plan to seek good profit in agriculture both by small land owing farmers who can perform fruits harvesting actively by use of groundwater as well as large commercial farmers. By these reasons, this Study is not aimed at large land owners only.

Basic regional development policy is to enhance sustainability in the Study Area as a field for living, producing and resting. In this Project, the sustainability shall be directly and indirectly sought by means of construction of delay action dams. Following points have been taken into consideration for preparation of the development plan:

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

- 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.

- Operation and maintenance plan of the Project facilities shall be prepared not to force upon the beneficiaries the works with highly advanced and complex specifications.

- The participation of the beneficiaries in the Project shall be promoted to give them the sense of ownership of the facilities.

Agricultural development strategy in the Study Area is to promote sustainable agriculture and livestock under existing natural conditions. To assume the cropping pattern, marketability, availability of labor force, soil suitability, farmers intention besides profitably have to be considered. With this objective the cropping pattern should shift from mono-cereal to the pattern including vegetables, from the pattern with vegetable cultivation to pattern introducing fruits. Furthermore, extension services for farming technology is required. On the farm economic survey in the Study Area, big difference of income was found in each farmers group categorized by cropping pattern and farmers' agricultural technology.

Livestock production is also one of the important agricultural activity 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 counter the land degradation, range land management will be necessary measures along with watershed management.

Surface irrigation method should be altered to new irrigation method where hard-soil with low permeability extends widely, and when available electricity is limited, or prompt effect for stable groundwater stage is urgently required. For the introduction of new irrigation method such as drip irrigation, farmers' recognition for the necessity of the introduction of new method, and understanding of new method is definitely necessary.

The dam operation study was done to calculate reservoir stage on monthly bases, inputting runoff into reservoir from the catchment area, and releasing outputs (evaporation from reservoir water surface, recharge from reservoir bed, and flowing water out for downstream recharge).

Water use for recharged water by the delay action dam is 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 a short distance. Unspecified water use is a utilization of water for any beneficiaries located in the concerned groundwater basin, for purposes of agricultural and drinking use. Based upon these considerations, available quantity of recharged water for specified groundwater use and unspecified groundwater use were estimated as follows:

Expectable Quantity of Groundwater Recharge by the Proposed DAD

(1,000m3/year)

	DAD	Specify	Unspecified		DAD	Specify	Unspecified
1	Brewary	300.0	210.2	8	Sanzali	59.6	143.0
2	Ghutai Shela	11.5	17.9	9-1	Ghazlona	71.6	111.1
3	Wali Dad	67.6	70.4	9-2	Samaki	22.7	35.1
4	Dara	189.7	197.6	10	Sakhol	123.7	191.9
5	Murgi Kotal	213.4	149.6	11	Mangi	470.2	489.4
6	Kach	221.8	532.7	12	Kad Kacha II	230.4	239.8
7	Jigda	49.5	456.0	13	Iskalkoo	39.5	61.3

(Development Components)

The development components by each proposed delay action dam are shown in table below.

Major Proposed Facilities

Dam Name	Dam Type	Embank Vol.(m3)	Height (m)	Recharging Pond	Detention Pond	Karezes Repair
Brewary	Gravity dam	9,600	32.4	B15.0mxL100.0m	Âl	Âl
Dara	Earth dam	285,000	22.8	B105.0mxL110.0m	Concrete: 1 Gabion: 2	Âl
Murgi Kotal	Earth dam	278,000	35.6	B90.0bxL100.0m	Gabion: 4	Âl
Kach	Earth dam	480,000	45.9	B75.0mxL80.0m	Gabion: 2	Âl
Jigda	Earth dam	114,000	23.9	B40mxL150mxH1.5m B60mxL150mxH1.5m	Gabion: 3	2,100 m
Sanzali	Earth dam	106,000	19.2	B50.0mxL60.0m	Gabion: 4	2,700 m
Sakhol	Earth dam	187,000	14.5	B30.0mxL40.0m	Âl	2,500 m
Mangi	Earth dam	171,000	12.7	B116.0mxL130.0m	Âl	6,000 m
Kad Kocha II	Earth dam	152,000	14.0	B100.0mxL150.0m	Âl	Âl
Ghazlona	Earth dam	76,000	20.9	B26.0mxL30.0m	Gabion: 2	Âl
Ghutai Shela	Earth dam	33,000	13.0	B70.0mxL70.0m	Gabion: 2	Âl
Wali Dad	Gravity dam	3,700	23.0	B85.0mxL100.0m	Concrete: 3	Âl
Samaki	Earth dam	35,000	15.5	B40.0mxL40.0m	Âl	Âl
Iskalkoo	Earth dam	46,000	16.0	B50.0mxL60.0m	Gabion: 4	Âl

(Project Evaluation)

Project benefits through implementation of the dam schemes were estimated on the basis of increasible groundwater recharge by the proposed delay action dams. The project benefits consist of benefit on agriculture and domestic water use in specified beneficial area, benefit in unspecified beneficial area, and flood mitigation benefit. Moreover, another function of the delay action dam for sediment control by installing sediment capacity was taken consideration into cost estimation subtracting cost of alternative sediment control facility from the delay action dam cost. Estimated benefits of the delay action dam are summarized as follows:

Valuation of Benefits of the Project

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

Making cash flow of the scheme, Economic Internal Rate of Return (EIRR) was calculated. As a key economic indicator, EIRR of each proposed DAD scheme as well as the rank by EIRR is shown in the following table.

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

(Rs.1,000)

Dam name	construction Cost	Specified Benefits Domestic	Irrigation	Unspecified Benefit	Flood	Total Benefit	EIRR	Ranking
Brewary*	49,688	89	2,809	1,016	487	4,402	22.5%	1
Ghutai Shela+	14,785	132	0	82	34	248	0.1%	14
Wali Dad+	46,697	112	524	275	102	1,012	0.9%	11
Dara*	85,726	63	1,883	992	312	3,250	8.5%	5
Murgi Kotal*	75,474	153	1,430	1,027	370	2,982	4.6%	8
Kach*	151,905	112	2,123	4,632	829	7,759	6.3%	6
Jigda*	91,739	40	484	2,283	235	3,042	10.8%	4
Sanzali*	57,209	13	112	955	117	1,198	0.3%	12
Arambi (Ghazlona)*	28,351	86	274	495	103	957	6.3%	7
Arambi (Samaki)+	16,688	64	64	203	38	369	0.2%	13
Sakhol*	69,522	190	386	536	419	1,532	4.0%	9
Mangi*	78,869	292	3,099	2,174	1,395	6,960	15.9%	3
Kad Kocha II*	64,281	238	2,563	1,014	681	4,496	17.4%	2
Iskalkoo+	23,955	53	137	384	87	662	2.4%	10

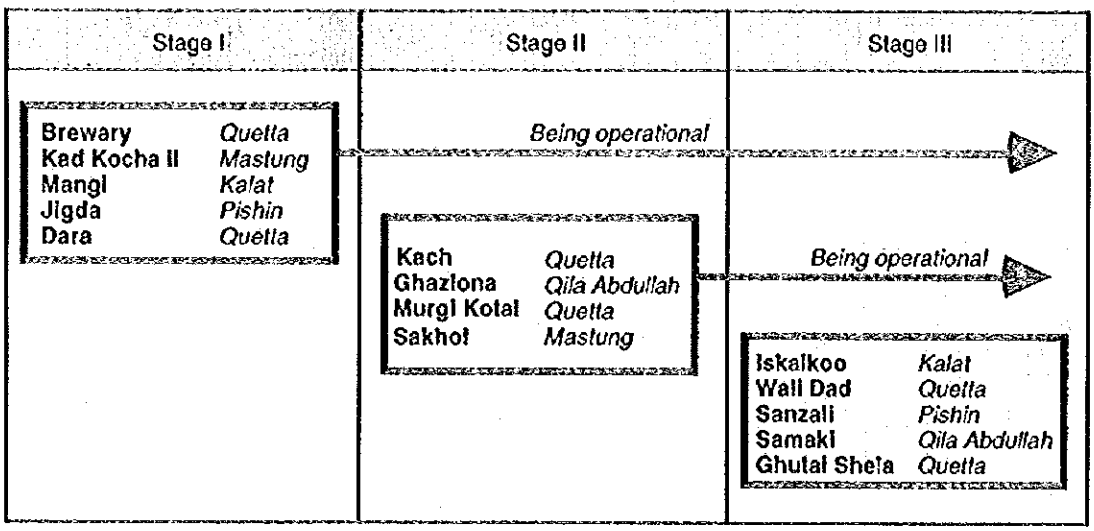
Note: The Construction Cost is a total financial project cost including costs for all components.
* ; proposed dams evaluated through F/S, +; proposed dams evaluated through pre-F/S

The financial analysis on the farm economy is made for the evaluation of the impact of the project implementation on the farm income in the beneficial area. The typical farmers to be analyzed are; 1) small-scale fruit producer and 2) medium-scale cereal producer. As a result, fruit producer, even small-scale farmer, is expected to get greater profit than cereal producer. Furthermore, when the recommended effort toward improvement of cropping is made together with the DAD construction, the additive effects by combining them is significant especially among the less-developed farmers.

The Project was judged to be socially sound due to its function of conservation of the groundwater resources and social structure. The necessity and anxiousness of the water conservation might push the plan toward immediate implementation even if the economic feasibility of the project is relatively low. As a result of the IEE, all environmental issues do not strongly claim a modification or cancellation of the DAD schemes. Therefore, no EIA was executed in the Study. Through these analysis, the Project was evaluated being sound and sustainable in view of social and environmental aspects.

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

Stagewised Implementation Program of the Project



Along with the implementation plan, the integrated scale, benefit and economic efficiency of the DAD groups are analyzed, assuming the stage I is implemented in the first year, the stage II in the second year and the stage III in the third year. When the Project achieves full development at the end of the stage I, the 5 DADs will contribute groundwater recharge of 3.0 MCM/year causing Rs. 22.2 million of benefit. The implementation of the stage I is judged to be highly feasible due to the integrated EIRR of 14.5 % as well as necessary and desirable. Progressing to the stage II, the integrated EIRR decreases to 10.2 %, which is still higher than opportunity cost of 10 %. The implementation of the stage I and II is also feasible for public investment. Eventually, the integrated EIRR becomes 8.7 % at the end of the stage III. However, the social and environmental importance of the DADs leaves room for consideration toward implementation. If the construction of DADs of the stage II and III takes medium and long term, instead of continuous implementation within 3 years as this analysis shows, the economic indicator may become lower.

Accumulative Project Evaluation under Stage Wide Implementation

	Stage I	Stage I & II	Stage I, II & III
Dam Site (Number)	5	9	14
Recharge Volume (cu.m/year)	3,028	4,924	5,466
Total Beneficiaries (person)	12,900	24,200	37,100
Irrigation Area (ha)	1,029	1,368	1,667
Construction Cost (Rs.'000)	346,926	641,040	801,668
Annual Benefit (Rs.'000)	22,150	35,045	38,868
EIRR (%) *	14.5	10.2	8.7
NPV (Rs.'000) *	74,569	4,696	-36,210

Note*: Assuming implementation of the stage I in the first year, the stage II in the second year and the stage III in the third year.

