BALOCHISTAN

FLOOD WATER IRRIGATION SCHEMES
VOLUME 1
GENERAL BACKGROUND AND CONCLUSIONS

REPORT PREPARED FOR
THE ROYAL NETHERLANDS EMBASSY,
ISLAMABAD

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ABBREVIATIONS

a.m.s.l.	Above mean sea level
BID	Balochistan Irrigation Department
B.M.	Bench mark
C.L.	Center line
cumec	cubic meter per second
cusec	cubic feet per second
D/S	Downstream
DES.	Designed
EX.	Existing
GoBal	Government of Balochistan
G.W.C.	GROUND WATER CONSULT
H.F.L.	High flood level
L.S.	Left side
NESPAK	National Engineering Services of Pakistan
N.T.S.	Not to scale
ODA	Overseas Development Agency
P.C.C.	Plain concrete cement
R.C.C.	Reinforced concrete cement
R.C.D. Highway	Regional Cooperative Development Highway (Coastal road from Karachi to Bela)
R.D.	Reduced distance (from a reference point)
R.L.	Reduced level (from a reference point)
R.S.	Right side
SWHP	Surface Water Hydrology Project
U/S	Upstream
WAPDA	Water and Power Development Authority

I GENERAL

I. GENERAL

1 INTRODUCTION

Flood water irrigation schemes, often of a very primitive nature, have been built for many centuries by people living in arid and semi-arid mountainous areas. During rainy seasons, especially when high intensity rain storms occur, flash floods may develop which originate in mountains and hills. Sparse vegetation or the total absence of plant growth in a catchment area considerably contribute to these high volume, flashy floods. Large quantities of erosional material like sand, gravel and even large stones are carried along with the water and consequently, these floods are often very destructive: large areas may be suddenly inundated and damage to houses and loss of life of cattle and people are not uncommon.

Water being so valuable in these arid and semi-arid areas, and because such large quantities of water are involved in these floods, people have always attempted to control these floods for their own benefits and protection. Small kachha dams across the expected path of the water flows, guiding bunds and diversion canals were constructed in order to divert at least a portion of the water to their fields, but due to the intensity of the floods these simple structures generally had to be rebuilt after every flood.

Later, although as early as the end of the last century, Government agencies took the initiative to construct more permanent and often much larger structures in order to divert larger quantities of water to the farmers' fields. Especially after the Independance the Pakistan Federal as well as the Balochistan Provincial Governments carried out extensive programmes to develop flood irrigation schemes which involved not only the construction of water diversion structures (weirs) but also building low dykes (bunds) and digging water diversion canals to the fields of the local inhabitants. But even these masonry and/or concrete structures often failed for various reasons.

Donor agencies have always been very interested in these flood water irrigation schemes, for example the O.D.A. of the U.K., the Kuweit Fund, the European Community, Asian Development Bank and the Netherlands, among others, are and were involved in various projects to harness flash floods.

However, information and documentation on the existing schemes in Balochistan are not readily available and therefore, in consultation with the Balochistan Planning and Development Department and the Irrigation and Power Department, the Royal Netherlands Embassy took the initiative to sponsor a project to make an inventory of Balochistans' existing flood water schemes which fall under the direct responsibility of the Provincial Irrigation Department.

GROUND WATER CONSULT, a firm based in Islamabad as a division of DESIGNMEN Consulting Engineers, was selected to carry out the project.

An important aspect of the project was to determine the impact of these schemes on the living standards of the population affected. To evaluate these socio-economic influences, SEBCON, an Islamabad based firm specialised in such investigations, was subcontracted to supply personnel for this task.

The whole project consisted of two parts: 1) field work to collect data and carry out surveys, 2) office work where the data was studied and a status report of each scheme was prepared with regard to its planning, design and operation.

Late November 1990 the field team started work in southern Balochistan. Avantage was taken of the cooler winter temperatures to carry out investigations in Lasbela, central Balochistan and the Sibi/Kachhi areas, while during the late spring/early summer work continued in the Zhob and Loralai areas. The field work was completed early July 1991, after having visited more than 70 sites.

GROUND WATER CONSULT/DESIGNMEN's engineer Mr. Nayyar Jamal was in chrge of the field team. He was accompanied by Mr. Khalid Saleem, socio-economist with SEBCON. Additional personnel consisted of assistent engineers, surveyors and drivers.

Office work began after the return of the personnel from the field to Islamabad. The processing of the data and the preparation of the final report was completed in December 1991.

GROUND WATER CONSULT/DESIGNMEN's Mr. B. A. Shakir, was responsible for the engineering aspects of the project and visited a number of schemes in different areas of Balochistan.

Mr. J. Morton, senior investigator associated with SEBCON, supervised the socio-economic survey. He also made several trips to different parts of the Province.

The whole project was headed by Mr. H. van Hoeflaken, director of GROUND WATER CONSULT, who also spent a number of days in the field at different occasions.

We like to express our gratitude to the personnel of the Irrigation Department both in the field as well as in Quetta. The Department supplied us with a map and information where the schemes were located. The Secretary was very helpful in instructing the Divisions and Sub-Divisions to cooperate with GROUND WATER CONSULT's field team. Executive engineers and other officers assisted in supplying data and lodging facilities which was highly appreciated.

We thank the Provincial Home Secretary for his assistance to issue security clearances to visit the often very far-flung areas.

The whole project would not have been possible without the positive and enthousiastic support of the Secretary, Irrigation and Power Department of Balochistan.

2 ORGANISATION OF THIS REPORT

The complete report consists of 7 volumes. The present volume (Volume 1) is a general text as an introduction to all aspects related to the project. It also includes conclusions and recommendations which were arrived at after the completion of the study.

Volumes 2 to 7 are regional volumes. For convenience sake the Province was divided into 6 areas, as follows:

Volumes 2 A and 2	BLasbela
Volume 3	Turbat, Panjgur, Khuzdar and Kalat
Volume 4	Kachhi and Sibi

Volume 5	Pishin and Quetta
Volume 6	Zhob
Volume 7	Loralai

On the enclosed general index map of the Province (enclosure 1) these areas are outlined.

Together these volumes form a catalogue of those flood irrigation schemes which are operated and maintained by the Provincial Irrigation Department.

Each volume contains a short introduction with information on the area, followed by detailed reports of each scheme, outlining the salient features, technical details, present condition, shortcomings in design/planning, operational problems if any, the areas which need rectification and our own suggestions. The schemes are organised in alphabetical order according to a letter code which is mentioned in the list of contents of each volume. The individual descriptions consist of a text, technical drawings and photographs.

The drawings are partly reductions of technical plans which were found in existing reports, and partly drawings made by G.W.C.'s surveying team in the field. Many more technical drawings and plans exist in the regional files of the Provincial Irrigation Department. Only those drawings were se-lected which will give an overall view of a structure with enough details for a technical reader. All drawings were adjusted and reduced in order to fit the size of the report. The original drawings are often much larger and cumbersome to handle. Photocopies of the original drawings are on file in G.W.C.'s offices. In adition, G.W.C.'s field team carried out topographical surveys of most of the schemes, both of a general as well as of a detailed nature. The present-day situation is often at variance with the original technical plan. Also these newly surveyed maps and plans were on a much larger scale and were also reduced to fit the report.

We consider the photographs to be a very essential part of the inventory. Several photographs may say more than a full page text. Not only will a photograph give a view of a structure, but it will also give an impression of the landscape around each location, the type of soil, topography and vegetation. Combined with the technical drawings a reader should be able to visualize the local setting and the layout of a scheme. During the survey many more photographs were taken and only a selection is included in the report. The remaining photographs are on file in G.W.C.'s offices at Islamabad.

Although we were able to visit most of the existing schemes in Balochistan we do not claim to present a complete picture. There are some more schemes which were built and are operated by other provincial agencies, for example the Forestry Department. However their number is very limited. We were unable to locate these schemes and consequently, did not visit them.

An attempt has been made in our study to critically analyse each scheme and in case of its inefficient working, partial or complete failure, to pinpoint the shortcomings in planning, design, execution or operation thereof. Suggestions have been given regarding remedial action needed in each case.

As an outcome of this study general guidelines have been prepared for planning of future flood irrigation schemes which may be of some value to the planners.

If any agency, provincial, federal or donor, wants to concentrate its attention on a particular scheme or area, this inventory wil prove very useful as a starting point. Additional detailed studies can be carried out as and when required.

3 ADMINISTRATIVE UNITS AND FIELD OPERATIONS OF THE DEPARTMENT OF IRRIGATION AND POWER

Balochistan is divided into a number of administrative units called Civil Divisions which are further subdivided into Districts. Figure 1 shows these units.

The Secretary of the Balochistan Department of Irrigation and Power resides in Quetta. The Department operates a number of field offices staffed by technical officers who handle the local activities of the Department. For this purpose the province is divided in a number of 'Irrigation Circles' and further subdivided into 'Divisions'. The Chief Engineer of the Department, who is based in Quetta, is in charge of all the Department's activities in the province. Each Circle is headed by a Superintending Engineer while Executive Engineers are in charge of the Divisions. Subdivisional Officers take care of the execution of projects in the field.

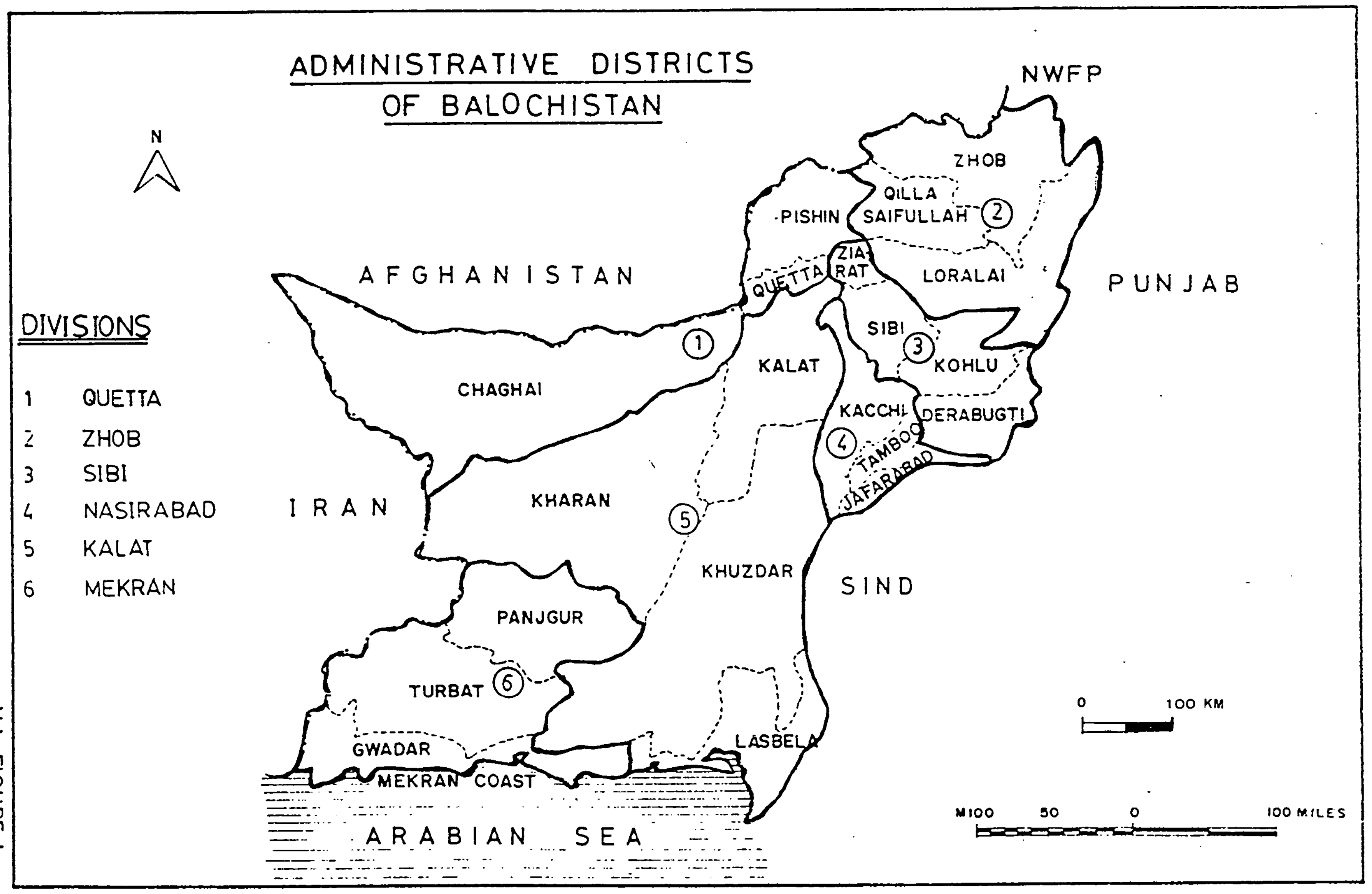
Here follows a list of the Irrigation Department's Circles and Divisions. (The management of the large irrigation canals is not included):

	Headquarter
1) Loralai Irrigation Circle	Loralai
a) Loralai Irrigation Division	Loralai
b) Zhob Irr. Div.	Zhob
c) Kohlu Irr. Div. Kohlu	
2) Kalat Irrigation Circle	Khuzdar
a) Turbat Irr. Div.	Turbat
b) Mastung Irr. Div.	Mastung
c) Khuzdar Irr. Div.	Khuzdar
d) Bela Irr. Div.	Uthal
3) Sibi Irrigation Circle	Sibi
a) Sibi Irr. Div.	Sibi
b) Kachhi Irr. Div.	Dhadar
4) Quetta Irrigation Circle	Quetta
a) Quetta Irr. Div.	Quetta
b) Pishin Irr. Div.	Pishin

Files on all past and present projects are kept at the Divisional headquarters. As far as we could ascertain, these files are fairly complete and we were able to find most of the required information on flood water irrigation schemes. At the Chief Engineer's office in Quetta only the more important files are kept. However, we wonder if not a number of schemes, built many years ago and which, due to extensive damage or 'siltation', fell in disarray and are now 'forgotten' without references in current files. It would be interesting to trace these forgotten structures to determine what went wrong and when this happened.

GROUND WATER CONSULT, during its field survey, studied only those flood water irrigation schemes which resort under the direct responsibility of the Irrigation Department. In addition, a few (4) schemes were visited which were constructed by local zamindars.

V.I, FIGURE I


ADMINISTRATIVE DISTRICTS
OF BALOCHISTAN
N
DIVISIONS
1 QUETTA
2 ZHOB
3 SIBI
4 NASIRABAD
5 KALAT
6 MEKRAN
AFGHANISTAN
IRAN
NWFP
PUNJAB
SIND
ARABIAN SEA
ZHOB
QILLA SAIFULLAH
PISHIN
ZIARAT
QUETTA
LORALAI
SIBI
KOHLU
KALAT
KACCHI
DERABUGTI
TAMBOO
JAFARABAD
CHAGHAI
KHARAN
KHUZDAR
PANJGUR
TURBAT
GWADAR
MEKRAN COAST
LASBELA
0 100 KM
M100 50 0 100 MILES

4 FIELD WORK

During the field work a few operational problems were encountered.