(Recommendation)

In pursuance of the results of the Study, the following recommendations are made.

1) The Stage I program of the proposed implementation plan is recommended to be implemented urgently and unconditionally due to superior feasibility considering availability of foreign country's assistance. The remaining two stages are suggested for consideration of the Government of Balochistan either to construct continuously or later on as the situation demands. These may be compared with other dams not included in this Study.

2) The Study Area especially Pishin-Lora basin is under severe situation in groundwater use. It is recommended that the Irrigation Department of Balochistan may launch a program of construction of delay action dams at proper sites in this valley instead of individual dams.

3) It is recommended that the Irrigation Department should hold construction equipment with proper number and adequate types which will be required for construction improved and effective operation. Considering present inventory of machinery to be insufficient, prompt procurement of equipment is strongly recommended taking into account the availability of foreign country's assistance.

4) For the future implementation of delay action dams, it is recommended that the Irrigation Department may strictly follow the technical guideline prepared in the Study.

5) It is suggested that some existing dams including those investigated in the Study having serious problems may be repaired consulting the technical guidelines.

6) Watershed conservation work should be done as an important component of the project implementation, which is necessary for keeping recharge function and improving natural environment of concerned area.

7) Constraints on irrigation and agriculture pointed out in the Study should be resolved by the concerned agencies. The existing irrigation systems need to be made more efficient by supportive action such as On-Farm Water Management Project conducted by the Department of Agriculture.

8) Establishment of new organization for groundwater management and regulation having necessary power and effective function is recommended with full cooperation of all the agencies concerned.

9) Additional and accurate monitoring data for the analysis of recharging effect of delay action dams are required. It is recommended to continuously monitor groundwater level at points adjacent to the dam, reservoir level, overflow discharge from dam, and so on.

10) Practical simulation method should be introduced for proper and sustainable groundwater management. Establishment of mathematical model for simulation of groundwater basins by the Water Bureau of Irrigation Department is recommended.

11) The four delay action dams included in the Study for which feasibility study has not been conducted should be studied in accordance with the guidelines given in this Report before construction.

FEASIBILITY STUDY
ON
THE IRRIGATION WATER RESOURCES DEVELOPMENT
WITH DELAY ACTION DAMS PROJECT
IN BALOCHISTAN

MAIN REPORT

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Abbreviations

ADB	:	Asian Development Bank
ADBP	:	Agricultural Development Bank of Pakistan
ADP	:	Annual Development Program
AO	:	Agricultural Officer
ARI	:	Agriculture Research Institute
AZRI	:	Arid Zone Research Institute
BHC	:	Basic Health Units
BRSP	:	Balochistan Rural Support Program
C/I ratio	:	Capacity-Inflow Ratio
DAD	:	Delay Action Dam
DDA	:	Deputy Director Agriculture
DFDC	:	Deciduous Fruit Development Centre
DFDP	:	Deciduous Fruit Development Plan
EADA	:	Extra Assistant Director of Agriculture
EEC	:	European Economic Community
EIA	:	Environmental Impact Assessment
EPA	:	Environmental Protection Agency
ETo	:	Potential Evaporation
FA	:	Field Assistant
GOB	:	Government of Balochistan
GOP	:	Government of Pakistan
HYV	:	High Yield Variety
IDA	:	International Development Association
IEE	:	Initial Environmental Examination
IPD	:	Irrigation and Power Department
ISRP	:	Irrigation Scheme Rehabilitation Project
IVDA	:	Integrated Valley Development Authority
JICA	:	Japan International Cooperation Agency
MC	:	Ministry of Construction, Japan
MCH centre	:	Municipal Committee Health Centre
NGO	:	Non Government Organization
NWFP	:	North West Frontier Province
O&M	:	Operation and Maintenance
OECF	:	Overseas Economic Cooperation Fund
OFWM	:	On-Farm Water Management
PHED	:	Public Health Engineering Department
QDA	:	Quetta Development Authority
RHC	:	Rural Health Centre
RWSS	:	Rural Water Supply and Sanitation
S/W	:	Scope of Work
SWHP	:	Surface Water Hydrology Project
T.B. clinic	:	Tuberculosis Clinic

UNDP	:	United Nations Development Plan
UNICEF	:	United Nations Children's Fund
WAPDA	:	Water and Power Development Authority
WASA	:	Water and Sanitation Authority
WUA	:	Water User's Association

Conversion

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer
ft	:	feet (1 feet = 0.305 m)
sq.m (m2)	:	square meter
sq.km (km2)	:	square kilometer
sq.mile	:	square mile (1 sq.mile = 2.59 km2)
acre	:	acre (1 acre = 4047 m2)
ha	:	hectare
cum (m3)	:	cubic meter
MCM	:	million cubic meter
MAF	:	million acre feet
kg	:	kilogram
t (ton)	:	ton, metric
sec (s)	:	second
hr	:	hour
cm/s	:	centimeter per second
m/s	:	meter per second
cum.s (cum/s, m3/s)	:	cubic meter per second (=35.310 cfs)
cfs	:	cubic feet per second (= 28.320 liters per second)
l/s	:	liter per second

1. *INTRODUCTION*

1.1 Background of the Project

Sustainability of groundwater resources demands that utilization through abstraction must be retained at a level below that of recharge to the aquifer. In Balochistan Province, irrigation water supply claiming the largest share in water demand, greatly depends upon groundwater through abstraction. Excessive groundwater exploitation for irrigation by tubewells corresponding with rapid expansion of orchards has brought about lowering groundwater level in recent years, which is an alarming situation for sustainable groundwater resources utilization.

To solve this problem, the Irrigation and Power Department of the Government of Balochistan has promoted artificial groundwater recharge by means of construction of the delay action dams (DADs) during these two decades. However, financial constraints and some technical difficulties in construction and operation and maintenance for the completed DADs come into prominence.

In these circumstances, the Government of Pakistan requested technical cooperation for the study for the DAD planning to the Government of Japan in June, 1994. In response to the request, the Government of Japan through JICA sent the preparatory study mission to Pakistan to confirm the Scope of Work (S/W) of the Feasibility Study on the Irrigation Water Resources Development with Delay Action Dams from December 8 to December 22, 1995 (see Attachment 1).

1.2 Objectives of the Study

The objectives of the Study are:

(a) To develop groundwater resources for irrigation by delay action dams, for improvement of the quality of life of farmers,

(b) To make a feasibility study report on the irrigation water resources development with delay action dams project in Balochistan, and

(c) To carry out technology transfer to the Balochistan counterpart personnel through on-the-job training in the course of the Study.

1.3 Study Area

The Study Area is bounded within five (5) districts of Quetta, Pishin, Qila Abdullah, Mastung and Kalat, which almost constitute the Pishin Lora Basin being under most severe situation on groundwater utilization. The Study covers 14 proposed delay action dams of 13 schemes and their benefited areas in the same districts. Ten (10) completed delay action dams located within the Study Area are also evaluated in the Study.

1.4 Study of Delay Action Dam Sites

1.4.1 Proposed Delay Action Dam Sites

In line with the Scope of Work of the Study, 13 delay action dam schemes have been studied within the Study Area. All the dam sites are situated in Pishin Lora Basin which is under severe condition for groundwater use. No potentiality for new development of groundwater exploitation remain any more in the basin.

The proposed dam schemes are arranged in the following table. Locations are shown in Location Map.

	DAD	Preparation of PC-I	Present Status as of 1996	Remarks
1	Brewary	Independent PC-I was not prepared. However, this scheme is included in the PC-I of "Construction of Delay Action Dams around Quetta" issued in 1994.	F/S of "Brewary Delay Action Dam" has been completed by NESPAK.	
2	Ghutai Shela	No PC-I was prepared yet. Estimation has been conducted by I&P.	Previous stage of submission of PC-I.	
3	Wali Dad	Independent PC-I was not prepared. However, this scheme is included in the PC-I of "Construction of Delay Action Dams around Quetta" issued in 1994.	No progress.	
4	Dara	PC-I was prepared and submitted in Feb. 1993.	This scheme was being included either in the ADP 1993-94 or in any other program likely to be financed by some donor agencies.	
5	Murgi Kotal	No PC-I was prepared yet. Estimation was made in 1979.	No progress.	

6	Kach	No PC-I was prepared yet. "Pre-F/S for Rehabilitation of Kach Dam" was conducted by NESPAK in 1987 so as to rehabilitate through financing out ISRP.	No progress has been taken because the ISRP was abolished.	The dam was constructed by Pakistan Army in 1968.
7	Jigda	PC-I was prepared and submitted in Feb. 1995	It is being through special grant of President of Pakistan.	
8	Sanzali	PC-I was prepared and submitted in 1992 on the direction of the Minister S&GDA.	It was being financed out of special fund of the Minister S&GDA.	
9	Arambi (Ghazlona)	PC-I was prepared and submitted in Jan. 1996.	ADP allocation for 1995-96 and 1996-97 was decided at the amount of Rs. 3.012 million.	
	Arambi (Samaki)	PC-I was prepared and submitted in Jan. 1996.	ADP allocation for 1995-96 and 1996-97 was decided at the amount of Rs. 1.820 million.	
10	Sakhol	No PC-I was prepared yet.	Previous stage of submission of PC-I.	
11	Mangi	PC-I was prepared and submitted in Jun. 1994.	This scheme was being included in the Prime Minister Special Development Program 1994-95.	
12	Kad Kocha II	No PC-I was prepared yet.	Previous stage of submission of PC-I.	
13	Iskalkoo	PC-I was prepared and submitted in Sep. 1994.	This scheme was being included in the Prime Minister Special Development Program 1994-95.	

1.4.2 Existing Delay Action Dam Sites

During the Phase I Study period, some completed delay action dams were evaluated for engineering, economy and other fields such as operation and maintenance, in order to have a feedback for further improvement on the planning, design, construction and operation. Ten typical and instructive dam schemes located within the Study Area were selected from among 64 completed dams (inventory is given in Table 1.4.1, and locations are shown in Location Map). The selection of the existing delay action dams for evaluation in the Study was done through series of discussion with Pakistani officials.

The name and major reason for selection of these delay action dams for evaluation in the Study are enumerated as follows:

	Name of Delay Action Dam	District	Reason for Selection
1	Khora Manda	Quetta	This is a typical dam operating and maintaining well, which was constructed in 1993 near Quetta City zone. It is also suitable to calibrate dam operation simulation due to precise records of the operation condition.
2	Marium	Quetta	There are problems in its function, such as having small catchment area. This is a typical instructive dam for selection of dam sites.
3	Bostan	Pishin	Small runoff has been observed in spite of having considerable catchment area. This is a typical instructive dam for dam planning.
4	Khushab	Pishin	This is a successful dam having full water in the reservoir during the study period. Instructions on dam selection and for devising new method for recharging can be effectively expected.
5	Tirkha	Pishin	Some measures for promoting recharge have been tried against decrease of recharge by siltation. This is an instructive dam to obtain information for the measures.
6	Amach	Mastung	There are many karezes immediate downstream of the dam site. This is a typical instructive dam for evaluation of the effects of delay action dam on existing karezes.
7	Kad Kocha I	Mastung	This dam has a long dam crest, being found with small siltation in the reservoir area. This is a typical instructive dam for sedimentation problem.
8	Gorpad	Kalat	Though much water has been conserved in the reservoir, a problem in water quality with high salinity is found. This is a typical instructive dam identifying necessity of consideration not only for quantity of water but also quality of water.
9	Laghmgir	Kalat	Wide flood irrigation area had been extended in the down stream of the dam. This is a typical instructive dam for the necessary arrangement between existing flood irrigation practice and delay action dam operation.
10	Sarbund	Kalat	There are some discrepancies between design and construction. This is a typical instructive dam on construction work.