In the Pishin District the local authorities required for security reasons that the field team should be accompanied by levies. Only day light travel was allowed and the team also had to return every day back to Quetta. As a consequence, two flood irrigation schemes could only be inspected in a cursory way.

In the Zhob District two flood irigation schemes close to the Afganistan border were 'out of bound' and the data on these schemes is based on existing reports.

The non-availability of topographical maps, especially on the scale of 1 : 50,000 caused some problems. Small scale maps, like 1 : 500,000 and 1 : 250,00 are more easily to obtain. It is regretted that topographical maps are not easily available.

In the field the team received very valuable help from the Irrigation Officers. District technical officers accompanied the team to show the structures in the field and to discuss the specific problems of the area.

The team used standard forms to record the required information. One schedule was specifically directed to obtain general and technical data while a separate schedule was used for the socio- economic survey. Blank copies of both forms are included in this volume (see appendices 1 & 2). In volumes 2-7 of this report the general outline of these schedules is followed to decribe the schemes. Certain questions often could not be answered satisfactorily. Here follows a short discussion of some of the technical questions.

A-5, CATCHMENT AREA

The figures regarding the size of the catchment area were generally obtained by measuring these areas on available maps, although in a few cases the size was reported in existing reports.

A-7, HYDROLOGICAL DATA

Only in a few cases we were able to obtain factual hydrological data on the rivers/streams where the structures were located. In general, no data was ever recorded in a systematic way on the discharge of the flash floods. In most cases, figures based on calculations made by the Irrigation Department were available on the maximum discharge of the floods. These calculations however, use emperical formulae and at best are rough estimates.

A-9, ANNUAL IRRIGATION ACHIEVED

When asking the local farmers this question, we sometimes got the impression that the answers were not always correct. For various reasons farmers often want to downplay the size of land which was irrigated.

A-11, TOTAL COST AT COMPLETION DATE

As stated, amounts always refer to the cost at the time of completion of the original scheme.

A-17, CHARGES COLLECTED FROM BENEFICIARIES

This question was also raised during the socio-economic survey and often more detailed comments can found in the write-up of these investigations.

B-1, SITE PLANS/TECHNICAL DRAWINGS

The essential technical data, including the drawings, which was available in the files of the offices of the Irrigation Department, were photocopied. Important drawings were redrawn and, if necessary, reduced and are included in this report.

II THE NATURAL ENVIRONMENT

II. THE NATURAL ENVIRONMENT

1 PHYSIOGRAPHY AND GEOLOGY

The physiography of the province is very varied: mountain ranges alternate with low lying plains, deserts and plateau areas. As all over the world, habitation is mainly concentrated in valleys. Balochistan is by far the largest province of Pakistan: the distance from the southernmost tip along the Arabian Sea to the northernmost point at the boundary with South Waziristan amounts to 850 km.

Geologically, the province lies in the collision zone of the Indian and Eurasian subcontinents which resulted in the development of a number of mountain ranges. Along the eastern boundary of the province two important mountain ranges run in a approx. north-south direction viz. the Suleiman and the Kirthar ranges. They are separated from each other by a remarkable flat and low lying area around Sibi. This plain is geologically known as the Sibi Reentrant. Directly north of this plain the Marri- Bugti hills are present, well known for large natural gas deposits.

To the west of the Suleiman range and the Marri-Bugti hills a plateau is present on which Quetta is located. A trip from the Sibbi plain up the Bolan pass to the plateau is a spectacular experience. On the plateau area some smaller mountain ranges occur, especially around Quetta.

Further south, west of the Brahui and Kirthar ranges, low hills alternate with plains, often of a desert-like appearence. This is the central portion of Balochistan.

South of central Balochistan the Mekran area extends down to the Arabian Sea. Also the Mekran is characterised by low mountains and hills alternating with river plains.

Limestones of different ages ranging from Jurassic to Eocene are a particularly conspicuous type of rock especially in the northern half of the province which often give rise to steep slopes and canyon type valleys. On the other hand, the Mekran consists predominantly of non-calcareous, clastic sediments, so- called 'Flysch' deposits. Igneous and volcanic rocks occur throughout the province, especially along the western boundaries.

Several excellent publications exist on the geology of the province, the most important of which are a) a set of geological maps published in 1958 as part of the Colombo plan, b) a book published in 1983 'Geodynamics of Pakistan', and c) a book dedicated to the geology of the coastal areas, published in 1984 'Marine Geolology and Oceanography of Arabian Sea and Coastal Pakistan'.

Physiography and geology are basic determinants of the success or failure of flood water irrigation schemes. A good understanding of these basic factors is essential when planning additional schemes or rehabilitating existing (damaged) schemes.

For a very recent description of the interplay of climate, geology, vegetation and human influences, which together characterise today's 'face' of the province, we like to refer to a publication 'Environmental Profile of Balochistan' (in press).

2 CLIMATE

Sources of meteorological data

In this report we are mainly concerned with data on rainfall and temperature, the latter being the determining factor of the rate of evaporation. A number of agencies are collecting this type of data. During British times, a great number of weather stations existed in Balochistan which started collecting data from 1891 onwards to 1946. All records from that period were computerized in the early eighties (see Packman, 1987) and subsequently used by Kidd et al. to set up a computer-based facility which can be used for the analyses of climatological variables. This facility consists of two parts: a) a rainfall data base using (with slight adaptations) the above mentioned previously organised data base, b) an analysis package (called Belinda) which can be used for a probabilistic analysis of the data.

This important data base and analysis package is described in detail in Kidd et al. 1988. The report includes a users manual. We strongly recommend to update the data base with post-1946 data and to use the programme as the central storage facility of Balochistan's meteorological data.

It can be stated that Balochistan is fairly well covered with meteorological stations.

Currently, the following agencies are involved in collecting meteo data:

1) Pakistan Meteorological Department, Karachi, which collects data from 13 stations within the province. The data is computer- stored and easily available. In Volumes 2 to 7 of the present report recent data supplied by the Department are given.

2) The WAPDA SWHP (Surface Water Hydrology Project), which is mainly concerned with collecting hydrological data under a contract with the Government of Balochistan, also maintains a number of weather stations. More stations are added to the network. See BMIAD's reports 1989 and 1990.

3) AZRI (Arid Zone Research Institute) at Quetta maintains 6 stations at different places.

4) Both the Provincial Irrigation and the Forestry Departments collect data at a small number of stations.

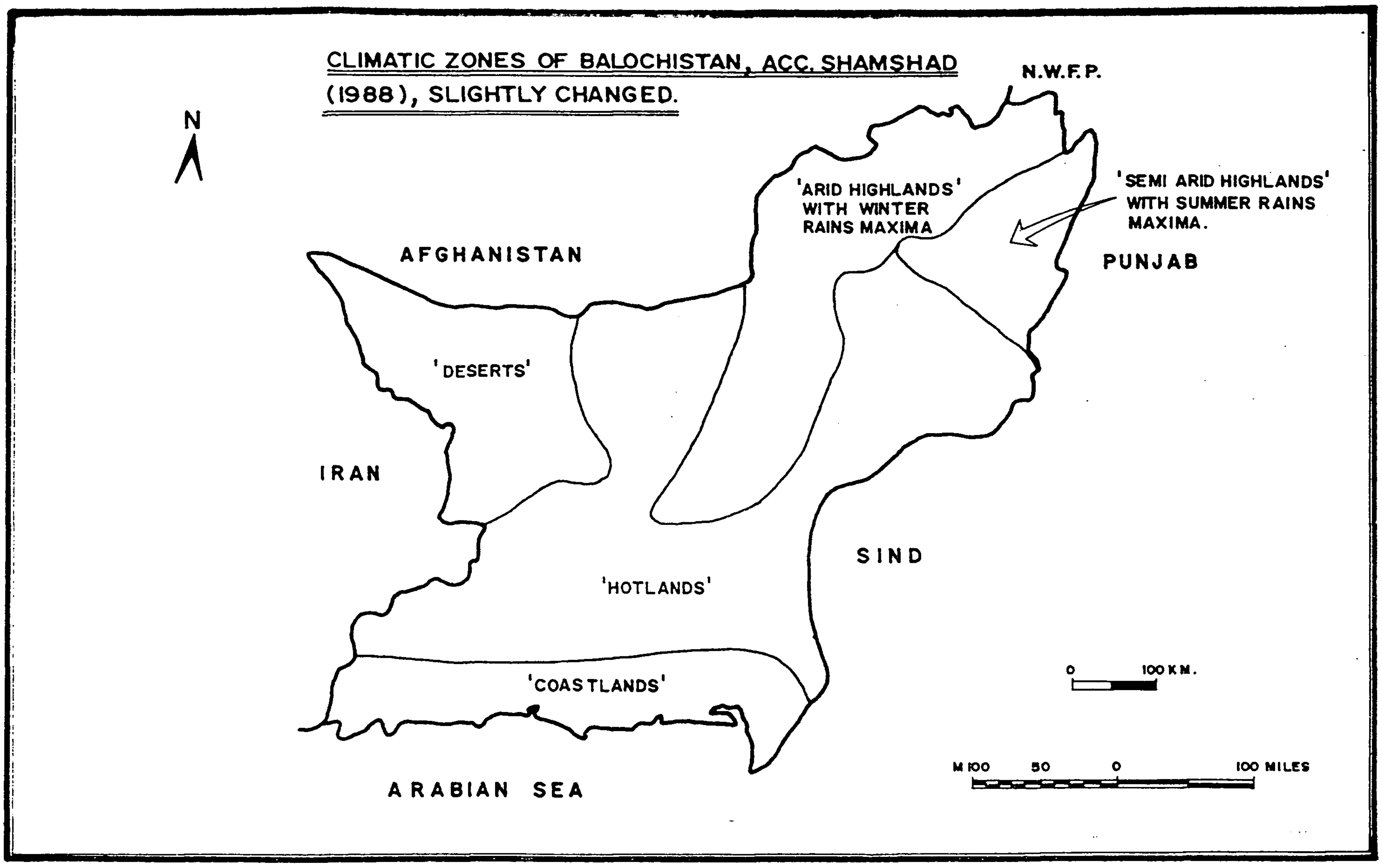
5) The Pakistan Air Force also collects data.

However, what is completely lacking is data on the intensity of rainfal during the course of a particular day. This kind of information would be very helpful to estimate the frequency of flash floods in an area.

Climatic zones

Although the first impression of Balochistan is that of a dry and often hot region, at a closer look a number of climatic zones can be distinguished based on mean temperature, precipitation, humidity and altitude.

Figure 2 is a map of the province on which climatic zones are plotted as defined by Shamshad 1988. His classification corresponds closely with other classifications. The map has been slightly adjusted to fit rainfall data. The boundaries between the zones are not sharp, except in cases where a sudden change in relief occurs, such as along the Sulaiman and Kirthar mountains. The five climatic zones as plotted on the above mentioned map, are characterised as follows:


CLIMATIC ZONES OF BALOCHISTAN, ACC. SHAMSHAD
(1988), SLIGHTLY CHANGED.
N
N.W.F.P.
'ARID HIGHLANDS'
WITH WINTER
RAINS MAXIMA
'SEMI ARID HIGHLANDS'
WITH SUMMER RAINS
MAXIMA.
AFGHANISTAN
PUNJAB
'DESERTS'
IRAN
SIND
'HOTLANDS'
'COASTLANDS'
0 100 KM.
M 100 50 0 100 MILES
ARABIAN SEA

V.I, FIGURE 2

1) Coastlands.

- Mean maximum temperature around 35 degrees centigrade,
- Mean minimum temperature around 14 degrees centigrade,
- Rainfall low in Mekran, 100 mm/year,
- Daily sea breeze,
- High humidity.

2) Hotlands. (A term proposed by Shamshad which refers to the low- lying plains of Sibi/Kachhi and south-central Balochistan)

- Very high temperatures with mean maximum temperatures during the hottest month (June) around 39-40 degrees centigrade,
- Rinfall between 100-230 mm,
- Still sufficient vegetation not to call it a desert.

3) Deserts.

- Mean maximum temperature above 40 degrees centigrade,
- Mean minimum temperature fairly low: 4-5 degrees,
- Precipitation less than 50 mm/year,
- Hardly any natural vegetation,
- Dust storms common.

4) Arid highlands with winter rains maxima.

- Mean maximum temperature around 34 degrees centigrade,
- Mean minimum temperature around 0 degrees centigrade,
- Mean annual rainfall between 130-230 mm, mainly falling during the winter season,
- Winters with frosty winds,
- Humidity very low,
- Natural vegetation sparse.

5) Semi-arid highlands with summer rains maxima.

- Mean maximum temperature around 37 degrees centigrade,
- Mean minimum temperature around 0 degrees centigrade,
- Mean annual rainfall above 230 mm, with summer maxima,

- Vegetation occurs throughout, with even forests developed in the mountains.

Figures 3, 4 & 5 are reproduced from the AZRI 1988 report and represent the best existing maps on annual and seasonal rainfall, however, calculated and normalized on data covering the period 1901-1940. Figure 6, from the same report, shows the ratio of summer to winter precipitation and supports the climatic zone as proposed by Shamshad.

Figures 7 & 8 are rainfall maps prepared by the Pakistan Meteorological Department, Karachi, covering a more recent time interval, viz. 1951-1980. If one compares these maps with Kidd et al.'s maps, significant differences will be noted. All the data should be critically reviewed and presented according a standardized method.

In the regional volumes graphs will be presented on rainfall and temperature data of the last ten years. The data was supplied by the Pakistan Meteorological Department, Karachi. The original data was collected at ten weather stations in Balochistan, viz. Lasbela, Jiwani, Pasni, Panjgur, Khuzdar, Kalat, Sibi, Quetta, Zhob and Barkhan.

For a thorough discussion on the climate of the province we refer the reader to the above mentioned AZRI report (April, 1988) and Halcrow's report of February 1991. Together these two reports offer a fairly detailed picture.

3 HYDROLOGY

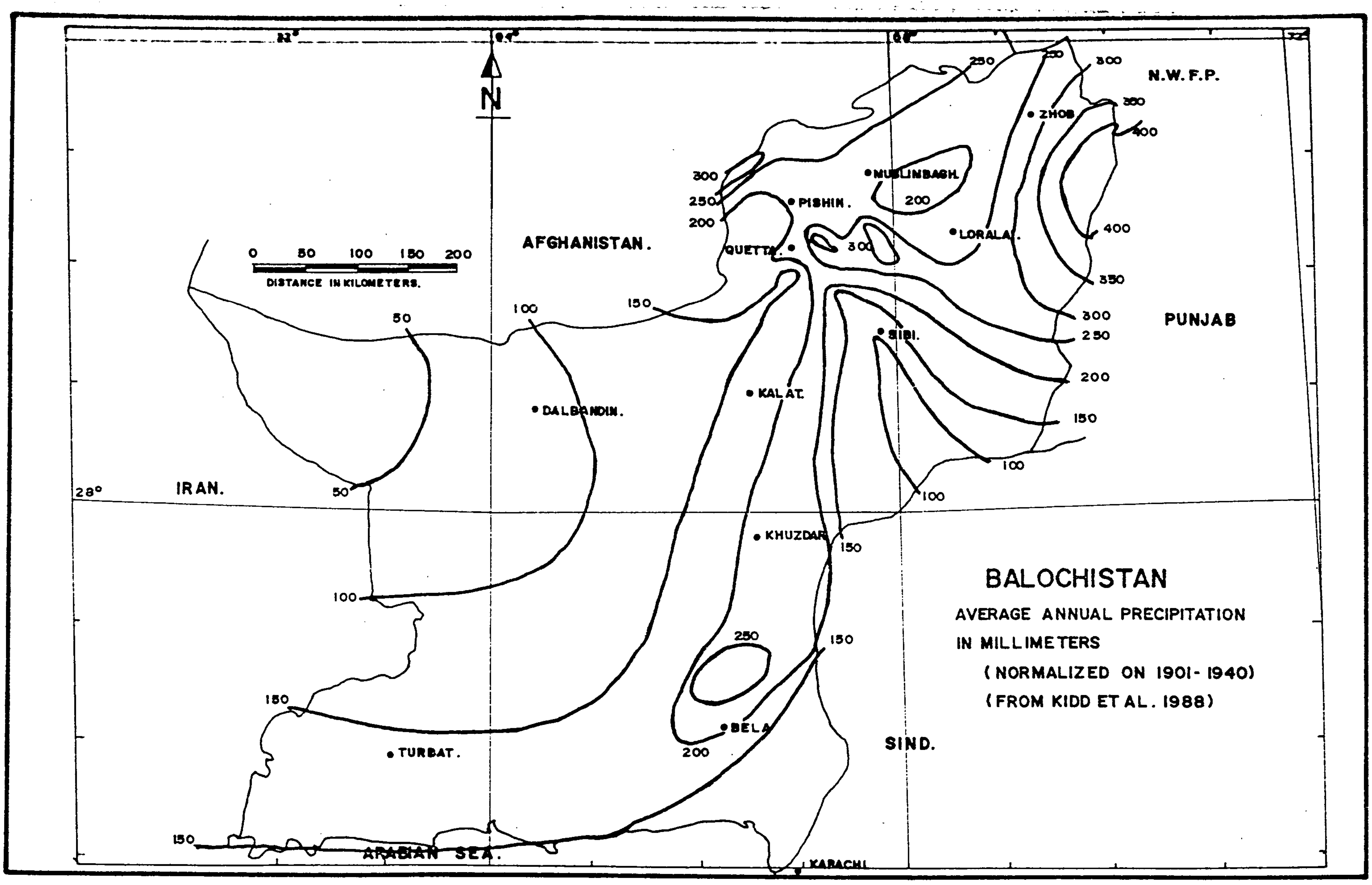
Sources of information

Principally it is WAPDA SWHP (Surface Water Hydrology Project), working under a contract for the Government of Balochistan, which collects data on river water levels and discharge volumes. The organisation maintains a number of stations throughout the province. The majority of these stations are located in perennial rivers, but a few (e.g. Winder Dhora in Lasbela) are established U/S of flood water irrigation schemes in ephemeral stream beds. At each station a water level staff gauge is installed and equipment which can be operated from a bridge or cableway, is available to measure the total water discharge. However, SWHP is behind in publishing the collected data. The most recent report was published in 1986. All data is logged by hand due to the lack of computers. Kidd's reports of 1990 and 1991 give a very thorough description of the present state of the hydrometric networks in the province, including recommendations how to improve the quality and the quantity of the measurements and to strenghten the organisational set-up. Currently proposals are formulated to implement Kidd's recommendations.

During the present project only occasionnally hydrological data was found in the files of the Irrigation Department. Often the information consisted of estimates by the Department without any reference to factual measurements.

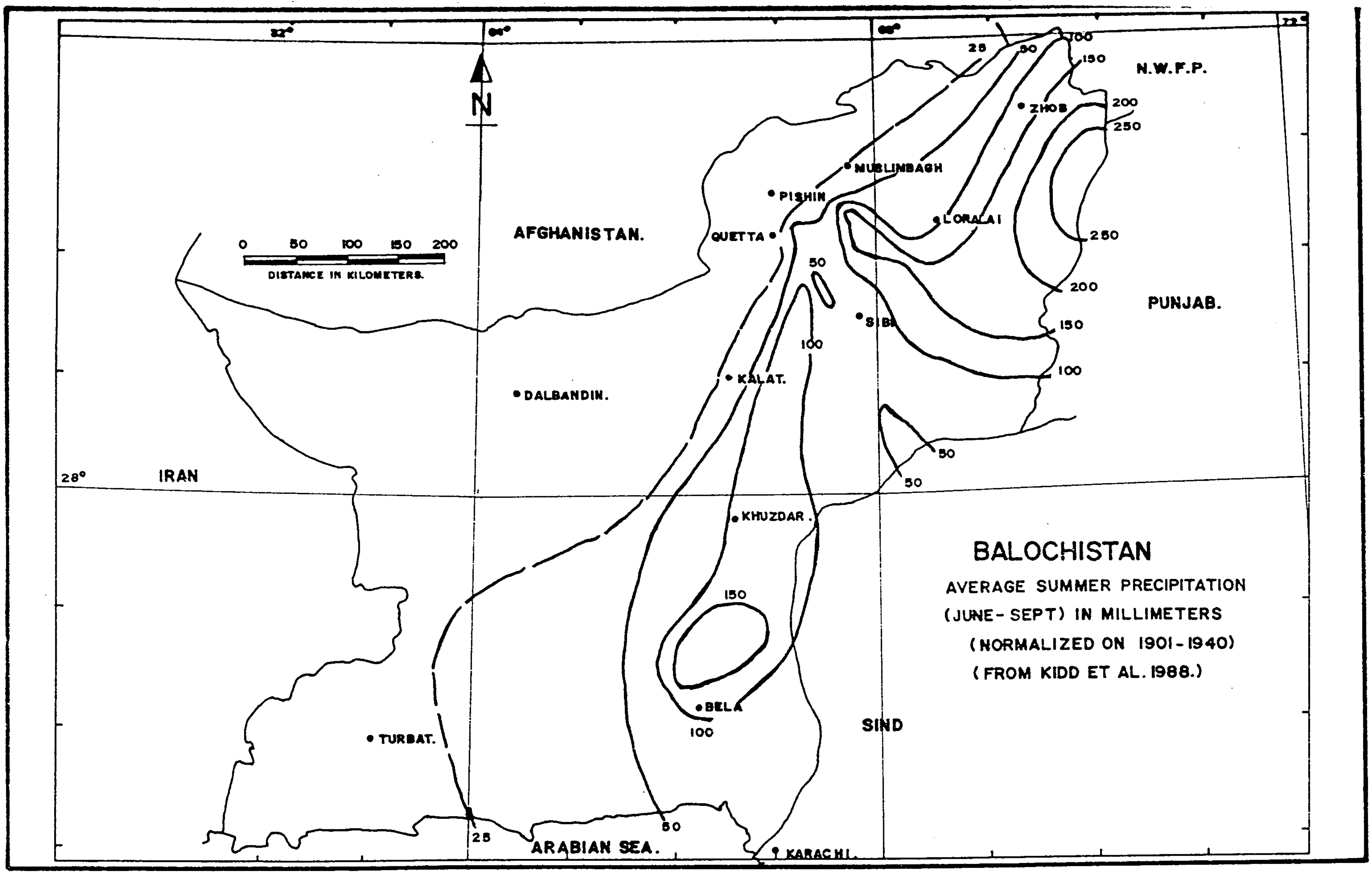
4 FLOOD WATER IRRIGATION SCHEMES

In Balochistan, deserts, barren mountains and sparsely vegetated plains dominate the landscape of the province. The area is predominantly arid to semiarid and the lack of water is the main factor which controlled human settlements during the past millennia. Only about 5 % of Pakistan's population live in this province, the largest of the country.

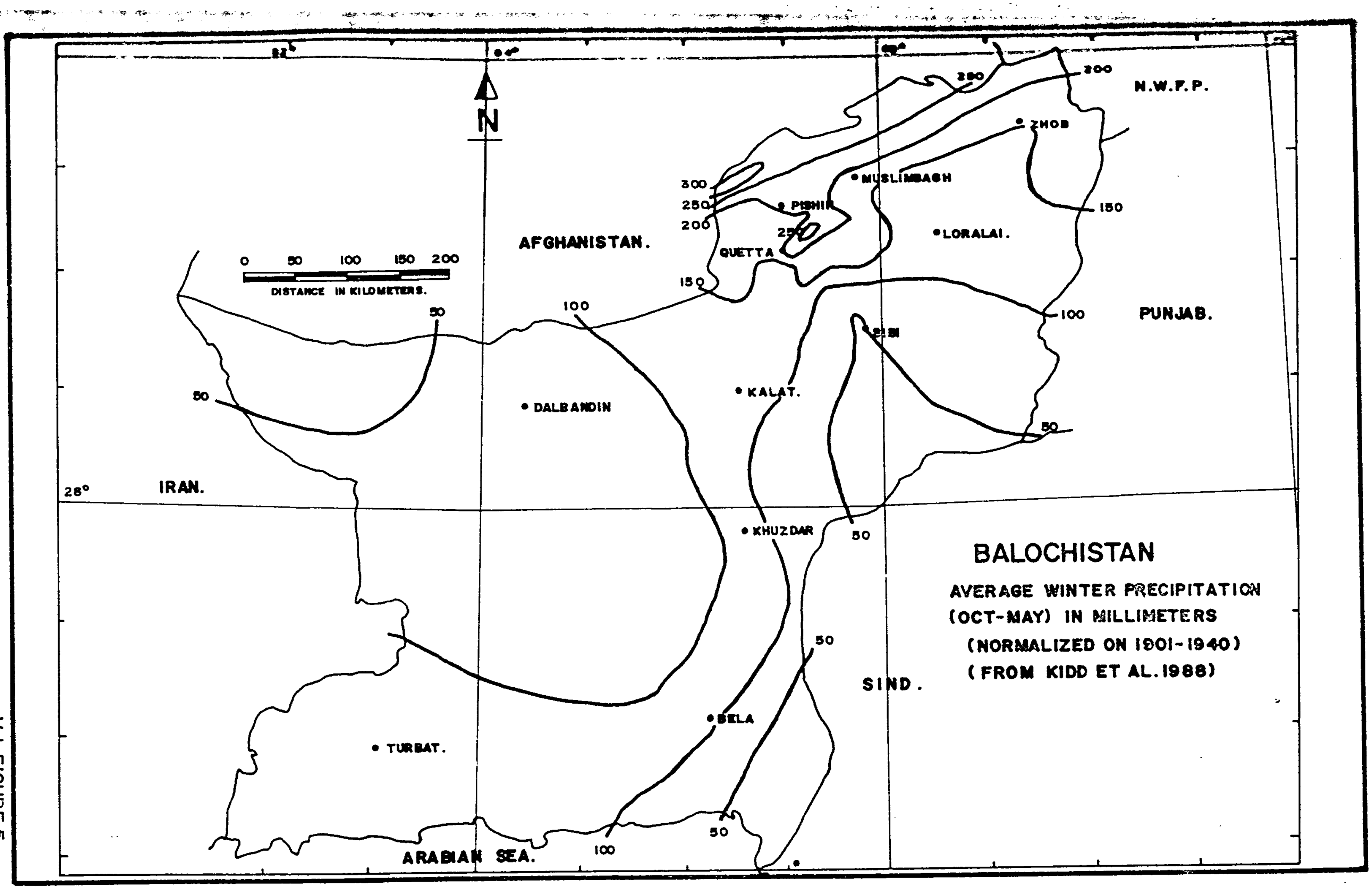


BALOCHISTAN
AVERAGE ANNUAL PRECIPITATION
IN MILLIMETERS
(NORMALIZED ON 1901-1940)
(FROM KIDD ET AL. 1988)