1.5 Scope of the Study

The study consists of two phases; the Phase I Study which was conducted from April 1996 to August 1996, and the Phase II Study which was carried out from October 1996 to May 1997. The Phase I Study and the Phase II Study cover the following study items;

(1) Phase I Study

The Phase I Study was made to establish a basic concept of delay action dam by reviewing the previous studies and analyses of data and information. Formulation of the proposed delay action dams' development plan and a technical brief guideline for delay action dam development method were made.

a) Preparatory Works in Japan
- Examination of available data,
- Preparation of plan of operation, and
- Preparation of the Inception Report.

b) Field Survey in Pakistan
- Explanation and discussion on the Inception Report with GOB,
- Collection of data and information,
- Review of other relevant projects and related projects,
- Field survey in each field, and
- Preparation, explanation and discussion on the Progress Report (I) with GOB.

c) Home Office Work in Japan
- Assessment of development needs, potential and constraints of the Study Area in view of irrigation water resources development,
- Evaluation of completed DADs, and formulation of technical brief guideline for delay action dam development method reflecting the results of the evaluation,
- Formulation of the proposed delay action dams' development plan and making priority among the proposed dams,
- Preparation of the Interim Report.

(2) Phase II Study

The Phase II Study was conducted for the feasibility study for priority delay action dams. At the end of the period the Progress Report (II) on the Study was prepared.

a) Field Survey in Pakistan
- Explanation and discussion on the Interim Report with GOB,
- Supplemental field survey and data collection,
- Field survey for the Feasibility Study for priority delay action dams,
- Formulation of a preliminary development plan for the Feasibility Study for priority delay action dams, and
- Preparation, explanation and discussion of the Progress Report (II).

b) Home Office Work in Japan

- Formulation of development plan for the Feasibility Study for priority delay action dams,

- Establishment of a delay action dam development method, and

- Preparation of the Draft Final Report.

c) Explanation and Discussion on the Draft Final Report with GOB

d) Preparation of the Final Report

Table 1.4.1 Inventory of Completed Delay Action Dams

Dam Name	Division	District	Completion of Dam	Construc-tion Cost (Million-Rs)	Dam Dimensions						Latitude			Longitude		
					Dam Height (m)	Crest Length (m)	Catchment Area (sq.km)	Storage Capacity (1000cum)	Design Flood Discharge (cum/s)	Embank. Volume (1000cum)						
Daber	KALAT	Kalat	12/31/93	1.6	9.4	762.2	17.19	190.0	226.70	286.2	29	25	53	66	31	28
Dasht-e-Goran	KALAT	Kalat	12/31/91	2.7	14.0	271.3	3.04	146.0	74.63	50.5	28	59	13	66	17	27
Gar	KALAT	Kalat	12/31/82	0.5	15.2	115.9	2.43	123.1	9.29	33.8	29	6	4	66	35	9
Gorpad	KALAT	Kalat	12/31/82	0.5	9.8	244.0	0.90	181.3	39.67	38.8	28	58	24	66	31	10
Laghamgir	KALAT	Kalat	12/31/93	2.5	12.2	135.0	29.20	254.5	153.02	77.4	29	23	51	66	27	53
Loveri	KALAT	Kalat	12/31/93	0.8	6.1	332.3	1.52	60.0	13.66	13.9	29	40	38	66	40	5
Tori Kafta	KALAT	Kalat	12/31/82	0.7	13.7	265.2	4.57	159.1	17.07	55.4	29	19	38	66	34	17
Zaloo	KALAT	Kalat	12/31/93	1.5	8.0	500.0	2.00	50.9	19.63	30.1	29	5	41	66	33	50
Eri Kalag	KALAT	Kharan	12/31/93	2.0	13.8	147.0	11.89	112.8	37.78	35.9	28	41	39	65	7	5
Hazarganji	KALAT	Khuzdar	12/31/81	0.5							27	31	6	66	11	14
Amach	KALAT	Mastung	12/31/87	2.8	15.2	762.0	25.70	1,050.0	83.27	136.0	29	46	55	66	54	39
Duzd Darra	KALAT	Mastung	6/30/84	1.5	15.2	111.3	2.48	12.2	25.11	52.5	29	58	59	66	50	21
Kanak	KALAT	Mastung	12/31/87	3.1	6.1	2225.0	7.01	2,073.2	33.29	124.2	30	10	29	66	46	17
Khad Kucha I	KALAT	Mastung	12/31/84	3.6	15.2	636.0	21.00	522.8	35.22	198.2	29	39	12	66	48	7
Nishpa	KALAT	Mastung	30/6/95	2.9	15.2	204.0	3.84	114.9	53.78	35.7	29	59	14	66	52	41
Sarbund	KALAT	Mastung	12/31/93	2.8	12.8	412.0	34.80	-	145.60	60.8	29	32	18	66	27	20
Gori	QUETTA	Chagai	6/30/85	2.5							29	39	10	66	7	46
Khaisar	QUETTA	Chagai	6/30/83	1.6							29	37	35	66	3	55
Adu	QUETTA	Pishin	12/31/87	0.6	11.9	137.5	3.89	2,343.7	50.98	403.7						
Aghberg Kach Hassanzai	QUETTA	Pishin	6/30/93	2.1	12.2	84.7	9.82	764.8	24.78	220.9	30	55	41	67	19	53
Aghbergai	QUETTA	Pishin	12/31/94	0.8	9.4	99.1	6.48	752.4	46.73	118.5	30	48	16	67	18	8
Aghbergi	QUETTA	Pishin	6/30/80	0.8	11.6	91.4	6.48	616.8	42.48	393.1	30	46	17	67	14	34
Amozai	QUETTA	Pishin	12/31/96	2.2	11.0	152.4	6.40	59.3	45.34	26.4	30	52	44	67	19	1
Bachak	QUETTA	Pishin	6/30/94	1.6	7.6	169.8	16.84	1,134.8	44.75	280.4	30	61	0	67	30	45
Balozai	QUETTA	Pishin	6/30/83	1.0	12.2	853.4	6.48	3,022.1	79.30	950.0	30	39	1	67	23	1
Biana	QUETTA	Pishin	6/30/89	0.8	13.7	152.4	10.00	863.5	62.30	298.1	30	45	54	66	50	59
Boghra Secondary	QUETTA	Pishin	6/30/83	0.9	8.1	118.9	24.61	320.7	87.79	268.3						
Bostan Dara	QUETTA	Pishin	6/30/89	6.0	16.0	272.0	23.40	210.0	114.00	164.0	30	24	0	67	2	0
Bund Khushdil Khan	QUETTA	Pishin	12/31/80	1.0	11.6	914.4	1165.54	55,507.5	141.60	573.8	30	41	9	67	3	53
Chachobi	QUETTA	Pishin	12/31/87	0.9	10.4	147.8	10.00	1,110.2	66.01	254.7	30	61	17	67	25	20
Dara Toghai	QUETTA	Pishin	6/30/94	7.0	11.6	259.1	72.52	3,416.8	84.96	977.3	30	49	32	66	58	2
Garang	QUETTA	Pishin	6/30/89	1.7	11.6	137.2	6.48	1,850.3	70.80	391.8	30	45	46	66	49	35
Ghargi	QUETTA	Pishin	6/30/86	1.0	12.2	76.2	19.43	1,233.5	42.48	403.1	30	60	48	67	20	59
Ghez	QUETTA	Pishin	6/30/84	0.2	11.9	329.2	10.10	2,615.0	59.47	351.4	30	54	51	67	22	17
Ghunza	QUETTA	Pishin	12/31/90	0.7	15.2	86.9	3.20	148.1	21.16	23.4	30	55	50	67	17	8

Dam Name	Division	District	Completion of Dam	Construc-tion Cost (Million-Rs)	Dam Dimensions						Latitude			Longitude		
					Dam Height (m)	Crest Length (m)	Catchment Area (sq.km)	Storage Capacity (1000cum)	Design Flood Discharge (cum/s)	Embank. Volume (1000cum)						
Injani	QUETTA	Pishin	6/30/83	0.8	4.8	146.3	5.44	986.8	94.90	398.1	31	10	30	67	26	60
Inzargai	QUETTA	Pishin	6/30/94	2.0	11.6	106.7	6.48	1,800.9	28.32	301.7	30	46	32	67	10	13
Kar Manda	QUETTA	Pishin	6/30/86	2.5	13.7	73.2	16.03	1,763.9	84.96	352.3	30	56	51	67	34	23
Khanozai	QUETTA	Pishin	6/30/83	1.2	11.6	670.6	3.89	3,207.1	87.79	1,034.0	30	38	29	67	21	54
Khushab	QUETTA	Pishin	6/30/86	2.0	15.4	164.0	15.20	392.9	75.12	52.2	30	33	34	67	19	52
Khusro	QUETTA	Pishin	6/30/83	0.9	12.2	91.4	16.84	2,713.7	141.60	790.8	31		41	67	35	53
Mahal Tangi	QUETTA	Pishin	6/30/86	0.5	9.1	170.7	10.36	3,022.1	55.22	345.1	31	9	57	67	27	24
Nadira Check detention	QUETTA	Pishin	6/30/93	2.0	2.3	85.3	3.24		49.16	96.3						
Nareen Jahlak	QUETTA	Pishin	6/30/93	1.7	13.7	75.3	10.36	1,800.9	31.15	356.8	30	43	36	67	22	4
Obeki	QUETTA	Pishin	6/30/83	1.0	9.8	231.6	11.66	616.8	56.64	236.0						
Sabnai	QUETTA	Pishin	6/30/86	2.0	11.3	91.4	11.66	740.1	87.08	210.1	30	38	44	67	36	27
Savgi	QUETTA	Pishin	6/30/81	0.4	8.1	118.9	24.61	320.7	39.59	90.2	30	58	39	67	27	13
Shadak	QUETTA	Pishin	6/30/83	0.7	15.1	91.4	9.19	493.4	56.64	349.7						
Sharan Manda	QUETTA	Pishin	6/30/93	2.0	10.4	210.3	14.89	1,196.5	50.98	391.5	30	45	45	66	46	7
Shikar Gat	QUETTA	Pishin	12/31/88	1.2	9.1	213.4	4.53	616.8	30.44	362.5	30	25	27	67	5	5
Spinkai	QUETTA	Pishin	6/30/93	1.6	11.6	85.3	13.80	814.1	29.74	271.9	30	48	28	67	25	9
Surtal	QUETTA	Pishin	6/30/84	1.1	12.2	493.8	19.68	3,083.8	169.92	1,041.6	31	4	38	67	42	35
Temrak	QUETTA	Pishin	12/31/96	7.6	1524.0	189.0	28.06	377.7	119.02	94.7	30	44	57	67	13	41
Tikha	QUETTA	Pishin	6/30/93	3.2	10.7	417.6	10.75	2,578.0	84.96	531.0						
Tokhai Malagzai	QUETTA	Pishin	6/30/81	1.2	11.0	106.7	12.95	1,171.8	53.52	241.9	30	55	34	67	20	55
Tore Khulla	QUETTA	Pishin	6/30/90	2.0	11.0	143.3	11.66	1,048.5	53.81	395.1	30	36	41	67	22	38
Uch Bianzai	QUETTA	Pishin	6/30/93	3.1	13.4	147.8	15.49	2,269.6	101.95	576.5	30	57	4	67	15	10
Ush Tara	QUETTA	Pishin	6/30/93	2.3	12.9	119.5	15.85	1,171.8	42.48	433.3	30	34	56	67	36	16
Zohri	QUETTA	Pishin	6/30/87	1.1	9.4	164.6	11.66	3,083.8	77.46	392.6	30	36	13	67	38	8
Habib Dara I	QUETTA	Quetta	6/30/72	0.1	9.2	54.9	10.36	493.4	16.99	72.5	30	12	42	67	4	45
Habib Dara II	QUETTA	Quetta	12/31/93	2.1	12.2	81.7	12.43	727.8	107.62	263.5	30	12	55	67	4	46
Khora Manda	QUETTA	Quetta	6/30/93	3.4	10.4	238.0	12.20	144.3	129.40	45.7	30	12	46	66	52	15
Marium	QUETTA	Quetta	12/31/93	3.0	14.5	122.0	0.50	43.5	52.71	42.3	30	16	10	67	12	36
Murghi Kotal	QUETTA	Quetta	6/30/79	1.0	8.5	45.7	19.70	493.4	56.64	122.7	30	19	31	66	57	27
Wali Dad	QUETTA	Quetta	6/30/73	0.2	7.7	31.5	5.40	161.6	14.16	56.5	30	17	56	67	16	19
Zawar Kan	QUETTA	Quetta	6/30/86	2.2	12.2	164.6	12.95	1,652.9	72.22	365.4	30	26	60	67	9	40
Akram Tangi	SIBI	Ziarat	12/31/76	0.2	7.6	137.2	5.18	36.6	5.60	8.5	30	23	50	67	45	35
Ghundi	SIBI	Ziarat	12/31/93	2.7	14.3	100.6	12.96	91.8	35.70	28.3	30	28	56	67	34	49
Gogi	SIBI	Ziarat	12/31/81	1.5	18.3	277.4	6.48	487.9	67.20	85.9	30	31	29	67	28	24
Kadi Kach	SIBI	Ziarat	12/31/91	3.0	12.9	114.3	3.88	32.6	23.81	59.0	30	28	2	67	20	39
Mana Storage	SIBI	Ziarat	12/31/92	10.0	36.9	41.8	72.70	1,924.7	275.00	-	30	27	27	67	45	50
Mangi Storage Dam	SIBI	Ziarat	12/31/82	1.0	12.2	125.6	46.74	134.2	126.00	-						
Nazi Tangi	SIBI	Ziarat	12/31/93	2.2	10.8	250.0	11.66	85.4	47.60	37.9	30	27	11	67	39	42

Dam Name	Division	District	Completion of Dam	Construc-tion Cost (Million-Rs)	Dam Dimensions						Latitude			Longitude		
					Dam Height (m)	Crest Length (m)	Catchment Area (sq.km)	Storage Capacity (1000cum)	Design Flood Discharge (cum/s)	Embank. Volume (1000cum)						
Pechi	SIBI	Ziarat	12/31/74	0.4	13.1	289.6	18.14	526.9	22.40	32.6	30	25	52	67	42	24
Pinakai	SIBI	Ziarat	12/31/91	2.1	12.8	167.7	15.55	326.9	19.60	35.3	31	35	5	67	26	58
Sasnak Mana Storage	SIBI	Ziarat	6/30/95	4.0	18.9	48.1	16.85	179.3	10.64	2.4	30	30	6	67	47	24
Sharan Storage Bund	SIBI	Ziarat	12/31/75	0.3	10.7	152.4	3.24	157.3	2.80	14.0	30	28	56	67	37	51
Storage Bund at Jungle	SIBI	Ziarat	12/31/79	0.5	10.1	135.7	7.78	36.6	8.40	8.5	30	29	34	67	22	18
Tangi	SIBI	Ziarat	12/31/93	4.9	14.8	126.5	20.74	334.2	31.20	24.0	30	32	21	67	29	51
Verchume Storage Bund	SIBI	Ziarat	12/31/75	0.2	12.2	152.4	-	158.6	5.60	27.6	30	29	19	67	32	40
Zargi Storage Bund	SIBI	Ziarat	1947	0.3	13.7	57.9	90.72	442.7	260.13	22.6	30	30	52	67	42	50
Zindra	SIBI	Ziarat	12/31/71	0.3	7.6	22.9	5.83	41.5	7.00	9.2	30	29	52	67	38	33
China Khundi	ZHOB	Loralai	12/31/93	2.2	9.4	152.4	10.53	38.0	119.00	19.3	31	9	33	69	55	42
Dabri	ZHOB	Loralai	12/31/80	0.3	8.1	30.0	7.77	17.0	14.00	18.2	30	26	7	68	56	24
Gadobra	ZHOB	Loralai			6.0	173.7	25.89	160.0	184.00	37.8	29	49	22	69	25	44
Ghara	ZHOB	Loralai	8/31/93	2.9	10.1	268.2	14.23	131.0	85.00	32.9	30	32	14	69	17	28
Gewari	ZHOB	Loralai	12/31/76	0.7	11.4	60.0	23.30	123.0	156.00	19.0	30	17	3	68	15	56
Gurmi	ZHOB	Loralai	12/31/71	0.3	7.5	41.2	13.30	55.0	42.46	4.5	30	31	16	67	51	56
Kuncha	ZHOB	Loralai	12/31/88	2.1	11.9	164.6	10.36	78.0	52.30	53.8	30	21	12	67	55	19
Mando Kara	ZHOB	Loralai	12/31/85	1.0	9.1	91.4	7.77	58.0	48.13	12.0	30	22	51	67	54	50
Sur Gund	ZHOB	Loralai	6/30/93	1.8	12.2	126.8	9.77	58.0	48.13	12.0	30	35	22	67	48	50
Tirkha Lahri Small (I)	ZHOB	Loralai	6/30/93	5.0	2.7	29.9	12.95	1,095.0	92.55	95.3	30	5	41	68	57	56
Wahvi Small (I)	ZHOB	Loralai	12/31/90	1.9	9.1	60.0	10.36	247.0	92.55	95.3	30	3	41	68	56	19
Bahana	ZHOB	Qilla Saifullah	6/30/91	2.3	12.2	106.7	14.23	163.4	171.63	47.0	30	41	48	68	19	20
Gaati	ZHOB	Qilla Saifullah	12/31/75	0.1	10.7	40.4	2.58	22.0	22.40	13.9	31	2	13	67	48	31
Ghunda Mana	ZHOB	Qilla Saifullah	12/31/92	2.4	11.0	159.3	14.23	107.3	140.00	61.0	30	39	10	68	6	46
Inder Bes	ZHOB	Qilla Saifullah	5/31/85	1.0	15.2	51.8	20.71	109.1	140.00	34.7	31	1	30	67	47	53
Kafir Toi	ZHOB	Qilla Saifullah	6/30/90	2.1	12.5	115.9	38.83	279.3	168.00	56.7	30	39	58	68	33	46
Kan Mehterzai	ZHOB	Qilla Saifullah	12/31/75	0.9	12.8	198.2	9.06	256.1	84.00	95.1						
Kandil	ZHOB	Qilla Saifullah	6/30/93	2.7	15.2	161.6	12.94	137.8	140.00	115.0	30	50	6	67	44	4
Khajir	ZHOB	Qilla Saifullah	6/30/91	6.8	15.2	219.6	25.89	487.9	196.00	156.2	31	14	15	67	29	49
Khushkalwai	ZHOB	Qilla Saifullah	6/30/93	2.8	10.7	122.0	20.71	76.8	84.00	31.0	31	21	6	68	48	31
Mandak	ZHOB	Qilla Saifullah	4/30/81	1.0	12.5	335.4	12.94	208.6	70.00	115.9	30	52	27	67	44	33
Mulazai	ZHOB	Qilla Saifullah	5/31/76	0.6	12.2	122.0	7.76	134.2	70.00	35.0	30	47	51	67	36	8
Murgha Bakarzai	ZHOB	Qilla Saifullah	4/30/85	0.5	7.6	114.3	1.96	108.6	38.64	21.7	30	51	57	67	31	33
Pinakai	ZHOB	Qilla Saifullah	6/30/94	1.9	15.2	115.9	6.47	47.6	72.80	77.1	30	4	49	67	19	45
Sangar	ZHOB	Qilla Saifullah	12/31/83	1.5	14.3	129.6	90.65	170.8	98.00	76.9	30	41	43	67	31	45
Shinshobi	ZHOB	Qilla Saifullah	12/31/74	0.4	11.0	82.3	6.47	329.3	72.80	29.9	30	56	22	67	41	7
Tore Skhur	ZHOB	Qilla Saifullah	12/31/75	0.1	9.1	115.2	3.88	45.1	58.80	30.2						

2. *BACKGROUND OF THE PROJECT*

2.1 Pakistan

The Islamic Republic of Pakistan lies between 25° 30' and 36° 45' north latitudes and between 61° 00' and 75° 30' east longitudes. Pakistan has an area of 796,000 sq.km. The Indus River originating from Himalaya Mountains runs through the plains in the middle of the country, flows into the Sea of Arabia. The upper reaches of the Indus River have mountain areas, deep gorges and high plateaus, which form high-relief configuration. In contrast to this, the alluvial plain extends far and wide towards southeast downstream areas.

Pakistan is classified into subtropical climate, however, part of the country is located in the arid zone in Indo Pakistan subcontinent. Accordingly, annual rainfall varies from more than 900 mm in the northern mountain areas to less than 130 mm in the desert area and western part of Balochistan. Pakistan has two rainy seasons. One is Monsoon in summer from June to September (bringing about 70% of the annual rainfall), the other is winter from December to March.

The territory of Pakistan comprises the four provinces of Punjab, Sind, Northwest Frontier and Balochistan, the Federally Administered Tribal Areas, and the Federal Capital Territory of Islamabad. The provinces are autonomous units and each has a Provincial Assembly empowered to make laws for that province. For administrative purposes, each province is divided into a number of divisions, each of which is divided into districts, themselves sub-divided into tehsils.

There is considerable ethnic diversity within Pakistan. Main ethnic groups are the Punjabi (59.6%), the Sindhi (11.1%), the Pushtun (9.0%) and the Balochi (2.7%). Main languages are Punjabi (48.7%), Sindhi (11.8%), Pusht (13.1%) and Balochi (3.0%). Some other minor local languages are also spoken. The official languages are Urdu and English. Ninety-four percent of population is Muslims. There are also several small religious communities, such as Hindus (1.5%) and Christians (1.4%).