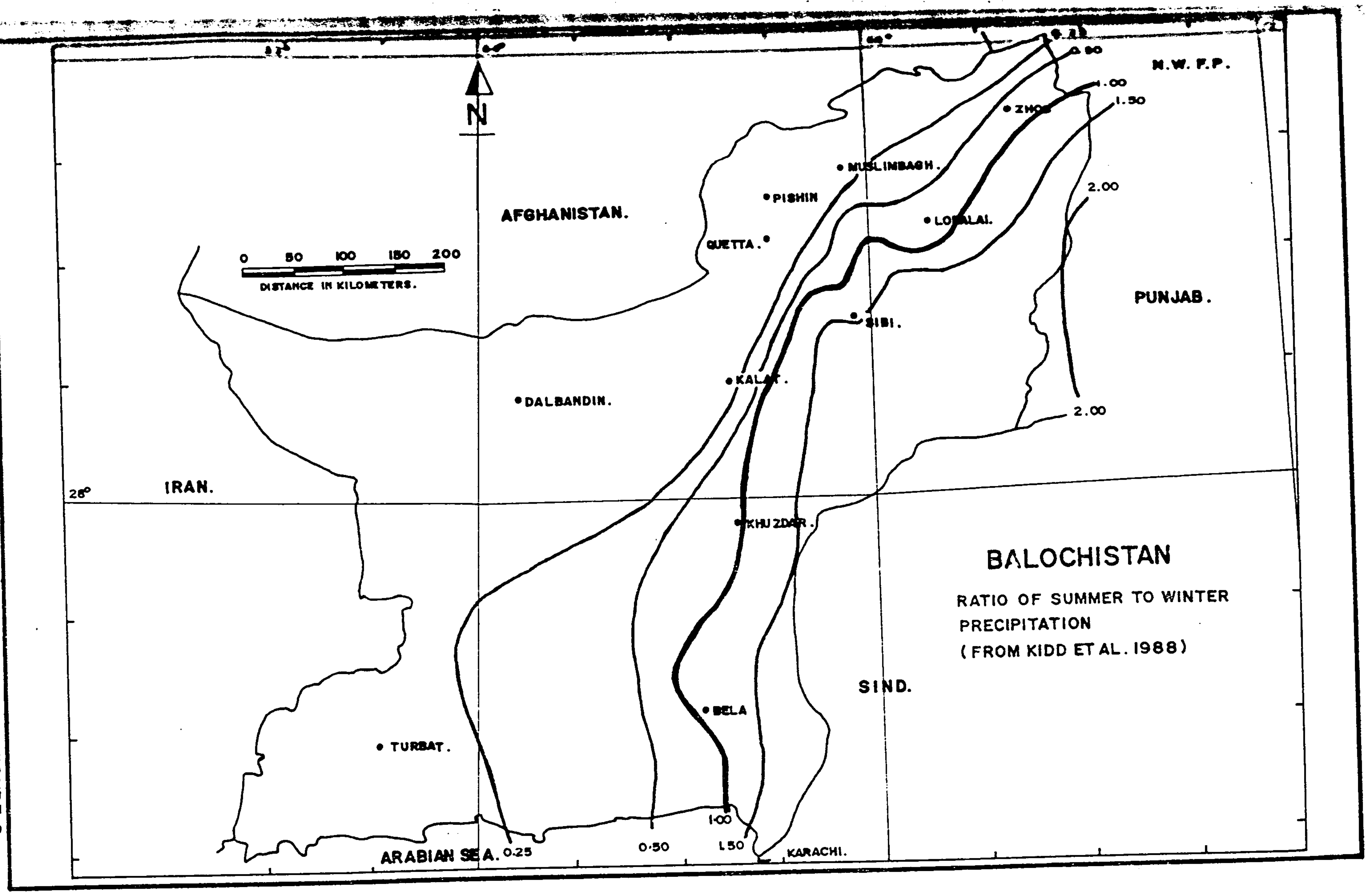
V.I, FIGURE 3


BALOCHISTAN
AVERAGE SUMMER PRECIPITATION
(JUNE- SEPT) IN MILLIMETERS
(NORMALIZED ON 1901-1940)
(FROM KIDD ET AL. 1988.)
AFGHANISTAN.
IRAN
N.W.F.P.
PUNJAB.
SIND
ARABIAN SEA.
QUETTA
PISHIN
MUSLIMBAGH
ZHOB
LORALAI
SIBI
KALAT.
DALBANDIN.
KHUZDAR .
BELA
TURBAT.
KARACHI.
0 50 100 150 200
DISTANCE IN KILOMETERS.
N
28°

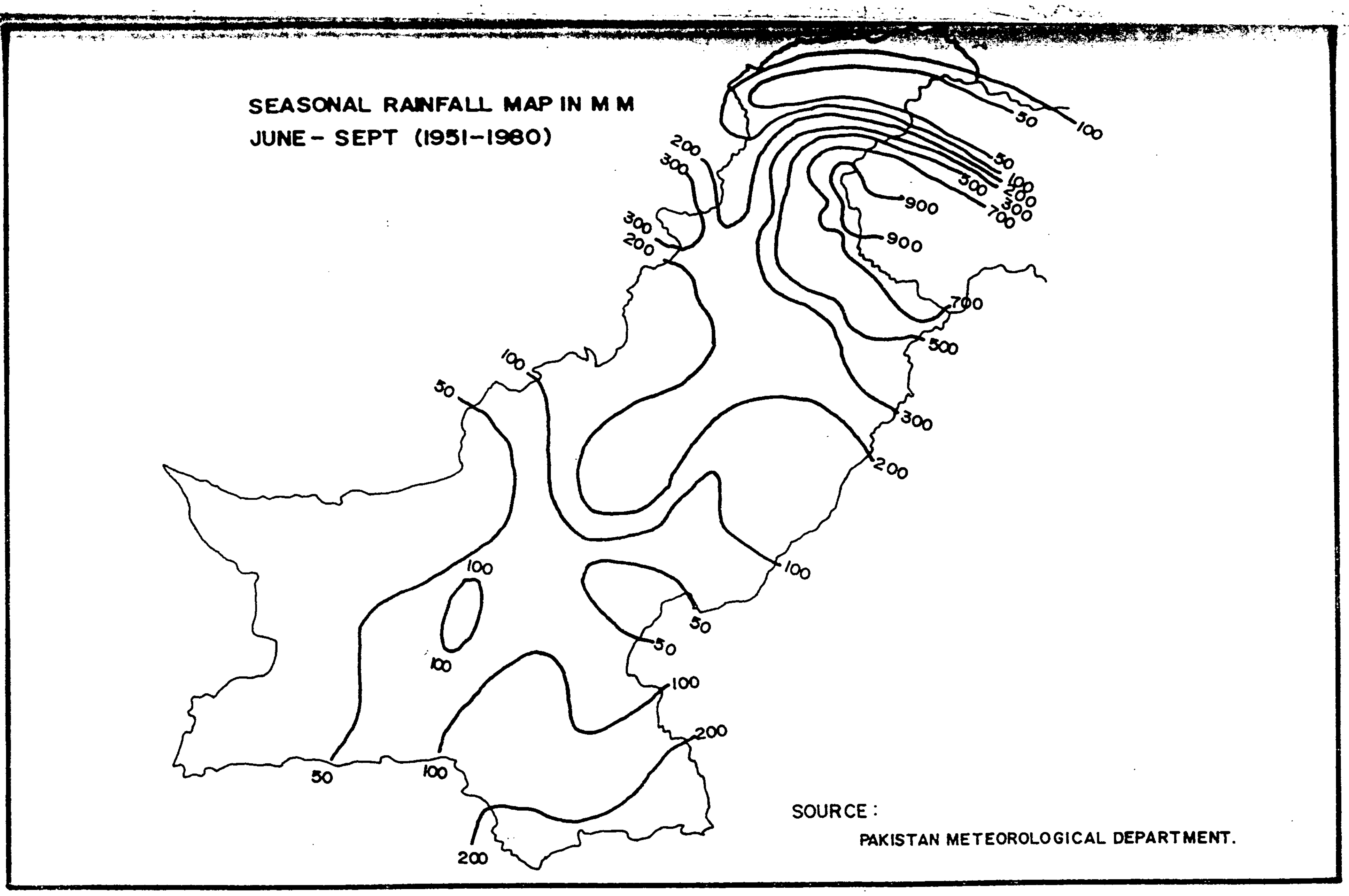
V.I, FIGURE 4


N
AFGHANISTAN.
IRAN.
N.W.F.P.
PUNJAB.
SIND.
ARABIAN SEA.
0 50 100 150 200
DISTANCE IN KILOMETERS.
28°
ZHOB
MUSLIMBAGH
PISHIN
QUETTA
LORALAI.
KALAT.
DALBANDIN
KHUZDAR
BELA
TURBAT.
SIBI
300
250
200
150
100
50
BALOCHISTAN
AVERAGE WINTER PRECIPITATION
(OCT-MAY) IN MILLIMETERS
(NORMALIZED ON 1901-1940)
(FROM KIDD ET AL.1988)

V.I, FIGURE 5

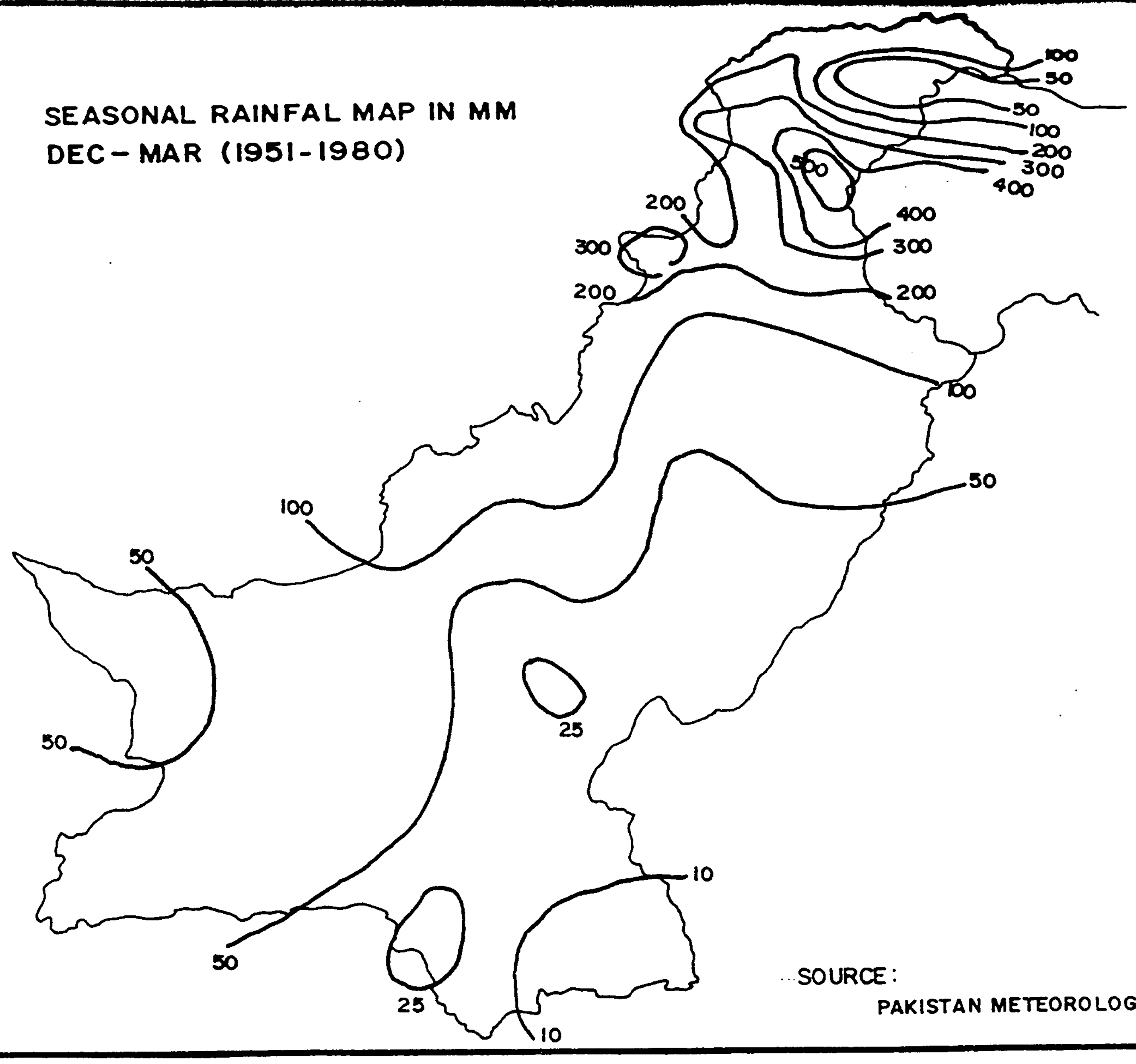

BALOCHISTAN
RATIO OF SUMMER TO WINTER PRECIPITATION
(FROM KIDD ET AL. 1988)
N
0 50 100 150 200
DISTANCE IN KILOMETERS.
AFGHANISTAN.
IRAN.
N.W. F.P.
PUNJAB.
SIND.
ARABIAN SEA.
PISHIN
QUETTA.
MUSLIMBAGH.
ZHOB
LORALAI.
SIBI.
KALAT.
DALBANDIN.
KHUZDAR.
BELA
TURBAT.
KARACHI.
0.25
0.50
1.00
1.50
2.00
28°

V.I, FIGURE 6


SEASONAL RAINFALL MAP IN M M
JUNE - SEPT (1951-1980)
50
100
200
300
500
700
900
SOURCE:
PAKISTAN METEOROLOGICAL DEPARTMENT.

V.I, FIGURE 7.

SEASONAL RAINFAL MAP IN MM
DEC – MAR (1951-1980)



SOURCE:
PAKISTAN METEOROLOGICAL DEPARTMENT.

V.I, FIGURE 8

A few perennial rivers occur in the province, but they discharge only relatively small amounts of water. Ground water is often deep and in certain areas saline. Precipitation rates are low: rainfall is mainly concentrated during certain seasons and is often limited to rainstorms of high intensity but of short duration, causing flash floods.

Water then, is the basic requirement for people in order to survive the harsh climatic conditions of the region.

Since immemorial times the local people have developed methods to increase the amount of water available for agricultural and domestic uses by damming up and diverting perennial and ephemeral surface water through canals to their fields, In addition, shallow water wells were dug and karezes excavated to exploit the ground water. Bunds (low dykes) were constructed to guide water to the desired places and to retain water on the fields.

Recently, although as early as 1890, more permanent structures are being constructed using bricks, natural stone and concrete in conjunction with earthen embankments (bunds) to catch and divert water from the flash floods in order to irrigate the fields. These schemes are generally known as flood water irrigation schemes. After the independance of Pakistan up to the present a great number of schemes have been designed and constructed, mainly by the Provincial Irrigation Department. However, for different reasons many of the schemes failed after a few years, and moreover, maintenance costs turned out to be often exorbitant. Therefore the need was felt to make an inventory of the existing schemes to try to determine the problems involved with their functioning.

In addition, information could be collected on the socio-economic impact of the schemes on the living conditions of the local population.

5 SEDIMENTATION PATTERN

A water diversion structure (weir plus sluices, regulators, etc.) upsets the natural equilibrium of a stream by changing the discharge and the sediment transport capability. In essence, the structure acts as an obstacle which will have a direct influence on the sediment deposition both upstream as well as downstream of the structure.

Sand and larger clasts (gravel, pebbles and even cobbles) are carried in a stream as bed load and with any reduction in water velocity or in the presence of an obstacle, these clastics will be deposited.

Silt and clay are carried as suspension load and will be deposited as soon as water no longer flows (stagnant conditions) in pools, lakes or bunded fields. These very fine grained sediments are important fertilizers if deposited on the fields of the farmers.

Often the term 'siltation' is used as a general term to describe the deposition of sediments (whether coarse or fine grained) in channels/canals, sluices and around weirs. This is not the correct use of the term, as silt refers to a particular particle size (between approx. 0.004 and 0.06 mm), and the so-called 'silted up' sites are actually clogged with clastics like sand, gravel and larger clasts. It is better to use the term 'sediment accumulation' or simply 'sedimentation'. Only in special cases like at sites on the flood plains, one may safely use the term 'siltation'.

In this report examples are given of both 'silted-up' sites

as well of places which are completely clogged with coarser sediments.