The population of Pakistan was estimated at 128 million as of 1995. Population density for the whole country was recorded at 161 person/sq.km. The population growth rate was as high as 2.9%. Pakistan has experienced rapid urbanization, but it tends toward slowdown.

The total labour force was estimated at 36.7 million in 1995. Around 34.9 million workers keep a job in that year, of which 10.0 million lived in the urban area and 24.9 million in the rural area. Agricultural population occupied about 50% in all population, it represented the largest percentage of the all occupations. Trade occupied 12.8%, mining and manufacturing 10.1%, construction 6.5% and transport 5.0%.

The gross domestic product of Pakistan attained Rs. 2,174 billion at current price basis with a growth rate of 6.1 % in 1995/96. Agriculture sector made up 24.8 % of GDP, and the growth rate was put at 6.7 %. Manufacture sector shared 26.5 % in GDP, and the growth rate was 6.1 %. The contribution of service sector in GDP was 48.7 %,.and its growth rate was 5.8 %. The consumer price index varied around 10 % in 1990's.

In the budget of the government of Pakistan, total expenditure and revenue in 1995/96 was Rs. 494.9 billion and Rs. 386.5 billion, respectively. The financial deficit reached Rs. 108.5 billion or 21.9 % of the budget. The disbursed and outstanding debt was estimated at $ 23.1 billion, which was equivalent to 35.7 % of GDP. During 1995/96, debt service payments would aggregate to $ 2.1 billion or 3.2 % of GDP.

Total export value in 1995/96 was estimated at Rs. 9.2 billion with a growth rate of 16.8 %. Leading commodity in export was a cotton group, consisting of raw cotton, textile, clothes and so on, whose share was as high as 62.2 %. Leather group and rice followed it at 6.8 % and 5.4 %, respectively. The total import was estimated at Rs. 10.9 billion with a growth rate of 7.9 %. Machinery, chemicals, petroleum products and edible oil had shares of 20.8 %, 18.4 %, 12.2 % and 7.7 %, respectively. The ratio of trade deficit to GDP has decreased continuously in 1990s, and became 3.1 % in 1995.

Recently, the human development index (HDI) was used for measuring capabilities of human development. The HDI is based on three indicators: longevity, as measured by life expectancy at birth; educational attainment, as measured by a combination of adult literacy and combined primary, secondary, tertiary enrollment ratios; and standard of living, as measured by real GDP per capita (PPP$). The average of the HDI among developing countries of 0.563 was much lower than that of developed countries of 0.909. The HDI of Pakistan was 0.441, making it 134th among 174 countries all over the world in 1993. Life expectancy of Pakistan is 61.8 years being higher than the average of developing countries'. Real GDP per capita is the same as the average of developing countries. On the other hand, gender-related development Index (GDI) and gender empowerment measure (GMI) - showing the disparity in achievement between men and women - was estimated at 0.383 and 0.165, respectively, and they were lower rank than that of HDI among all countries.

Eighth Five Year Plan (EFYP) is scheduled to be implemented from 1993/94 to 1997/98. Annual growth targets were set at 7.0 % in GDP and 4.1 % in per capita GDP. The annual growth rate of agricultural sector was expected to be 4.9 % during the EFYP period. The primary spectral goal is the achievement of a growth rate higher than the population growth, in order to ensure food security, self-sufficiency and large exportable surpluses. Emphasis was laid on integrated management of agriculture, irrigation and drainage, efficient land management and efficient water management.

Agriculture sector is the largest economic sectors, contributing 24 % of GDP, employing a half of the labour force, and sustaining 75 % of the population, as mentioned above. Value added of agriculture sector was estimated at Rs. 4.3 billion in 1994. Each major crop and livestock sub-sector contributed 40 % of the total agricultural production, as shown in the following table.

Sub-sectoral Values Added in Agriculture Sector in 1994

	Major Crops	Other Crops	Livestock	Fisheries	Forestry	Total
Production (Rs. mil.)	1,733	726	1,724	102	33	4,318
Share (%)	40.1	16.8	39.9	2.4	0.8	100

Source: Pakistan Statistic Year Book 1995, Government of Pakistan

The major food crops are wheat and rice in Pakistan. The yield of wheat of 2100 kg/ha is close to world standard. However, Pakistan does not achieve self-sufficiency in staple food, and imported 2.6 million tons of wheat in 1994. The main cash crops are cotton and sugarcane. Main vegetables are potato and onion, and important fruits are citrus, banana, mango and apple in weight.

Cropwise Production in 1995

	Food Crops		Cash Crops		Vegetables		Fruits in 1994		
Items	Wheat	Rice	Cotton	Sugarcane	Potato	Onion	Citrus	Mango	Apple
Production (mil. ton)	17.6	4.0	18.8	45.2	1.1	1.0	1.9	0.9	0.5

Source: Economic Survey 1995 - 1996, Government of Pakistan

Since Pakistan mostly lies in arid and semi-arid climatic zones, its agriculture substantially depends on irrigation. The irrigated area was 1.7 million ha, out of 2.2 million ha of the total cropped area in 1994. The irrigated area widely spreads in alluvial plain of Punjab and Sind Provinces. Canal irrigation and canal/tubewell irrigation area occupy about 80 % of total. On the other hand, the rapid irrigation development has brought about water-logging and salinity problem, especially in Sind Province. National Drainage Project and Salinity Control and Reclamation Project (SCARP) have been launched.

Irrigated Area by Water Source in 1995

	Canals	Wells	Canals /Wells	Tubewells	Canals /Tubewells	Others	Total
Irrigated area (mil. ha)	7.51	0.17	0.1	2.83	6.41	0.18	17.2
	43.7	1.0	0.6	16.5	37.3	1.0	100.0

Source: Economic Survey 1995 - 1996, Government of Pakistan

Livestock sub-sector is vital for the overall agriculture sector. A large population of livestock is raised, as shown in the following table. This sub-sector grew by 5.6 % per annum in 1995. The population of goats was especially high, standing at third rank next to China and India.

640,000 tons of mutton including goats' meat was produced in Pakistan, making it forth largest producer in the world.

Major Livestock Population in 1995

	Buffaloes	Cattle	Goats	Sheep	Poultry
Population (mil. num.)	20.2	17.9	45.6	29.8	345.0

Source: Economic Survey 1995 - 1996, Government of Pakistan

2.2 Balochistan

The Balochistan Province is situated between 24 ° 54' and 32 ° 04' N and 60 ° 56' and 70 ° 15 E, and bounded on the north by Afghanistan and North West Frontier Province, on the east by Punjab and Sind Province, on the south by Arabian Sea, and on the west by Iran. The province covers a total of 347,056 sq.km, about 43 % of the country. Out of the total provincial land, only 4.8 % is cultivated land, 3 % is forest, and remaining are uncultivated or unreported areas.

The province has vast arid and semi-arid tracts, and is naturally divided into four regions that are the upper highlands, lower highlands, plains and deserts. The altitude ranges from sea level at southern coast to over 3,300 m of the highest peak of Sulaiman mountain range. In the western desert average temperature in summer reaches 48°C, while in eastern mountain range -17°C has been recorded in winter. The rainfall is highly variable and unreliable, and average annual rainfall varies from less than 100 mm in the west to 400 mm in the northwest. More than half of the province is covered by soil-less and plant-less mountains. Therefore, water resources are very limited and the natural environment is fragile and subject to deterioration.

The population of this largest province was about 4.3 million according to the census in 1981, and currently (1995) it is estimated at 7.4 million. The recent annual population growth rate has been very high comparing to national level (3.1%), though the population density is still very low (21 person/sq.km) to national average of 165 person /sq.km. Quetta is the seat of the provincial government and the largest urban center where there has been rapid urbanization during the last two decades.

Large parts of the province can be characterized as tribal area. There are three major ethnic groups in Balochistan, that is, Baloch, Brahui and Pashtun. Besides, the Sindhi, Punjabs, and some other ethnic groups also live in this province. Pashtun tribes live mainly in northern mountainous areas, the Baloch live predominantly in the southwestern and eastern part of the province and Brahui inhabit mainly the Kalat plateau. Each ethnic group has its own social structure and traditional customs. During Afghan war a large number of refugees (about 1.5

million) immigrated into this province, but most of them are being repatriated to Afghanistan. It is certain that, in Balochistan, a significant proportion of the population is engaged in nomadic activity. Though it is very difficult to estimate the exact number of the nomad people due to the high degree of seasonal mobility between and within countries and provinces, reportedly they may share about 10 % of the rural population in Balochistan.

Before partition, Balochistan was divided into the British Balochistan that mainly included Pashto speaking area, and the native Balochistan mainly consist of Kalat, Kharan and Bela states. In 1955 they became part of Pakistan and were raised to a province in 1970. At present, administratively, this province consists of 6 divisions that can be divided into 27 districts. As the lowest tier of the local government, there are about 360 Union Councils whose members are elected by villagers. From law and order point of view, this province is divided into two parts. One is the area including Quetta city and its suburb (about 25 %) which is controlled by regular police force, while the other is the rural area (about 75 %) which is dealt with by the traditional force being recruited from tribes, called Levy.

In 1993 the literacy ratio in Balochistan was 20.9 % (29.3 % for men and 11.8 % for women) which are very low comparing to national average of 35.5 % (45.3 % for men and 24.7 % for women). Though this ratio was higher in urban area, 44.4 % (55.2 % for men and 30.4 % for women), in rural area it was quite low with 16.2 % (23.5 % for men and 8.3 % for women). During recent 15 years, this ratio has been considerably lifted up, but it is still be very low, especially in rural area.

Agriculture is the dominant sector of the province contributing 54 % to the GDP and directly employing 62 % of the labour force. The 80 % of the active population are engaged in the crop production and animal husbandry. The number of small farmers having an area less than 5 ha account for 63 %, and that less than 10 hectare reaches 80 % to the total number of farmers. On the other hand the vast land in the province belongs to the tribal Sardars and chiefs. About 48 % of the cultivated land of 1.67 million ha are irrigated, while about 52 % is under rainfed farming. Irrigation in southeast plain is mainly depend on the large scaled canal systems, while in the other areas main irrigation water sources are tubewells and open surface wells, karezes, and springs that are generally of small scale.

In irrigated uplands, several fruits and vegetables production are prevailing in summer. The main varieties of fruits are apples, pears, peaches, plums, grapes and cherries in highlands, and dates in southern region. Rice, maize, millet, tobacco and cumin are also some of the main summer crops. In winter, wheat, barley, legume, rape and mustard, and some winter vegetables are mainly planted. While, in rainfed areas, wheat, barley, beans, melons and some other cash crops are mainly planted, however those areas fluctuate year by year due to the unreliable rainfall. The production and yields of irrigated crops have considerably increased

over the years, due to increase in irrigation facilities and better management practices such as the adoption of high yielding varieties, increased use of farm inputs, etc., while that of rainfed crops has fluctuated very much depending on the amount and distribution of annual rainfall. If the rainfall is inadequate to mature crops, immatured crops are grazed.