Flash floods can be expected after heavy rainfall. If a hilly or mountainous area is devoid of soil and the vegetation is sparse or absent, rainwater will not be absorbed in the ground but will flow downhill through small rivulets and merge with water from other streams. During intensive and concentrated rainstorms large volumes of water will accumulate in a short time span and this water will rush down towards lower areas. In Balochistan hills or mountains are generally sharply separated from the plains. Gorges (canyons), often fairly narrow, act as passages where water will discharge onto the plain and along the mountain front large amounts of coarse grained sediments will be deposited. These deposits are called 'Alluvial Fans' which are very characteristic in many parts of the province. Figure 9 is a portion of a topographical map (Lasbela district) where the above described drainage pattern can be clearly seen. On the alluvial fan the water courses break up in numerous shallow stream beds. The main channel can change its position easily. This phenomenon is very important when selecting a site for a diversion structure. Firstly if the site is too close to the mountain front, large amounts of unsorted clastic material will immediately clog the different parts of the structure and its diversion canals or, even more serious, may badly damage the structure due to the force of a heavily sediment-loaded flash flood. Secondly, the water may suddenly change its course, bypassing the structure. If this happens, the structure will be left standing in a permanently dry area as a kind of solitary monument.

Below the alluvial fan finer grained sediments, such as gravel and sands with silt and clay are deposited. This is the so-called flood plain. It is the area where most of the agricultural activities take place. Settlements are often situated along the border between the alluvial fan and the flood plain.

Close to the sea or lakes, very fine material is deposited, mainly silt and clay.

The block diagramme, figure 10, illustrates the depositional model as described.

Flood Water Diversion Structures

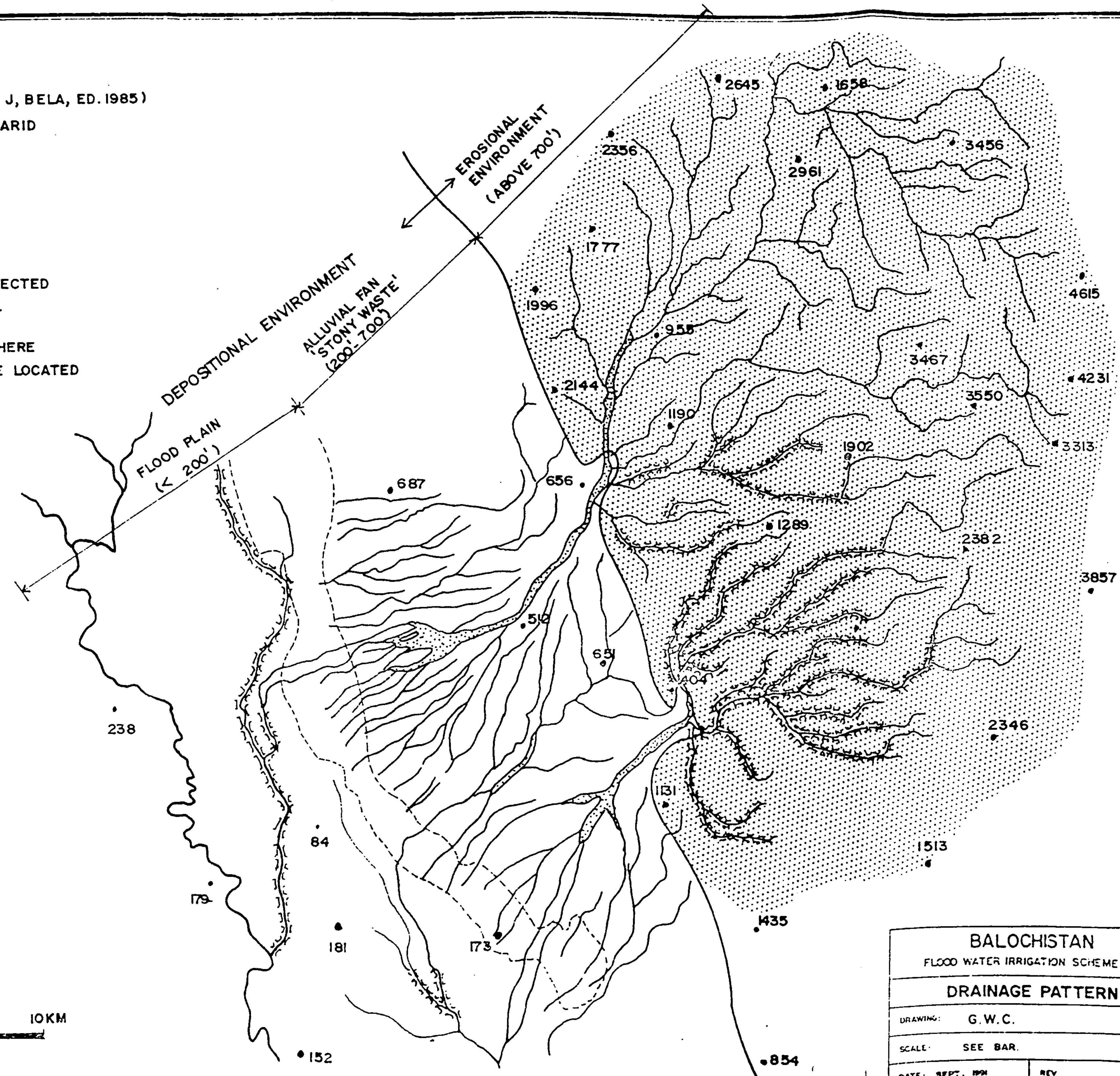
The selection of the site where a diversion structure should be build, is of prime importance. Local people will know from experience in which streambed flash floods of suffficient magnitude can be expected.

PORTION OF THE 1:250,000 MAP (NO. 35 J, BELA, ED. 1985) SHOWING THE DRAINAGE PATTERN OF AN ARID AREA WITH SPARSE OR NO VEGETATION.

LEGEND.

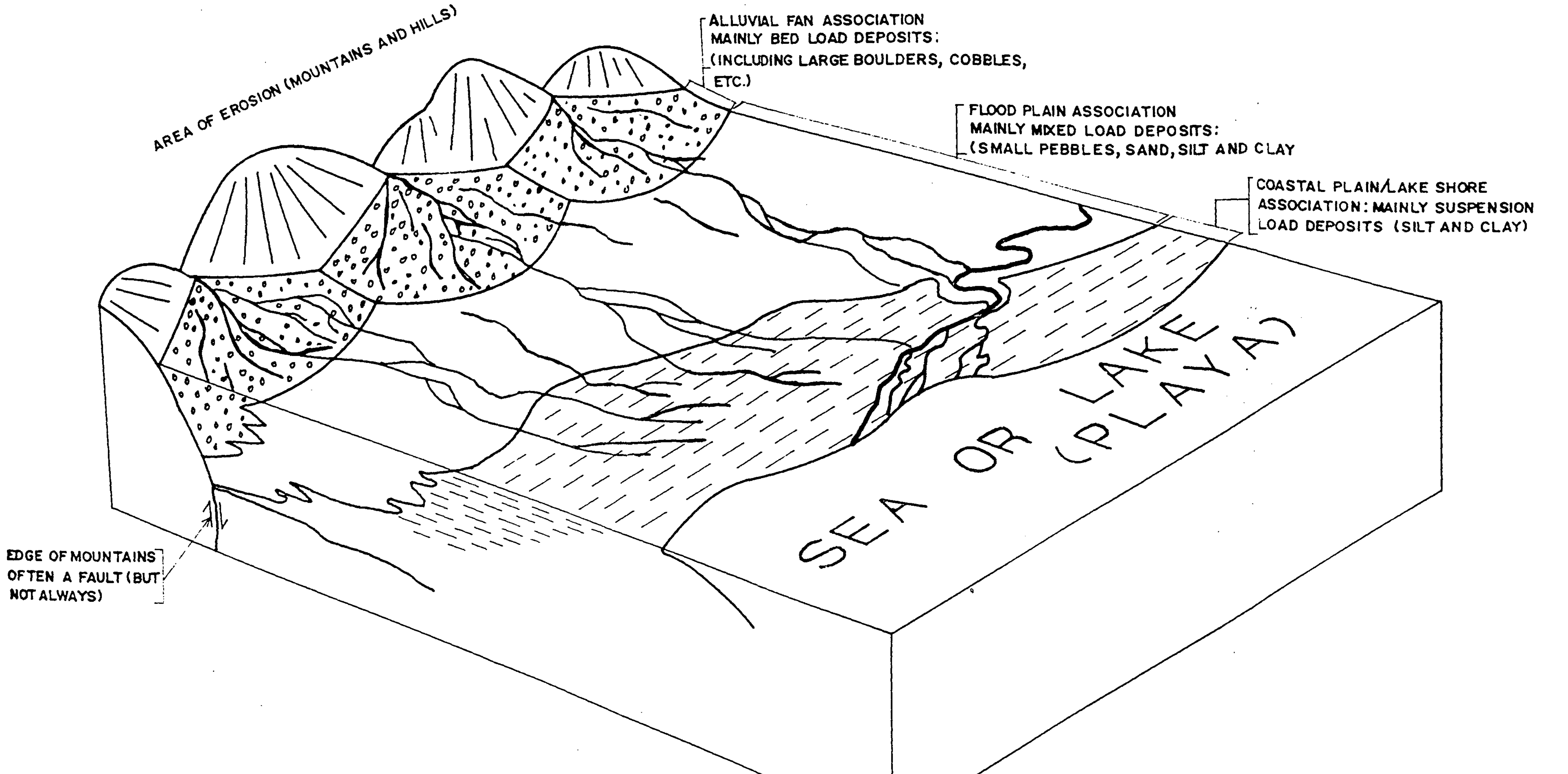
- (dotted box) MOUNTAINOUS AND HILLY AREA DISSECTED BY EROSIONAL DRAINAGE STREAMS.
- (blank box) AGRICULTURAL LAND AND AREA WHERE VILLAGES, HAMLETS AND HUTS ARE LOCATED AND WATER WELLS OCCUR.

ELEVATIONS IN FEET.



BALOCHISTAN	
FLOOD WATER IRRIGATION SCHEMES	
DRAINAGE PATTERN	
DRAWING: G.W.C.	
SCALE: SEE BAR.	
DATE: SEPT., 1991	REV
GROUND WATER CONSULT	

V.I, FIGURE 9



MODEL OF THE DEPOSITIONAL PATTERN IN AN ARID ENVIRONMENT, WITH LITTLE VEGETATION AND RAINFALL LIMITED TO OCCASIONAL HEAVY RAINSTORMS CAUSING FLASH FLOODS.

BALOCHISTAN FLOOD WATER IRRIGATION SCHEMES
BLOCK DIAGRAMME DEPOSITIONAL MODEL
DRAWING G.W.C
SCALE: NO SCALE.
DATE: SEPT., 1994. REV
GROUND WATER CONSULT

V.I, FIGURE 10

III TECHNICAL APPRAISAL

III. TECHNICAL APPRAISAL

1 Introduction

A flood water irrigation system, as the term implies to the schemes under review, utilises the short duration run-off which flows down the rivers after each rainfall. The main component of such schemes is a diversion weir built across the stream/river bed to obstruct the flow, raise its level by a few feet and divert it through head regulators built on either bank for feeding the irrigation canals. The success of a scheme depends largely on the selection of a proper location of the weir and sound planning and design of the structures.

2 Design Categories

The design of the diversion weir and its construction materials vary from site to site, in view of various technical considerations, including also the foundation soils, area topography, as well as the demands on the structure. We like to divide the structures generally built in Balochistan, into the following categories.

CATEGORY-A. (Regulation of canal supplies possible)

i) A P.C.C./R.C.C. or masonry weir (rigid structure)

ii) Gate operated canal head regulators

iii) Gate operated undersluices/ungated sluicing bays

iv) With or without additional silt exclusion/ejector devices

v) Main canals constructed

CATEGORY-B. (Regulation of canal supplies not possible)

I) A P.C.C./masonry weir (rigid structure)

ii) Open canal head regulators with or without breast walls

iii) No sluicing bay

iv) Main canals constructed

CATEGORY-C. (Regulation of canal supplies not possible)

i) Weir made of gabions or packed stone/boulders (flexible structure)

ii) Wing walls/canal head regulator built in masonry/gabions

iii) Main canals constructed

CATEGORY-D.

i) A P.C.C/masonry or gabion weir or a 'Pachhad' (stone mat) built across the river width to stabilise the section and the flow over it is divided in 2 - 3 channels.

ii) Gabion or stone pitched earthen bunds built to provide segregation of flow between the channels on the D/S of the weir/Pachhad

iii) Canals not constructed

These structures are basically proportional distributors, with no control on regulation.

CATEGORY-E.

i) River channel bifurcators/divide bunds/groynes/current/deflectors/guide bunds etc.

ii) Inundation canals

3. CONSTRAINTS AND LIMITATIONS IN PLANNING A FLOOD IRRIGATION SCHEME.

3.1 It is important here to observe that the flood irrigation schemes cannot be justifiably compared to non-perennial or even the inundation canals in the Punjab or Sind because these Kharif canals, though operating through the summer monsoon months only, get a dependable and consistent supply during the period of 3-4 months. The reason being the fact that the river flows during these months depend not only on the rain run-off, but also on snowmelt. Obviously based on a consistent minimum average supply, a proper canal network and effective distribution system to the fields can be planned which makes possible an economical and beneficial use of water.

The great handicap in operating the existing Flood Water Irrigation Schemes effectively is the absence of an adequate irrigation canals distribution network which could meet the following demands:

i) Distribute all the available supply at the canal head to the command area efficiently.

ii) Supply the water to the various fields in quantities which could be managed by the farmer without wastage i.e., avoiding over-watering.

iii) Distribute the available water to all the beneficiaries proportionately and in a fair manner, i.e. prevent its use by only a few at the cost of many others.

The existing system discourages the lower riparians to the extent that they lose interest in their lands, migrate to urban areas and adopt other means of livelihood.

3.2 However, there are constraints in providing an extensive distribution network on spate irrigation schemes. These are:

i) Almost the whole of Balochistan, leaving aside the northern areas of Zhob, Pishin and parts of Loralai, receives very little precipitation. The annual average varies from less than 100 mm in the southern and central portions of the province to more than 250 mm in the north. See chapter II of this volume for more details. Some of the years are hardly without any precipitation. This scanty rainfall is moreover, divided almost equally over the summer and winter monsoons. Obviously the normal level of precipitation cannot provide a sustained minimum run-off over the full crop growing period.

ii) By and large the catchment areas are mountainous/sub-mountainous with fairly steep slopes and sparse vegetation cover. This helps generate flash floods extending over very short periods, i.e. less than 24 hours to a maximum of 7 - 10 days at a time. Building an irrigation network to utilise to an appreciable extent such a pattern of inflow would be exhorbitantly expensive, inefficient and comparatively little productive. It is therefore almost impossible to utilise all this run-off in such a short time.

To derive maximum benefits this water should be stored. However construction of storage dams is not possible at every place and there are many limitations, two of these being very low rainfall and excessive evaporation rates. Consequently flood irrigation has been practiced since times immemorial, being the only practical solution.

3.3 The objectives of spate irrigation thus are twofold, one to spread the waters on the farm land quickly and secondly on maximum area possible. To achieve these objectives we need the following:

i) A structure across the river/stream bed for diversion of the entire flood waters or the maximum amount possible.

ii) A large canal system with a distribution network to spread the diverted waters over the entire command area within the time limitations i.e. 24 hours to 7 - 10 days.

The above requisites of spate irrigation do need an engineering solution, however the parameters i.e., short time and large amount of water and farm area, are divergent and not mutually complimentary. Consequently any solution with an objective of utilising maximum supplies would be prohibitively expensive. Even if resource mobilisation is done for the initial outlay, the financial returns would not be commensurate even with the operation expenses of such a scheme.

3.4 In Balochistan, almost no hydrological data has been collected even on major rivers/streams, the lack of which is a great handicap in planning and design of any scheme on a realistic basis. We understand that this lack of data is being rectified by the activities of the WAPDA'S SWH Project.

3.5 There are traditional water rights of land owners based on the principal of the upper 'Riparian' getting the first right. This principle is very strictly adhered to, disregarding any engineering parameters. Even if the upper area is not in command from a source but the landowner is powerful, he will not let the canal pass through his lands unless his lands are given the waters first. Many schemes are lying abandoned because of such an obtrusive attitude, and presently nobody is able to intervene. It must be recognized that, in most cases it is not possible to supply irrigation waters to areas adjacent to a diversion weir through gravity flow, as these areas are higher than the water level in the canals.

3.6 Earthen embankment along the weir (guide bunds marginal bunds etc.) and canal embankments which come in contact with water only occasionally after having remained dry over long periods, are more difficult to maintain and subject to more frequent breaching.

4. STUDY OF EXISTING FLOOD IRRIGATION SCHEMES IN BALOCHISTAN.

4.1 We have carried out site surveys of almost all the flood irrigation schemes built in Balochistan after 1960, except a few we could not approach due to security reasons and for which no data was available. These schemes have all been built by the Irrigation Department except a few completed earlier by the Local Government. Presently all are being looked after by the Irrigation Department as these fall under its jurisdiction.

The survey included technical as well as socio-economic appraisal. The data was collected by field visits extending over a period of 9 months, and consisted of the following:

i) History of the scheme.

ii) Basis of design and details of design if available (very little was available).

iii) Plans and detailed drawings.

iv) Hydrological data if available (very little was ever observed).

v) Topographical survey was carried out at each site to observe existing site conditions.

vi) Sites were visited to study visual features. Photos were also taken of the important structures and damages caused thereto.

vii) Enquiries from local technical staff / operating staff.

viii) Discussions with beneficiaries to find out if they were satisfied with the functioning of the scheme. If not what were their grievances?

ix) Socio-Economic Survey.

4.2 Individual reports have been prepared for all the schemes, based on the data collected and surveys carried out. Separate folders are enclosed covering the existing situation vis-a-vis the condition of structures, canals etc., operational problems if any, and the extent of benefits accruing. We have also added our observations as to the deficiencies in planning, design or operation of the schemes and also suggestions for needed action.

A synopsis containing the outline information has also been prepared in a tabular form, which is enclosed as Appendix 3. The schemes have been listed together according the categories outlined in paragraph 2. This would help to study the characteristics and problems of similar schemes side by side, so as to comprehend these better. The listing is also an inventory of schemes which could be directly consulted while making priorities for resource allocation to achieve a useful rehabilitation or extension programme in flood irrigation.

4.3 The study would be, we hope, useful in giving direction towards developing more realistic guidelines in planning, design and operation of flood irrigation schemes in Balochistan.

5. GENERAL DEFICIENCIES IN EXISTING SCHEMES.

Generally the results on the existing schemes are not encouraging. There are many reasons of their total or partial failure, the major ones being the following:

i) The farmers or landowners have, as it looks, not been fully consulted in advance as to the siting of the scheme, the alignment of the canal, the command area to be included and the extent of benefits they can expect. This has resulted in situations where the influential landowners have not allowed passage of the main canal through their lands, and enjoy an exclusive right on the flood waters. Specifically, the landowners closest to the weir site whose lands were not in command or in poor command, insisted on inclusion of their area and had their way if they were sufficiently influential. This resulted in silting of the canals at head, and caused failure of the schemes.

On a few schemes the farmers have actually shown apathy towards the use of irrigation waters. Such situations should be sorted out in advance and schemes planned only after the matter of water rights etc. has been mutually agreed to between the landowners and the concerned administrative department.

ii) The tendency so far seems to have been to build weirs at sites where flood irrigation has been practiced since olden times. Such sites are not necessarily the most ideal ones technically for the location of a diversion weir. The reason why earthen bunds were being deployed at these locations for irrigation purposes for so long, may have been the fact that a major or powerful landowner had his holdings close by or that the area is occupied by a major tribe who could muster the manpower and resources to rebuild earthen diversion bunds after each time these were wasted away by a flood.

iii) Almost no hydraulic data had been collected on these river / streams to enable the engineers to plan the flood routing capacity of the diversion weir structure, and to fix the optimum size of the offtaking canals i.e. the capacities to be designed and the extent to which the water could be dependably utilised. The latter would dictate the length of the canal system and the area to be served.

iv) Surveys were generally not carried out to find alternative locations for the weir and to select the best one. This would also help to plan a proper geometry of the weir and guide bunds etc. which is essential for a successful operation. A judicious alignment of the main canals would also depend on such location surveys.

v) As a result of shortage of data as well as lacking the engineering state of the art, the design of the structures and their geometry has been inadequate and inappropriate, which caused failure of many of the schemes.

vi) Some of the structures very recently designed, although safe against high floods, are exhorbitant. On the other hand these schemes having been built on existing or old sites, lack in improved planning and suffer from the same drawbacks as discussed earlier. The result is disappointing and in spite of very heavy costs the benefits are limited and disproportionate.

vii) There is no system of regular maintenance of these schemes. The weir structures, the guide bunds and the canals once completed are left unattended. As the flow across the weir and into the canals is open i.e. no gates to control the flow, nobody seems to bother until some damage occurs which then is repaired only in case special funds are allocated. Quite often, repairs can only be arranged after a lapse of a few years, and in the meantime the damage progresses further and the farmers remain without water.

viii) For weirs which are provided with gated canal head regulators or undersluices, trained staff is not available all the time to operate the system judiciously, so as to reduce silt entry into the canals during high floods. The result is that even these canals are generally silted up badly in the head reach.

ix) No gauges have been maintained on the scheme sites to collect hydrological data of river flows. Such data if collected would be very useful in planning any modifications/improvements to these schemes as well as planning new schemes on the same river.

6. FUTURE APPROACH

The constraints and handicaps outlined in paragraph 3 should not be a hindrance from improving and implementing better engineering solutions. Infact these should give a fillip to a more dedicated and enthusiastic involvement of the professionals to formulate a more scientific and rational approach, rather than let the zamindars continue with the old practices. However they should only frame technically feasible schemes and unproductive investment should not be supported just because of political considerations and individual's influence.

With the background explained in paragraphs 3 and 5, it is concluded that the major considerations in planning a new scheme should be:

i) The water rights vis-a-vis willingness of the beneficiaries to cooperate in any new venture for a realistic and rational distribution of water.

ii) The capacity of offtaking canals.

iii) The minimum size of the distribution network (canals) that would be needed to disperse quickly the diverted flood waters to a maximum area and the maximum size which can be afforded with respect to costs but commensurate with the expected benefits.

iv) The justification and limits of resource allocations in view of the overall productivity and benefits of the scheme.

Considering the above major factors the following guidelines are suggested in framing new schemes.

7. GUIDELINES FOR PLANNING OF NEW SCHEMES

7.1 The most important requisite for planning of a flood irrigation scheme is the availability of hydrological data and the assessment of the quantum of water that will be normally available for diversion. The specific problems as enumerated earlier lead to the suggestion that these schemes be based on the low, and lower/medium river/stream flood flows only, as the diversion of higher flows will neither be economically feasible nor properly manageable.

7.2 After arriving at the probable river flow figures, the second important step would be to determine the culturable commanded area and its extent which could be assured irrigation waters from the weir site. In carrying out this exercise the length of the main canals needed should be optimised viz-a-vis the cost of construction, the water losses expected, practicability of on-farm water management and the efforts needed from the landowners. The shape of the irrigation area and its configuration will also influence these factors.

7.3 At this stage the landowners must be brought into the picture and kept informed about the siting of the weir, canal alignment and area to be given irrigation supplies vis-a-vis existing water rights.

7.4 An appropriate number of outlets should be provided so that the traditional system of water application could be handled without much difficulty and unnecessary wastage. The practice of providing only a tail cluster with 2 to 3 outlets catering for 200 - 500 cusec supply is not advisable, being very inefficient and wasteful. A canal with 100 cusec flood supply must at least have 5 - 10 outlets. The size of the outlets should however be optimised keeping the specific terrain, farming area field configuration, topography etc. in view. This would definitely increase the length of main canals but it would be worth the cost.

The sizing of outlets needs further in-depth study.

7.5 The canal head regulator must always be gate regulated. This would avoid excess supplies going down the canals which cause frequent breaches, and excessive silt entry during higher floods. The latter has been observed to be one of the main causes of failure or inefficient working of many of the systems so far built.

7.6 Inclusion of a silt excluding device in the head regulator in highly recommended. This can be a cheap arrangement and not necessarily very elaborate.

7.7 If the above guidelines are strictly adhered to the envisaged irrigation figures would be very realistic, and exaggerated and incorrect forecasts would be eliminated. When realistic estimates of anticipated benefits are available one would like to limit the cost of diversion structures, embankments, guide bunds etc. accordingly. Economy in design will then be an overriding consideration, of course without sacrificing the durability or safety of various structures.

7.8 As a corollary to the above observations about the sizing of various components, we strongly suggest that the diversion weirs for flood irrigation should not be built across major rivers. The cost of a weir structure adequately designed to pass the high flood flows and the training works alone, would be very high at such sites. On the other hand the system would also not be easily manageable or efficient for spate irrigation while the maintenance and operation costs will be very high.

It will therefore be appropriate to plan such diversion weirs across smaller rivers/streams or tributaries of large rivers and their smaller branches, where the flow is low and manageable.

As an illustration Mithri, Nigong, Seakal, Buddo, Titian Nai & Uthal Kantra are quoted where the offtaking canal capacity is low while very long weirs had to be built to cater for high flood discharges. Obviously the benefits cost ratio is disappointingly low.

On major rivers, inundation offtakes would only be economically feasible.

7.9 The rigid weir structures capable of withstanding the highest flood discharge would be ideal across smaller rivers/streams in areas of higher annual rainfall, so that the capital outlay and annual operation costs would be justified in view of larger cropped area.

Gate controlled canals heads and open sluicing bays must always be provided on such schemes.

7.10 On medium rivers/streams the weirs may well be built in flexible gabions, however, the abutments and canal head regulators should be in masonry and preferably gate controlled.

7.11 An open earthen canal head must always be avoided, as it would encourage excessive discharge passing down the canal during higher floods causing damages and gradual widening of the waterway, which may ultimately induce outflanking of the weir.

7.12 Constriction of the river width leading to a weir should never be very high, as it entails the following drawbacks:

a) The more the reduction of the waterway at the weir, the higher would be the intensity of the flow across it during high floods. Naturally, for the dissipation of energy on the downstream, a longer and deeper cistern as well as a deeper cut-off wall will have to be provided.

b) With the decrease in the waterway the afflux at the weir increases, which requires higher wing walls, as well as higher and longer guide bunds. This adds to the initial capital outlay and later maintenance costs.

c) Close to the weir the velocities will be very high and there are chances of the formation of eddies and swirls along the guide bunds in case their lay-out geometry is not conducive to smooth flow. These eddy currents induce scour near the toe of the bunds causing slippage of the pitching and ultimate breaching of the embankments.

This phenomenon puts a lot of pressure on the guide bunds needing constant attention and costly repairs.

d) In case of very high constriction, the canals have to be aligned through the "Khadir" (river bed) for a short length at the offtake. This reach would be built in high fill and will always remain vulnerable to river currents. This was the case at Seakal where the canal had been washed away during the floods of 1988.

e) In situations like at Seakal there is always a possibility of outflanking of the weir during very high floods.

Too much constriction, as may be appreciated, does not always lead to economy.

7.13 However, building a weir across the full width of the river bed will entail its own drawbacks. The flow in the rivers of Balochistan varies excessively i.e. from a very high level to almost nil, and then too the supply continues for very short periods. The river belly is obviously wide and the average or normal-average flow being quite low, the river generally meanders across its width. Meandering close to the weir will create problems of proper feeding of the canals, 'Bela' formation and masking of the weir on the upstream, and excessive silt entry into the canals. The fluming or constriction of the waterway has therefore to be judiciously decided.

7.14 In case of medium sized rivers the construction of distributors/bifurcations in 'gabions' to proportionately divide the flow going down into different channels, is a practicable and cheap proposition. The design criteria however, need a further in-depth study, for formulation of sound parameters.

7.15 The location of a weir, alignment of its axis and the guide bunds, as well as the overall layout geometry must be worked out very carefully. For this a reconnaissance and actual topographical survey of the river reach must be done and alternative sites studied with respect to geology, river bed configuration, meander width, approach conditions, suitability of canal alignment, height of weir necessary and area command. These variables need an in-depth study under the guidance of an experienced engineer fully conversant with the subject. A mistake in this important facet of planning could mean disaster for the Project, and it should not be left to a novice.

IV SOCIO-ECONOMIC ASPECTS

SOCIO-ECONOMIC ASPECTS

INTRODUCTION

Investigation of socio-economic aspects of the flood irrigation schemes was carried out by SEBCON (Pvt.) Ltd of Islamabad. SEBCON's team for the study consisted of a Socio-Economic Consultant based in Islamabad, who devised survey instruments, paid superviory visits to the field and took overall responsibility for report-writing, and a Field Socio-Economist who carried out the fieldwork. The Field Socio-Economist travelled to each district with DESIGNMEN's team, but did not necessarily travel to the same sites on the same days.

1.1 Methodology

The choice of a methodology was determined by several factors. Firstly, time available for studying any particular scheme was very short. Secondly, the survey instrument had to be adaptable to a variety of ecological zones, ethnic groups and tenurial arrangements, on which there was little background data. Thirdly, it was known that rural people in Balochistan are conservative, often suspicious of outsiders, and sparing with information. It was also known that, at least in Baloch and Brahui areas, access to ordinary rural people lies through powerful traditional leaders and is in practice very difficult to gain.

All these factors, as well as the qualifications of the team members, meant that research would be primarily qualitative rather than quantitative, and that the best survey instrument was a semi-structured interview schedule, that could be used either with key informants or in a larger meeting of village men. A summary of topics covered in the schedule, as it was adapted in the light of the first month's fieldwork, is reproduced in Appendix 2. In general, one such interview was held per scheme, and with a physical inspection of fields and distribution systems, and travelling time from the district centre, this took up approximately one day. In some larger schemes, especially where two or more distinct villages were concerned, the schedule was used two or even three times. In some schemes under construction, completely abandoned, or not falling into the strict definition of flood irrigation schemes, either no fieldwork was done, or briefer and less structured enquiries were made. A few schemes, in Pishin and Zhob Districts, were not visited at all due to security reasons.