Because of the topographical and climatic constraints, crop production can hardly be undertaken economically in the considerable areas. About sixty percent of the area is rangelands with poor and deteriorating natural vegetation. However these rangelands are important for nomadic and semi-nomadic people. According to the livestock population census in 1986, their area 11.1 million heads of sheep, 7.3 million heads of goats, and 1.1 million heads of cattle in this province. The heads of sheep and goats are 47 % and 25 % of the total heads of country respectively. The livestock sector contributes about 37 % to provincial agricultural GDP, and about 20 % of total provincial GDP. However, it is anxiety about that the continuing degradation of the rangelands is reducing the livestock population. Most of other indigenous industries are based on the processing of agricultural products that is a predominantly micro and small scale, but some medium and large scale industries are located in Lasbela and Quetta. In addition there are a number of coal mining.

The current agriculture in Balochistan has several constraints. Especially the scarcity of irrigation water is a major limiting factor. The continuous dropping down of the groundwater table due to the excessive pumping up with tubewells has become the most serious problem. As the countermeasures to prevent dropping down of the groundwater level, the constructions of a lot of delay action dam and the regulation of new setting up of tubewells in a part of the province are being taken by the government. Besides, the low uses of fertilizers, insufficient supply of quality seed and seedlings, inefficient and uneconomical use of agricultural machinery, weak agricultural marketing system and the lack of infrastructure for marketing, seasonal shortage of feed and overgrazing in livestock raising, etc. are also main constraints against the development of agriculture in the province.

Currently, Balochistan provincial governments are conducting several projects such as the preparation of physical infrastructure, water source development, production increasing plans, social development, etc., according to the Eighth Five Year Plan (1993-1998). These projects are being carried out especially under taking consideration of the environment protection, improvement of the status of women, rising up of the education level, etc. Besides, several international agencies and developing countries are giving economical and technical aids to the provincial government. However the financial situation of the government is now seemed to be very serious.

2.3 Groundwater and Hydrogeology in Northern Part of Balochistan

In the northern part of Balochistan, where the Study Area is located, three major mountain ranges namely Toba Kakar, Central Brahui, and Sulaiman are running in the direction from east to west.

Watersheds separated by these mountain ranges form separate hydrological basins as shown in Fig. 2.3.1. The Study Area is located in the central part of Northern Balochistan, and Pishin Lora Basin occupies the major part of the Study Area as shown in Fig. 2.3.2. The Pishin Lora Basin is surrounded by Chaman Valley and Kadanai Basin in the north, Zhob River Basin, Nari River Basin, and Kachhi Plain in the east, and Mula River Basin, Hingol River Basin, and Hamun-e-Mashkhel (including Khaisa Basin and Baddo River Basin) in the south and west direction.

Delay action dams in the Study are all included in Pishin Lora Basin as major basin in the Study Area. Groundwater potential available in Pishin Lora Basin, which is approximately 400 MCM annually, is already over exploited resulting into significant drawdown of groundwater level year after year, and if pumping continues at this rate, groundwater resources may be exposed to danger of drying up.

Base rocks in this area are composed mainly of Permo-Triassic to Cretaceous limestone with subordinate shale and sandstone overlain by Tertiary System, Pleistocene silts/clay strata accumulates on the subsurface valley of base rocks in the lowland of northern sub-basin. In the north-eastern side, very thick molasse is deposited forming very large synclinorium. In the lowland area separated by these steep mountain ranges, Quaternary System such as alluvial fan deposits, river deposits, floodplain deposits are found in very thick layers. The model of drainage system in Pishin Lora Basin is shown in Fig. 2.3.3.

Groundwater resources in the area are mostly mined from the aquifers in alluvial fan deposits, and partly from subsoil water in the river deposits or from springs out of the fissures and cavities in the limestones of new age mainly in Kalat Sub-Basin situated in the southern part of the Basin.

The distribution pattern of alluvial deposit as an important groundwater storage basin is as follows:

> Piedmont area composed mainly of alluvial fan deposits consists of highly permeable sands/gravels strata forming excellent unconfined aquifers suitable for groundwater recharge.

The area several kilometers away from mountain foots is composed of the inter-fingering strata of silts/clay and sands/gravel which consist of confined or semi-confined aquifers.

Proceeding further downstream the proportion of silty/clayey strata is gradually increasing, and the lower reaches of the valley floor are composed of almost entirely of silty/clayey strata forming impervious barrier like underground dam. The subterranean groundwater flow to other sub-basins is therefore relatively low.

The water from the aquifer in alluvial fan area is extracted mainly by tubewells through out the year. The utilization of subsoil water from river deposits or springs in the rock fissures, etc., is done by karezes, a traditional method in this province for groundwater uses. The recent increase in the number of tubewells has resulted into excess pumping over recharge culminating into drawdown of groundwater level in the basin.

2.4 Present Condition of Delay Action Dams

(1) Delay action dam projects

Delay action dams construction in Balochistan was commenced in 1971, and 110 dams have already been constructed and another 84 dams are proposed to be constructed. Dam locations and its inventory are plotted in Fig. 2.4.1 and Annex I, respectively. Existing dams have been constructed in highland regions surrounding Quetta city which is situated in Sub-tropical continental highlands (Pishin Lora basin, Dasht river basin, western areas of Zhob river and Nari river basins). In Balochistan, the highland regions have relatively better water sources compared to other regions due to high precipitation of more than 200 mm per annum. The future proposed dams are planned in Kachhi-Sibi Plain and Dasht river basin located along Markran Coastal belt. These regions are situated in the Sub-tropical continental lowlands and the Sub-tropical coast lands, respectively. These regions have small annual precipitation of 100 to 200 mm. Delay action dam construction in this region would be less viable owing to inadequate water resources as compared to the highland regions. The rainfall is irregular and wide seasonal variations are a common feature in the whole of the Balochistan Province. Generally the plains and lower highlands receive rainfall in summer monsoons during July to August and the upper highlands in winter during February to March from storms advancing from the Persian Gulf.

Delay action dams have their beneficial agricultural area of 85 ha from the existing dams and 320 ha from the proposed dams on the average. Fill type material is suitable for the dam body

to accelerate groundwater recharge through the dam and reservoir foundation. Most of the dams are less than 15 m high.

Existing/Proposed Delay Action Dams and Beneficial Areas (ha)

Irrigation Circle	Existing dams		Proposed dams		Total	
	Dam No.	Beneficial area	Dam No.	Beneficial area	Dam No.	Beneficial area
Sibi	17	1,140	9	770	26	1,910
Quetta	9	460	7	480	16	940
Pishin/Qila Abdullah	41	3,800	20	3,860	61	7,660
Khuzdar	16	1,150	34	14,070	50	15,220
Loralai	27	2,070	14	2,810	41	4,880
Total	110	8,620	84	21,990	194	30,610

Source: Irrigation Department, Balochistan

Delay action dam construction is increasing in and around the Quetta valley where severe decline of the groundwater surface has been observed. Construction of new dams (Shagai I, II, Hingi and Tabai) is planned across the four tributaries of Sariab and Hanna rivers out of their 14 tributaries. However, implementation schedule of these four dams is not prepared as yet. In the Pishin District, several dams are under construction in the Kadania river basin (Qila Abdullah), northern area of the Pishin Lora basin (Arambi) and north-eastern area of the Pishin Lora basin (Pishin). Delay action dam project aiming at groundwater recharge and sediment control of the Khushdil Khan Bund, whose storage capacity has been reduced by excessive high inflow of sediment, is envisaged in the Pishin District. In the Mastung and Kalat Districts, the annual precipitation ranges between 100 to 150 mm, accordingly less river run-off is expected. Therefore, delay action dams with relatively large drainage areas have been selected to ensure the project viability.

Presently 64 delay action dams have been constructed in the Study Area. These dams are, however, spread within the limited area, and also lack in the absolute capacity to halt the groundwater decline. In parts of Pishin District, groundwater level has a rising tendency due to use a series of the delay action dam construction. Contrary to this, rapid decline of the groundwater surface is becoming region-wide problem in the Study Area. The following districtwise table summarizes the existing delay action dams in the Pishin Lora basin.

Delay Action Dams in Pishin Lora Basin

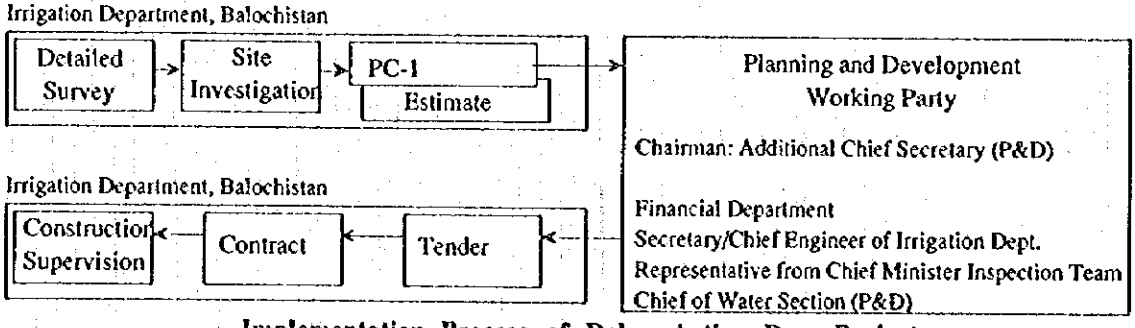
Cap.: Reservoir capacity (1,000m³)

Districts / Basin/Sub-Basin	Qila Abdullah Nos.	Qila Abdullah Cap.	Pishin Nos.	Pishin Cap.	Quetta Nos.	Quetta Cap.	Mastung Nos.	Mastung Cap.	Kalat Nos.	Kalat Cap.	Total Nos.	Total Cap.
Pishin Lora Basin												
Pishin	0	0	22	20,519	0	0	0	10	0	0	22	20,529
Kuchlagh	0	0	12	15,263	1	2,073	0	10	0	0	13	17,346
Quetta	0	0	0	0	8	1,686	1	12	0	0	9	1,698
Kolpur	0	0	0	0	0	0	0	0	0	0	0	0
Mastung	0	0	0	0	0	0	2	1,573	0	0	2	1,573
Shirinab	0	0	0	0	0	0	1	60	0	0	1	60
Mangochar	0	0	0	0	0	0	0	0	1	159	1	159
Sardar Khel	0	0	0	0	0	0	0	0	0	0	0	0
Patki Shah Nawaz	0	0	0	0	0	0	0	0	1		1	0
Kalat	0	0	0	0	0	0	0	0	7	955	7	955
Kopoto	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	0	0	34	35,781	9	3,759	4	1,665	9	1114	56	42,319
Other Basin	0	0	6	15,263	0	0	2	84	0	0	8	15,347
Total	0	0	40	51,044	9	3,759	6	1,749	9	1114	64	57,666

The K.K.Bund (Pishin) having reservoir capacity of 55,507,500m³ was not considered in above table.

(2) Project implementation of delay action dam

Implementation procedure of the delay action dam project is illustrated below. The Irrigation Department is responsible for the detailed survey, design and cost estimate, and preparation of the proposal for approval of the "Provincial Development Working Party" of the Balochistan Government. The Irrigation Department then puts the work to tender and awards contract subject to a availability of funds. Construction of the dams are supervised by the Sub Divisional Officer (SDO) or Sub-Engineer in the respective Irrigation Circle. Dam construction is carried out using the machinery and equipment owned by the contractor, or those owned by the Irrigation Department rented to the contractor.