An abbreviated form of the main interview schedule, for interviewing key officials who had knowledge relating to more than one scheme, was developed after fieldwork had been completed in Las Bela District. A different schedule, for interviewing individual farmers, was devised at the beginning, but in practice this was seldom used, as time constraints prevented gathering of information from a meaningful sample at any single site.

Fieldwork generally took place in Urdu, as the Field Socio- Economist is not fluent in any of the local languages. In some areas many of the men spoke good Urdu, in others interpreters between Urdu and local languages were recruited on the spot. Given the timeframe and the level of information required, working through Urdu was not a problem.

The survey instruments were designed and adapted with inputs from both team members, who remained in close contact throughout the survey to discuss difficulties. The Field Socio-Economist was debriefed at length and played a role in report-writing. This close contact allowed the use of a very open-ended schedule, and allowed the Field Socio-Economist to adapt the survey to local conditions.

Even after adaptation, and even given the great variety of local conditions, not all parts of the survey schedule proved useful. Information obtained was also very variable in quantity and quality. This depended on many combinations of circumstances; the availability of good informants, the perceoved relevance of survey schedule to their needs, and the sort of information they had to impart. To give two contrasting examples, people in the command area of Titian Nai scheme, in Las Bela, had many grievances concerning the scheme and other subjects, and it was easy to complete two full interviews. In an area near the top of the nearby Winder scheme, a village meeting completely fell apart about two-thirds of the way through the schedule, as people who were basically satisfied with the scheme lost interest in the survey. In other areas information on some topics was very cursory and on others fuller than expected.

As was to be expected, reliable quantitative information was difficult to gather. Informants in one part of a large scheme might have little or no idea of total population or acreage. Sometimes the scheme reports make use of official statistics, in which case this is indicated, but these can be of almost equally uncertain validity. Crop yields might be given in obscure and variable local units. Even if yield figures could be obtained clearly, there was rarely a useful baseline for comparisons. Asking people for pre-scheme figures was generally felt, based on the team's experience elsewhere in Pakistan, to be of very limited usefulness. Only in some cases where particularly clear data was obtained, or where nearby rainfed land could stand as a proxy for pre-scheme cultivation, is much yield data presented.

In general, informants' accounts were used fairly directly, or modified in the light of other interviews. Although some dates of scheme construction have been modified in accordance with official records, the socio-economic sections of each report generally express local people's views on the appropriateness of scheme design, the level of consultation etc., and thus may appear to conflict with information obtained from official sources. It was rarely possible to even attempt to check information obtained from local people on the actions of official bodies or powerful individuals, and the scheme reports must be read with this in mind. It should also be borne in mind, however, that a perception that (for instance) the Irrigation Department acted wrongly or irrationally may be just as important as the fact that it did so, and in this respect the reports represent an important social reality. Further reference will be made in Section 2 to the different topics covered by the schedule and its effectiveness in gathering data on them.

1.2 The 'Socio-Economic Notes' and Tables

Although the primary objective of the survey was to provide an insight into the socio-economic aspects of each scheme, it was thought appropriate to attempt to summarize findings from each district or group of districts. A Socio-Economic Note is therefore included in each volume. Again, these achieve their aim with varying degrees of success. That for Las Bela is able to reach substantial, if speculative, conclusions on the failure of schemes, while Volume III includes too few schemes, over too wide an area, for effective generalization.

In order to present some findings in more summary form, two standard matrices were used for tables in each volume. In each case, not all schemes were included in these tables. Schemes still under construction, or not visited, were not included, and neither were schemes that had been gross technical failures, especially soon after construction.

The first matrix attempts to summarize six factors that could be a priori supposed to affect the success of schemes, together with a statement of the success of the scheme. In fact, these tables generally show remarkably little pattern. There is certainly no single factor that determines the success of schemes, and some schemes were successful despite the absence of consultation, an organizational framework, and popular participation, that might be considered necessary for success.

The second matrix is an attempt to summarize aspects of scheme success or failure; the effect of the scheme on land tenure, crops, livestock and social relations. In many cases there was no discernible effect; '-' can either mean no effect, or incomplete information. For instance, beneficiaries might voice great satisfaction with a scheme, but because there was no baseline for comparison of yields, and no effects mentioned on land tenure, livestock and social relations, no information would be presented. These questions are returned to in section 2 below.

1.3 Women

Although the impact of the schemes on women was part of the original TOR, very little data was gathered on this topic, or on women in general. Rural society in nearly all parts of Balochistan is intensely conservative with regard to the role and status of women. Men from outside the community are unlikely in the highest degree to be allowed to talk to women, and even talking about them would arouse great suspicion. To gather meaningful information about women the team would have to have been expanded by the addition of a female sociologist.

Apart from the greater costs involved, it would have been extremely difficult to recruit a female sociologist who spoke any of the three major languages of Balochistan. As very few rural women in Balochistan speak much Urdu, this, unlike in fieldwork with men, would have been a strong requirement. The incorporation of a woman in an otherwise all-male touring team would also have been a problem.

Male informants were asked if women inherited different categories of land, and this information is included in each scheme report. Such information is not likely to be terribly reliable; many men are vaguely aware that inheritance by males only is contrary to sharia, and place their customs in what they see as a favourable light. Men attested in good faith that women had the right to inherit land, and then revealed on closer questioning that no woman had exercised this right in living memory. The survey was not the place to explore the subtleties of ownership versus control of land and access to its fruits, or the dynamics by which women 'voluntarily' cede land to their brothers. In general, however, men were most likely to make some claims that women could inherit in Las Bela, Makran and Kachhi, and most likely to state immediately that women could not inherit in Pathan and Khetran areas. There were also cases in which women in the families of traitional leaders, but not other women, inherited. This may conceivably be a recent innovation, linked to avoiding the effects of individual land ceilings imposed during the seventies.

Questions were included on the division of agricultural labour. In most areas women have some involvement in weeding and harvesting, but answers were generally too vague to merit inclusion in the scheme reports. Another question was designed to uncover qualitative changes in agricultural labour, including changes in the division of labour, but was not really successful. A question was also asked on domestic fuel-use. Wood was reported in nearly every case.

There is undoubtedly an enormous need for information on rural women in Balochistan, and grave obstacles to obtaining it. One can suggest three, complementary, solutions. More basic, and primarily quantitative, research on women's lives, less tied to immediate project objectives, should be commissioned and funded. Secondly, a long-term effort could be made to train women from Balochistan in the social sciences and social enquiry, in order to form a cadre for future projects. Thirdly, imaginative solutions should be looked for to enable highly-qualified women social researchers from other parts of Pakistan to make a contribution, perhaps through selecting untrained, but Urdu-speaking, informants and assistants in rural areas.

2 THE SCHEMES; BACKGROUND AND FINDINGS

An attempt to draw conclusions from the survey about the socio- economic conditions of successful flood irrigation is made in Section 2.5, and conclusions about the effects of successful schemes in Sections 2.6-2.8. Prior to that, the background to the schemes, drawn from survey findings and other sources, will be presented.

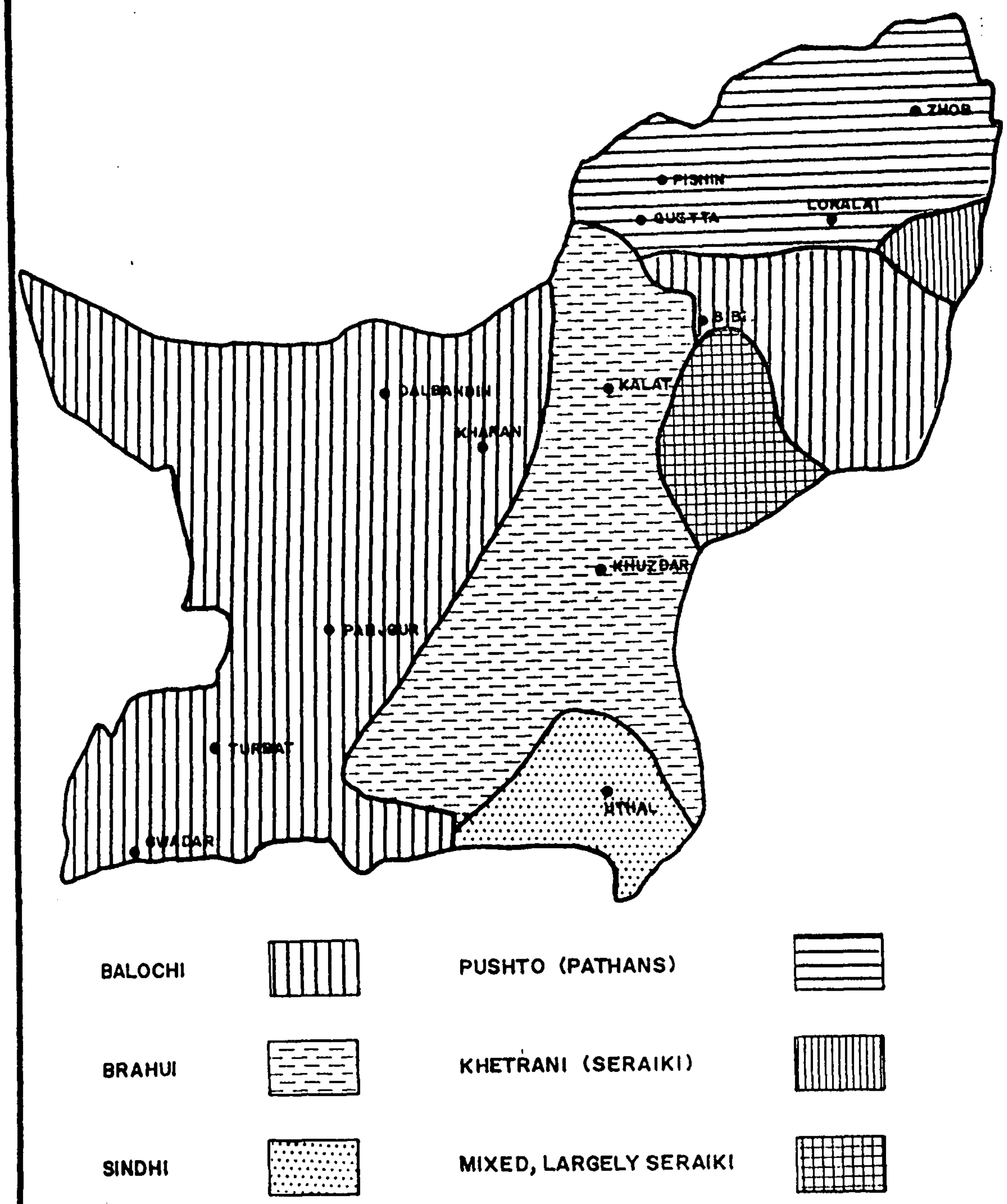
2.1 Balochistan: an Anthropological Overview

Balochistan is Pakistan's largest province, and its surface area, at 347,190 km^2, is about ten times that of the Netherlands, but it is inhabited by only around 5 million people. It is generally a very inhospitable area, with low rainfall and infertile soils. Such an area has become home to conservative, tribal societies, the Baloch, Brahui and Pathans. It has also been largely by-passed by economic developments taking place in the more central, fertile, and densely populated areas of Pakistan.

Despite the small population, and the impression of homogeneity, there is in fact great variety in the social, cultural and economic conditions of Balochistan. Including Persian, spoken in a few villages, there are six vernacular languages, the approximate distribution of which is shown on the accompanying map, figure 11. Brief mention of the dominant ethnic groups is made in the socio-economic note accompanying each volume.

At a high level of generalization, one can say that Baloch and Brahuis, living in the most inhospitable areas in the west and centre, have a hierarchical social structure in which considerable deference is given to hereditary tribal leaders. Terminology varies from place to place, but village headmen are often called waderas, and the next rank of leaders motabars. The leaders of major tribes are known as sardars and the system of their rule as sardari. Most of these tribes were formerly organized into the Brahui state of Kalat, and its dependencies of Kharan and Makran. The more fertile lowlands of Kachhi, directly under Kalat, and

BALOCHISTAN: APPROXIMATE DISTRIBUTION OF LANGUAGES/ETHNIC GROUPS.



NOTE: THIS MAP IS BASED ON AVAILABLE INFORMATION AND IS NOT TO BE REGARDED AS AUTHORITATIVE.

V.I, FIGURE 11

Las Bela, a dependency, were part of this political organization, though they largely retained the lowland languages of Seraiki and Sindhi. The Bugti and Marri Baloch tribes, not covered in this survey, and the Khetran of Loralai, have a similar sardari system, but never came under Kalat. Sardari systems are now in decline in most areas, but at very varying rates. They vary greatly in the extent to which they are perceived as benign by those who are ruled by them.

In the north of the province, generally more fertile, the Pathan tribes exhibit a much more egalitarian social structure, in which households retain their independence, issues are decided in tribal councils or jirgas, and leadership is more fluid and competitive. Local leaders are generally known as maliks. Nevertheless, some powerful ruling families, such as the Nawabs of Qila Saifullah, have emerged in Pathan areas, and it is important not to place too much reliance on the generalization of Baloch hierarchy versus Pathan individualism.

2.2 Land Tenure

Knowledge of tenurial conditions in Balochistan is still very incomplete. Ownership of cultivable land in the vicinity of schemes was nearly always by individuals or families, rather than extended families or tribes. In only a few cases, mainly in the north, was any form of common ownership of cultivable land still to be found, and the traditional periodic redistribution was reported only once (in Untum, Kachhi area). This does not mean however, that there was a fully-developed market in land. In most areas sales were rare, in some they were unknown, and in a few the idea seemed abhorrent to people.

Reference is made in each volume to the Agricultural Census of 1981, which gives the percentage of farms cultivated by their owners (as opposed to tenants, and to those who owned some of their land and rented some from others) and the percentage of total farm area represented by these farms. The overall figures for Balochistan are as follows:

Farms operated by owners:	78%	= 75% of farm area
owner/tenants:	7%	= 11% " "
tenants:	15%	= 14% of " "

Despite these figures, heavily skewed towards owner-cultivators, some form of sharecropping or land rental was reported at nearly every scheme. To some extent, this may have been due to the form of the question, in that sharecropping would be reported even if it accounted for an insignificant proportion of farm land. Unless figures are given for landholding households and tenant households, or owner-operated land and rented land (as they are for some schemes, particularly in Las Bela and Loralai Districts) statements about sharecropping in the scheme reports should be treated with some caution. It may however be that either scheme land, or the tehsils in which schemes lie, are more liable to sharecropping than the districts considered as wholes. The latter is probably the case in Loralai.