Implementation Process of Delay Action Dam Project

As tabulated below, construction machinery and equipment owned by the Irrigation Department have been used for a long period (more than 15 years), so that the working capacities have

deteriorated despite proper maintenance by the Department. Accordingly, the dams have been constructed by the machinery owned by the contractor. However, proper construction was not always performed because of a lack of the construction machinery. Machinery and equipment is maintained at the workshop in Quetta by a section of Irrigation Department. Sufficient equipment and tools are available in the workshop for the ordinary maintenance works except those for grinding and engine overhaul. Spare parts inventory for recently procured models is well maintained in the workshop.

Machinery and Equipment of the Irrigation Department

Machinery	Specifications	Number	Operation Period (year)	Present Conditions
Bulldozer	200 HP	22	17-18	21 out of order/under repair
	140 HP	25	10-11	21 out of order/under repair
	116 HP	2	10	1 out of order/under repair
Backhoe	0.2-0.7 m^3	8	2-10	Working condition
Wheel Loader	1.0-2.0 m^3	5	2-16	Working condition
Vibratory Roller	10 ton	7	2-13	Working condition
Dumptruck	10 ton	9	12-18	4 out of order/under repair
Trailer	26 ton	2	15-17	1 under repair
Truck	2.0-4.0 ton	9	16-18	8 out of order/under repair
Motor Grader	Blade 3.7m	4	2	Working condition
Compressor	20-60m^3/m	5	18	5 out of order/under repair
Generator	50-100 KVA	1	15	Out of order
Water Truck	6 m^3	12	12-21	8 out of order/under repair

2.5 Related Projects

Some projects related with objectives of the Study have been implemented and completed in and around the Study Area. In this section, several projects having keen relation with the Study are selected and summarized below.

(1) Integrated Area Development Programme

Food and Agriculture Organization (FAO) of the United Nations has executed several projects which aims at promoting sustainable use of renewable natural resources, to innovate the technology of agricultural and livestock productivity and to improve the quality of life in the rural area of Balochistan. In June 1996, the five on-going FAO projects, namely, 1) Integrated

Range-Livestock Development Project, 2) Watershed Planning and Management Project, 3) Feed Resources Development Project, 4) Outreach and Transfer of Fruit Technology in Balochistan, and 5) Inter-Regional Participatory Upland Conservation and Development Project were combined to concentrate their efforts on much larger areas. Among above 5 programs, number 2 is co-funded by the World Food Programme (WFP) and the Government of Italy. Number 5 is funded by the Government of Italy, and the remaining are funded by UNDP programs. The IADP covering three districts of Loralai, Qila Abdullah and Mastung is being implemented by giving technical, social and economical assistance for organizing, strengthening and proper functioning of the farmers organizations through participatory approach, in accordance with the basic policy of Participatory Rural Appraisal (PRA). This new methodology of watershed and range conservation and management being a major objective of the programme, has led to improvement of social awareness for the natural resources. A remarkable rehabilitation of covered vegetation by planting trees and/or grasses, conservation of restricted range area and its protection by an active involvement of the local population has been taken place. The programme will be completed by middle of 1997.

(2) BMIAD Project

The Balochistan Minor Irrigation and Agricultural Development Project (BMIADP) is an on-going project started in 1983, with the objectives to increase agricultural production and farm incomes through minor irrigation and command area development and improved agricultural practices. It covers 10 districts of Zhob Loralai, Khuzdar, Las Bela, Pishin, Ziarat, Kachhi, Quetta and Qila Saifulla. Phase I of the BMIADP has been implemented for 42 perennial schemes covering about 11,000 ha. It is financed with credit assistance from IDA and the German Government and grant from the Netherlands Government. Socio-economical impacts of the Project and its technical soundness have been throughly studied. New approach of participation of the beneficiaries for operation and maintenance has been applied. Following the Phase I, the phase II programme has been launched.

(3) Balochistan Groundwater Resource Re-assessment Study

In most of the northern part of the Balochistan, groundwater use is under serious unsustainable threat due to rapid lowering of groundwater stage as a result of increased groundwater exploitation. ADB, therefore, conducted an assessment study for groundwater resource on 6 major basins located in northern Balochistan in 1995. The objective of the study was to assess groundwater potentiality, seek realistic development objective of irrigated agriculture, and to prepare comparative scenarios for management of the groundwater resources including

institutional reforms. The Final Report of the Study recommends establishment of Integrated Valley Development Authority for further sustainable groundwater use management.

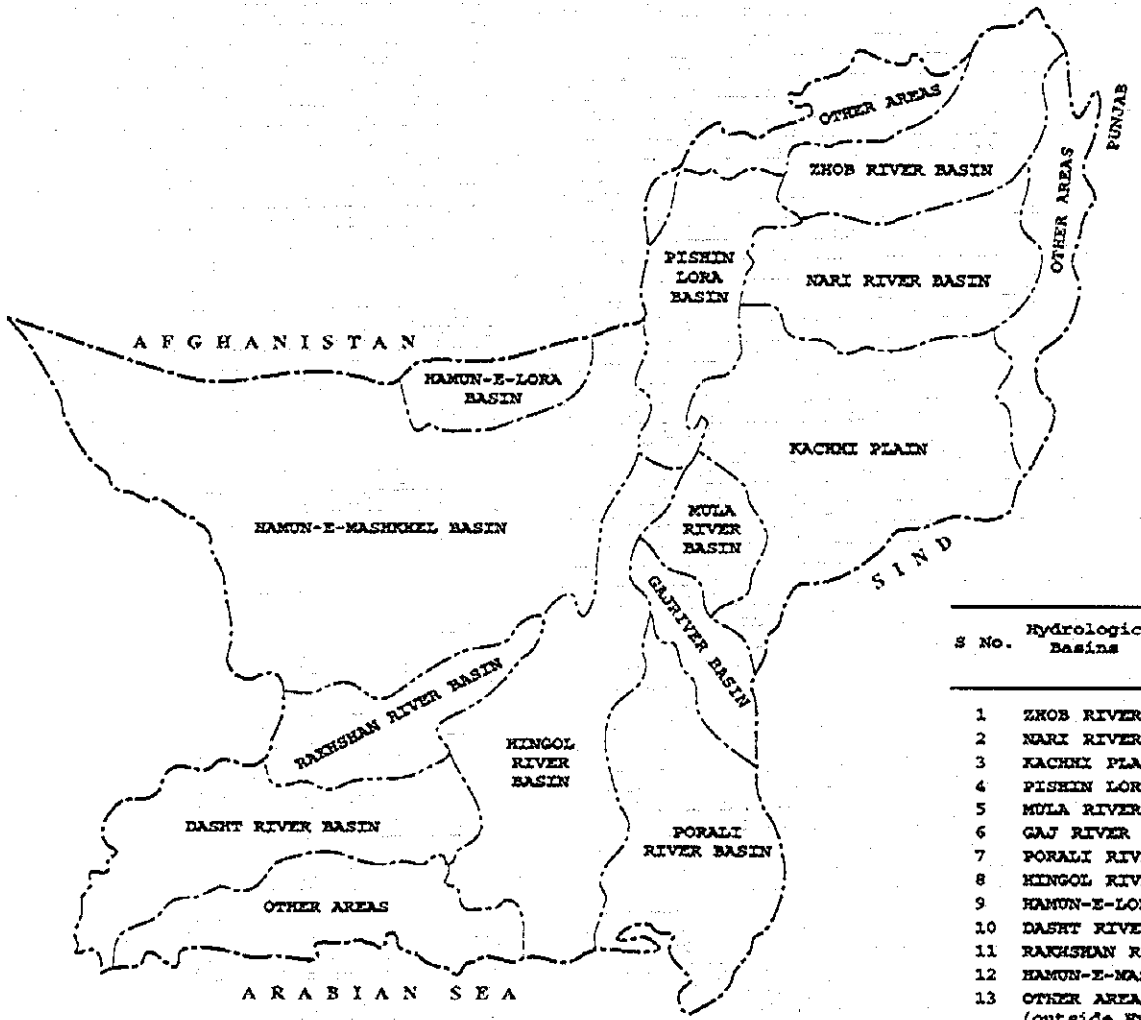
(4) Balochistan Irrigation Development Project through Groundwater Development

In the 1980's, northern areas of the Balochistan came under rapid development of groundwater due to improved availability of electricity and high demand for fruits production. An effective and precise groundwater research were required during the decade. The Government of Japan technically assisted the execution of the Balochistan Irrigation Development Project through Groundwater Development (BIDPGD) in the response to the request of the Government of Balochistan Province, for 2 districts of Quetta and Kalat located in northern Balochistan. The Master Plan Study was conducted for irrigation development applying new research technology of gamma ray spectrometry which has a clear advantage for investigation over a large area. Field survey of the Study was completed using helicopter in 1986, and final report of the Study was submitted in March 1987. The report, however, did not propose any countermeasures against groundwater depletion, but only exploitation of groundwater was recommended.

(5) Balochistan Groundwater Development Project

In 1994, the Government of Balochistan Province requested the Government of Japan for drilling machines to be used for groundwater extraction in permissible areas. In response to the request, the Government of Japan granted 6 drilling rigs through execution of the Basic Design Study.

The project is a grant aid program with WAPDA as the implementing agency, for the project area mainly consisting of Panjgur and Turbat Districts which are located in south-western Balochistan falling behind in groundwater development. Though detail investigation for allowable quantity of groundwater development was not conducted in the Basic Design Study, consideration for sustainable groundwater use was paid by giving priority to surface water development over groundwater extraction as much as possible. Objectives of this project coincide with the present project in so far as the sustainability of groundwater is concerned.



S No.	Hydrologic Basins	Total Catchment Area (sq. kilometers)	Available Groundwater for Future Use (MCM/Year)
1	ZHOB RIVER	15,390	40
2	NARI RIVER	26,960	76
3	KACHKI PLAIN	40,100	40
4	PISHIN LORA	16,930	0
5	MULA RIVER	8,480	10
6	GAJ RIVER	6,010	12
7	PORALI RIVER	22,650	85
8	HINGOL RIVER	36,540	128
9	HAMUN-E-LORA	8,120	16
10	DASHT RIVER	30,600	28
11	RAKHSHAN RIVER	12,690	15
12	HAMUN-E-MASHOOKEL	75,010	43
13	OTHER AREAS (outside Hydrologic Basins)	47,580	31
	Total	347,060	523

Fig. 2.3.1 Hydrologic Basins of Balochistan

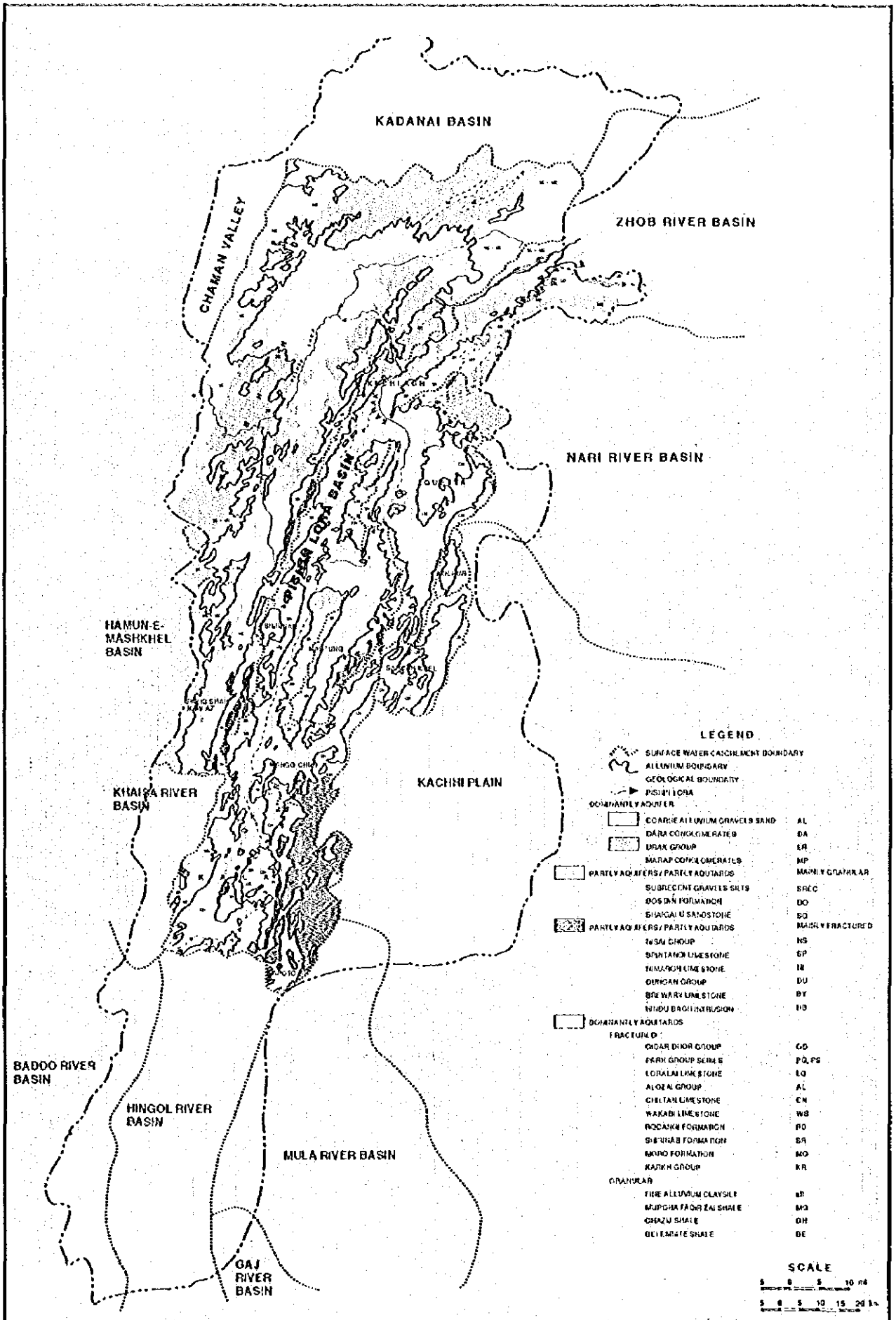


Fig. 2.3.2 Location of Pishin Lora Basin and Its Aquifers and Aquitards

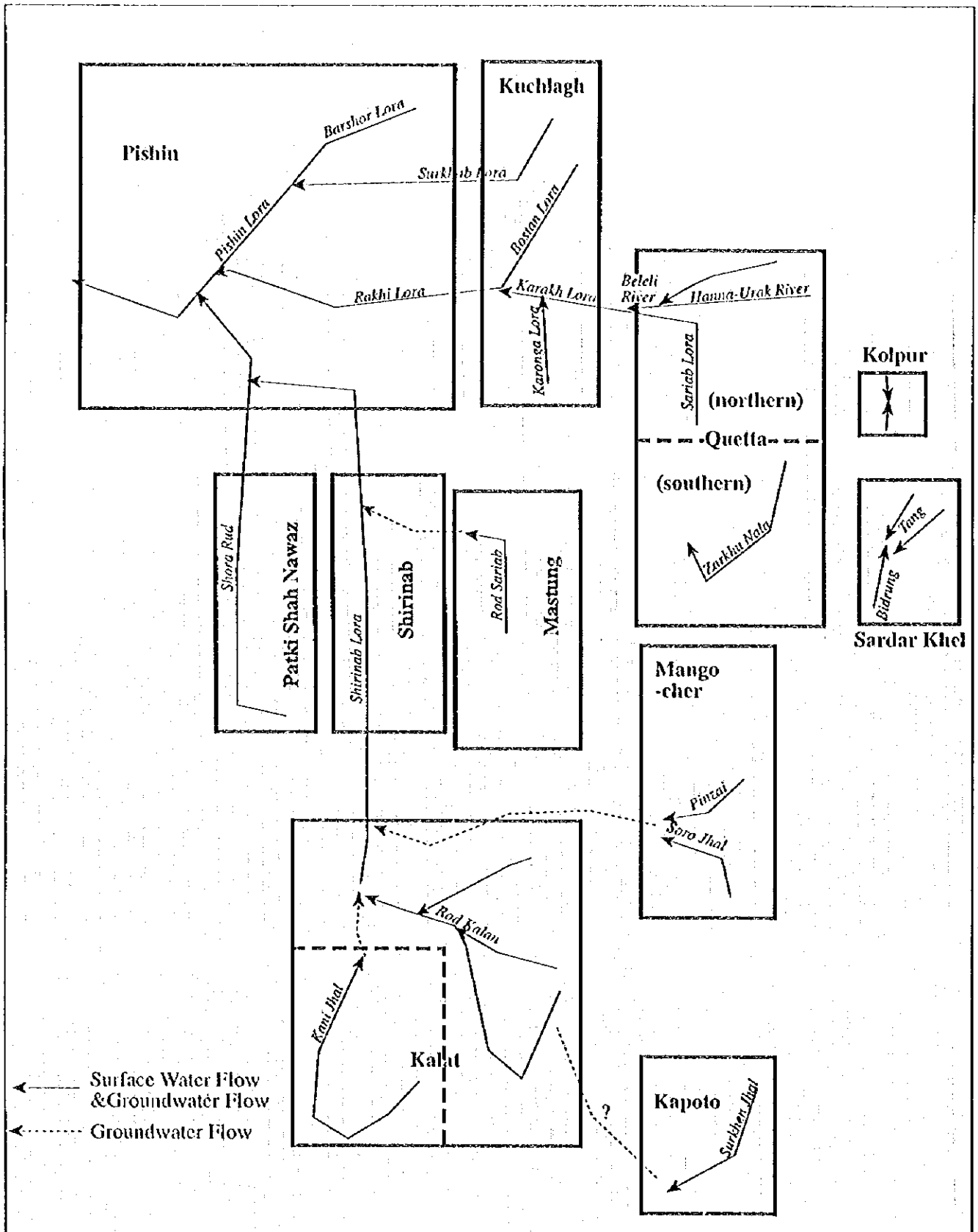


Fig. 2.3.3
Surface and Subsurface Drainage Flow System of Pishin Lora Basin

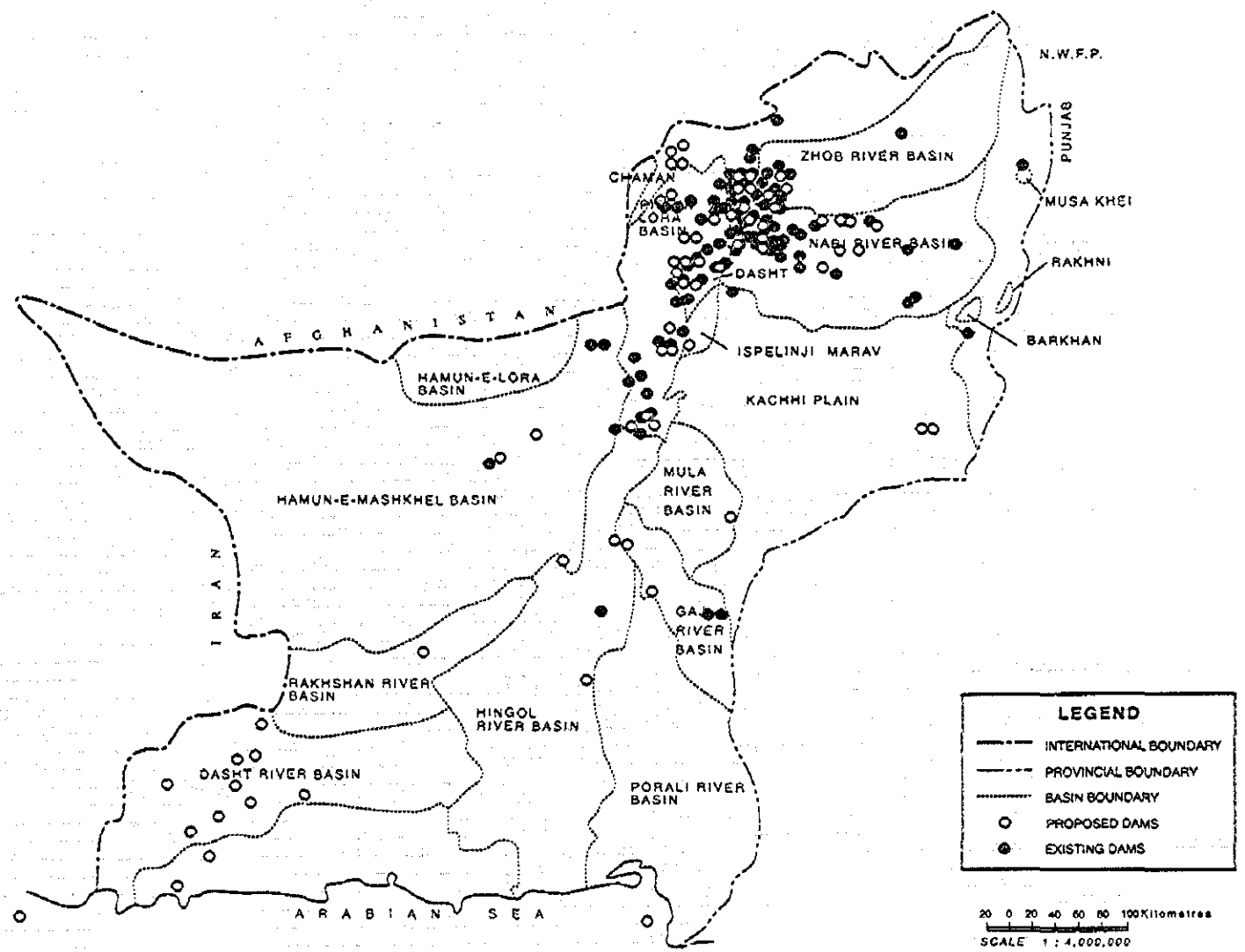


Fig. 2.4.1 Location Map of Delay Action Dams in Balochistan