The most striking fact about sharecropping and related practices is the great variation in terms, within districts and even within villages. This is partly explained by the variety of factors to be considered in a sharecropping agreement; land, labour, seed, farm power, water, but this does explain all the variation. Particularly in Las Bela there is a form of sharecropping linked to cash advances and very low tenant shares that is close to bonded labour, practiced alongside more equitable arrangements. In various areas a tenant making land cultivable for the first time becomes the owner of a fraction of it, or assumes most of the rights of ownership. Such people may themselves take tenants.

Grazing land is generally owned in common by a subtribe or village, and is frequently used freely by the herds of people outside those units. In some areas, particularly Las Bela, people were aware that grazing land belonged in theory to the government, but this may not have been the case elsewhere. The scheme reports reflect local understanding of land ownership rather than any legal status.

The question of grazing land is closely bound up with that of transhumant herders. Such seasonal visitors were reported at many schemes. Their relationship to local people varied greatly; they could be of the same subtribe or of different ethnic groups. In parts of Kachhi the seasonal visitors were themselves the owners of the cultivable land and the permanent residents their tenants.

In general, transhumants are well integrated into farming systems, for instance arriving at harvest to be hired as labour and get fodder for their animals. For further information on livestock, see the MART/AZR Project Research Report No.5.

2.3 Irrigation and Cultivation

Agriculture in Balochistan varies from the purely rainfed to the perennially irrigated, with many hazy categories in between. Khushkaba generally refers to the use of rainwater on sloping fields by contour bunds. Sailaba refers to the channelling of floodwater by channels and earthen bunds. The terms kacha and pukka are widely used (and are used in the socio-economic components of this report) to contrast earthworks and other structures that can be made by local people, with more permanent structures using imported technology and materials, such as concrete or gabions. It can be said that the flood schemes under consideration in this report are a pukka version of sailaba.

There are also perennial schemes with storage dams, particularly in the west and Pishin. The distinction between these and flood schemes is not always clear, and some perennial schemes were the subject of socio-economic surveys. The largest irrigation scheme in Balochistan, the Pat Feeder Canal on the Sindh border, is clearly in a different category, but is probably linked with flood schemes as a magnet for out-migration.

The karez is the traditional horizontal infiltration gallery, often very large and complex, and especially common in Makran and the Pathan areas. Persian wheels are used, especially in Loralai. Tubewells, both diesel and electric, are becoming increasingly common, and in some areas, particularly Las Bela and Loralai, this seems to be an effect of flood schemes. This relationship probably has two aspects; a hydrological one by which flood schemes recharge groundwater, and an economic one, by which some flood schemes increase prosperity to the extent that investment in tubewells becomes possible. These relationships should be a subject of further study.

Major crops of each area are reviewed in the Socio-Economic Notes, and effects of schemes on cropping in 2.6 below. Generally, all the major cereals except rice are grown in one area or another, with winter wheat and sorghum the most common. Various pulses are also grown. In Loralai and Las Bela, intercropping of mung and sorghum is popular. It is to be hoped that extension efforts will not discourage what is presumably a tried and tested strategy in these arid areas.

The usual Pakistani terms kharif for crops sown/planted during the main summer rains, and rabi for winter crops, are used. Areas vary with respect to getting one or two crops per year. A spring-planted crop, zaid rabi, is considered a separate crop in some areas. For more detailed discussion of agriculture in Balochistan, see the MART/AZR Project Research Reports Nos. 5 and 54.

2.4 Scheme Organization

Questions on subjects like consultation by the authorities and community participation produced information that was at first sight discouraging. In very many cases the Irrigation Department had made no meaningful efforts to consult local people on the need for a scheme. In virtually no case was there a formal water users' association. Only in Pishin District does the Department attempt to recover any costs from beneficiaries. In many areas beneficiaries collectively raised money or worked to maintain schemes, but it was not always clear whether this was on the headworks, or very near each farmers fields.

What is interesting is how little these factors actually correlate with scheme success or failure. For instance, the three schemes in Quetta District reported no community participation in maintenance, yet two of the three were highly successful. Schemes in Kachhi had codified and well-enforced systems of communal work, but were failures.

The same applies to water distribution systems. The most common pattern was that described in the Socio-Economic Note for Las Bela; branching channels, that could be temporarily blocked, watering the highest land first. There were many variations in physical layout; water could pass from field to field without channels, either over the top of each bund ('cascade') or by controlled breaching of the bunds (these different systems are described in more detail in WAPDA 1988). The rule of highest land first was modified in various ways; by lot, by starting distribution where the previous flood had stopped, by aiming to irrigate the same proportion of each farmer's land. At Shebo in Pishin, each of three villages in the same scheme had a different system. In perennial schemes, and schemes similar to them, some sort of time-share was sometimes practised. This generally contributed to scheme success, but on true flood schemes there seemed to be no such pattern.

2.5 Other Factors in Scheme Success

The overall conclusions of the socio-economic survey were that people's level of satisfaction with schemes was generally low, and that the success of schemes was hard to correlate with virtually any socio-economic variable. The Tables attached to the Socio-Economic Notes generally bear this out.

There were, however, distinct local patterns in the success or failure of schemes, as summarized below.

District	Remarks
Las Bela	Most schemes involved serious conflicts of interest between different villages; general dissatisfaction
Western	Some schemes successful
Quetta	Mainly successful
Pishin	Flood scheme subject to major conflicts, perennial schemes to declining maintenance
Kachhi	Serious technical failures and social problems
Zhob	Some schemes successful, others poorly planned and completely failed
Loralai	Schemes in Khetrani areas generally succesful; schemes in Pathan areas subject to conflicts

It is possible that cultural factors intrinsic to each ethnic group are relevant here. Several schemes in Pathan areas had experienced severe social conflicts that had obstructed scheme functioning (though three schemes in Zhob were successful). This could possibly be ascribed to traditional Pathan individualism and egalitarianism. Schemes in Brahui areas (Quetta, Kalat and to some extent Khuzdar) and Khetrani areas were generally successful, which could be ascribed to the cohesion of these societies around relatively benign traditional leadership. Schemes in the more socially complex areas of Las Bela and Kachhi showed very little success.

Two other factors are probably more useful in explaining scheme success or failure. The first is the previous use of the land irrigated by the scheme. Some of the most striking successes, in Quetta, Kalat and Zhob Districts, are of schemes irrigating land previously under khushkaba, grazing land or even land previously unused. These schemes were successful in terms of general satisfaction and lack of complaints; there is some evidence that they would be more successful (than other schemes) in terms of a cost-benefit analysis. As well as the gain in productivity, a few but not all of them were associated with some form of land reallocation at the time of construction, ensuring greater equity.

Looked at another way, schemes that replaced traditional sailaba schemes have rarely given enough benefits to satisfy the population. Some times they have proved less effective than what they have replaced, sometimes the new technology has raised popular expectations it could not fulfil, sometimes, as explained in the Socio-Economic Note on Las Bela, they have contributed to inter-village tensions.

The second factor is that of scheme size and complexity. The classically successful scheme seems to be one in which flood water exits from an uninhabited area, is used by one village or closely related group of villages, and in which no other village downstream has a claim on it. The successful schemes of Zhob fit this pattern well. Quantifying this variable is difficult, as it involves defining the limits of communities, and considering the linkages between separate schemes, but the overall impression is clear. The converse is equally true; schemes serving many distinct communities, or schemes linked to others along a major watercourse, are unlikely to be free from complaints. In many cases the complaints are translated into poor maintenance or unauthorized alterations and the scheme's technical performance declines drastically.

Although both findings are subject to exceptions (in particular, many successful schemes in Loralai were constructed on sailaba land), they seem clear enough for some policy implications to be drawn; that flood irrigation schemes have most chance of success when serving single homogeneous communities on previously unirrigated land.

2.6 Scheme Success and Agriculture
For reasons mentioned in Section 1.1, quantification of benefits from schemes would be very difficult and has not generally been attempted. In some schemes in Quetta, Kalat, Zhob and Loralai some form of quantitative information on increased yields is however presented.

It was not even always easy to determine whether changes in cropping patterns were the result of schemes, particularly with older schemes, or schemes not close to any rainfed land. The recent adoption of sunflower in Quetta is the clearest example of flood irrigation allowing a new cash-crop. In some areas farmers were able to diversify the cereals grown, particularly into maize, and to grow certain cereals primarily as fodder. It was not clear to what extent the cultivation of castor and cluster bean (primarily in Las Bela) and cumin (in Quetta, Pishin and the west) were made possible by flood irrigation. It is clear, however, that flood irrigation in the strict sense is not suited to the great range of fruit and vegetable crops made possible by perennial schemes, tubewells or karezes.

2.7 Scheme Success and LivestockAn interesting finding of the survey was the extent to which successful schemes were having positive effects on livestock. This was true wherever schemes were succesful. On schemes that had been succesful but then failed, a decline in benefits to livestock was reported. Benefits were not usually described in detail, but it was clear that both herd numbers and herd condition was improving. Many successful schemes were also attracting increasing numbers of seasonal visitors. Presumably the improvement was mainly due to the increase in standing crop residues (the technical term 'stover' is used in the rest of the report) but some schemes had allowed the growing of crops specifically as animal fodder.

Increased benefits to livestock had had varying effects on livestock sales; some successful schemes reported increased marketing, some decreased marketing, and some no change. Unsuccessful or failing schemes were also associated with both increased and decreased sales, although this can be interpreted as a short-term increase while herds are brought down to match reduced levels of fodder, followed by a long-term decline. Fodder and stover production, and livestock sales, should be included in any attempt to quantify costs and benefits, but more research is needed to understand how livestock, both of farmers and of seasonal visitors, is integrated into the overall farming system.

2.8 Social Effects
In a changing society like Balochistan, it is hard to identify specific social effects of something like a flood irrigation scheme. Traditional authority was in decline in most areas, but it would generally be absurd to attribute this to the schemes, and it has not been included in the tables as an effect of the schemes unless there

was a clearer link. The most significant effects were in failed schemes; it was here that resentment against traditional leaders had grown, as people began to perceive their power (including their preferential access to water) as more arbitrary and less benign. There is a genuine (and probably two-way) causal link between technical failure and inter-village conflict because of which the facility is not fully or effectively utilised. In few areas was it said that intra-village conflict was increasing. Virtually nowhere was it said that differences between rich and poor were increasing.

Effects on land tenure, where identified, made no coherent pattern. Only at Shabza, possibly at Hashim Rud, and in a sense at Khosti, all succesful schemes, had land been redistributed at the time the scheme was built. In some other areas land had been been redistributed earlier, either from common to individual ownership, or from large landlords. In some cases in Zhob and elsewhere, a failure to agree on the division of land meant that the schemes had never operated properly (see for example the report on Baber). Where schemes had been successful, it had sometimes resulted in more sales of land, as for instance at Winder in Las Bela, but sometimes also in fewer sales, as at Rindani Gat in Turbat.

Effects on tenancy were equally elusive. A few successful schemes were attracting new tenants. Only on perennial schemes was there a clear difference in sharecropping terms between irrigated and rainfed land. Failed schemes, such as those in Kachhi, and Chatti in Turbat, were associated with a drifting away of potential tenants and labourers that was probably a partial cause, as well as effect, of failure.

Questions were asked on the provision of infrastructure and government services around schemes, and this is generally included in scheme reports. Dates of provision were asked in case scheme construction had been a stimulus for the development of other services, but nowhere was this clearly the case. In some areas, specifically Zhob, the sardari system or its mutations were clearly obstructing the proper functioning of government services.

3 CONCLUDING REMARKS

Overall conclusions from the socio-economic component of the survey must remain tenuous, but the most important can briefly be presented.

3.1 The general performance of flood irrigation schemes in providing perceived benefits to farmers has been poor. While this has largely been due to technical failures, poor planning, a failure to take into account social factors and a failure to encourage participation have also been causes. 'Technical' and 'social' failure are related in complex ways, with poor social planning decreasing the likelihood of good maintenance, and poor technical design being the cause of inefficient distribution of water and resulting disputes.

3.2 That being said, there is very little specific correlation between factors like water distribution systems and community participation with success or failure of schemes. Each scheme represents a unique combination of technical and social factors combining to cause success or failure.

3.3 There are some fairly clear connections between scheme success and locality, with schemes in Quetta and Loralai being successful, and those in Las Bela and Kachhi failures. However, this is mainly related to the climate, amount of rainfall and the topography of the area.

3.4 It is fairly clear that schemes bring greater perceived and actual benefits, and are less likely to fail, when they bring land under irrigation for the first time, than when they replace traditional sailaba systems.

3.5 It is also clear that small, self-contained schemes are more likely to be successful than schemes serving several dsitinct communities, or schemes on major watercourses.

3.6 Scheme success generally has beneficial effects on livestock, and this must be taken into account when assessing costs and benefits.

3.7 Further in-depth social research on a few individual schemes is needed to explore the inter-relations of technical and social factors, agriculture and livestock, in which schemes succeed or fail. Loralai District might be a useful area to start, as most schemes were successful, while some failures would be available for comparison.

3.9 Any planning of future schemes demands much more careful consultation with local people, preferably by teams including a social scientist. Given the great cultural, agricultural and ecological diversity of Balochistan, this expertise, and project planning in general, should be de-centralized to District (or at least Irrigation Circle) level. Effective understanding of local conditions can best be achieved by professionals who are closely associated with the area and can appreciate fully the needs, aspirations and resources of the local people.

V ADDITIONAL RECOMMENDATIONS

V. ADDITIONAL RECOMMENDATIONS

In both chapters III and IV, dealing with technical and socio- economic appraisals of flood water irrigation schemes, a number of recommendations are included. In chapter III they are formulated as 'Guide Lines for Planning New Schemes', and in chapter IV as 'Concluding Remarks'. Moreover, specific recommendations for most of the schemes are given in the individual reports (volumes 2 - 7).

Two additional recommendations can be made of a general nature regarding the selection of new scheme sites and their integration into larger regional development projects.

1. When selecting new sites for flood water control schemes, extensive use should be made of aerial photographs or satellite images, preferably stereo pairs on a scale of 1:40,000 or 1:50,000.

   With the help of these images, a general river/stream and sedimentation pattern can be established. Field checks should be carried out to verify the interpretation and to determine the size distribution of the clastic material across the area.

2. All future schemes should be part of an integrated development plan for a certain watershed area. It should include:

   a) erosion control in the catchment area, with possible reforestation,

   b) flood water control on the alluvial fans, such as delay action dams and ground water infiltration schemes,

   c) educational facilities for the local population, with encouragement to set up local councils of water users,

   d) better irrigation methods.

An economic analysis of the whole development scheme should be made, whereby 'hidden' benefits should play an important role.

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VI. REFERENCES

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