Government of Balochistan

Balochistan Minor Irrigation and Agricultural Development Project

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PHASE II PREPARATION STUDIES

FLOOD IRRIGATION SCHEMES

CHANDIA

Feasibility Study 1

August 1993

VOLUME 1 - MAIN REPORT

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in association with
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NESPAK

HALCROW

GOVERNMENT OF BALOCHISTAN

BALOCHISTAN MINOR IRRIGATION AND AGRICULTURAL DEVELOPMENT PROJECT

PHASE II PREPARATION STUDIES

CHANDIA FLOOD IRRIGATION SCHEME

ABBREVIATIONS AND ACRONYMS

BMIADP	-	Balochistan Minor Irrigation and Agricultural Development Project
CADU	-	Command Area Development Unit
DoA	-	Department of Agriculture
DoI	-	Department of Irrigation
GoBAl	-	Government of Balochistan
LGP	-	Low Ground Pressure
MCP	-	Malaria Control Program
MPA	-	Member of Provincial Assembly
PHED	-	Public Health Engineering Department
PMD	-	Pakistan Meteorological Department
SSP	-	Soil Survey of Pakistan
SWHP	-	Surface Water Hydrology Project
WUA	-	Water Users Association

GLOSSARY

Chab	-	A low diversion groyne structure built from stones and brushwood at the edge of a river with a free intake
Gandha	-	Typically a large earthen bund built across the full width of a river to divert the full flow of the river up to the capacity of the bund
Kareze	-	Underground water collection channel
Kaccha	-	Poor quality, (earth construction)
Kharif	-	The summer irrigation season, from June to September
Nullah	-	River bed
Pukka	-	High quality, (cement construction)
Rabi	-	The winter irrigation season, from October to May
Sailaba	-	Flood irrigation

MEASURES

Distance	-	Feet, ft or miles, (metres or km);
Flow	-	Cubic foot per second, cusec or cfs. Cubic metre per second, (cumec or cms).
Volume	-	Million cubic feet, (Mcf). Million cubic metre, (Mcm).

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CHANDIA FLOOD IRRIGATION SCHEME

EXECUTIVE SUMMARY

Flood irrigation, particularly in the Kachhi Plains, forms a major and important form of subsistence level irrigated agriculture in Balochistan. Investment in improvement of flood irrigation systems in the past has often been poorly conceived, expensive and inappropriate for the requirements of the farmers.

The development of the proposed Chandia Flood Irrigation Scheme in Sibi District, is significant for a number of reasons, in particular; the farmers will participate in all stages of the development and be fully responsible for all future operation and maintenance; the development retains the main components of a traditional existing system developed by the farmers over many years and addresses only the fundamental problems whilst retaining the desirable safety features of that system in an appropriate manner without resorting to excessive engineering; the basic operating concept of the improved headworks follows similar rules to the existing traditional concept and are therefore readily understandable and operable by the farmers; and a flood simulation model, derived from all the available meteorological and hydrological data, drawn together for the first time, is used to predict a thirty year time series of flood events enabling the long term viability of the improvements to be accurately assessed.

The proposed scheme reduces the uncertainties of agriculture for the village, by the introduction of a increased and considerably more reliable supply of irrigation water, thereby increasing the area of agricultural production and incomes of the farmers.

Two options were studied, both based on improvements to the traditional gandha system diversion and field bunds for flood irrigation. The first option was a minimum intervention approach and included a flow regulator and limiter, breachable bund and dedicated plant to rebuild the breachable diversion bund. The second option provides greater control over the flood flows and includes a short weir, sediment exclusion skimming weir and sluice, flow regulator and limiter, sediment settling basin, breachable bund and dedicated plant to rebuild the breachable diversion bund. This second option was found to be preferred and would result in the median cropped area increasing from 205 acres to 883 acres. A 14km upgrade to the road to Chandia to improve access has also been considered.

Land users will have the benefit of a more reliable source of irrigation water which will enable them to expand crop production and they will fully participate in the development.

Most land is farmed on an owner occupier basis with water rights relatively equally distributed among 897 scheme beneficiaries.

Implementation will focus on extension and institutional support which will stimulate entrepreneurial activities at the village level through a Water Users Association, and thereby contribute to economic growth and sustainable development.

The expected costs for the preferred option are Rs20,569,024 for the main irrigation scheme. Cost per beneficiary for the irrigation works is Rs 2,931. The cost for the road is Rs 13,998,716 which is a cost of Rs 4,003 per beneficiary, where the total number of beneficiaries from the road improvements is 3,497.

The proposed flood irrigation scheme, if developed using the preferred option, offers a favourable rate of return for the type of project with a financial rate of return of 11.8% and an expected economic rate of return of in the range of 7.2% to 16.4% with the median value being 11.55%. The road is estimated to have an economic internal rate of return of 7.7% and provides a marginal rate of return to investment.

1 INTRODUCTION AND BACKGROUND

1.1 Application

The scheme was registered for consideration under BMIADP Phase II by leading members of the community in January 1992, in response to advertisements placed in local newspapers by the project. The original application was signed by Malik Sher Mohammed, Mir Nazir, Mir Mohammed and Sulaiman. The application was also supported by the Superintending Engineer for Sibi.

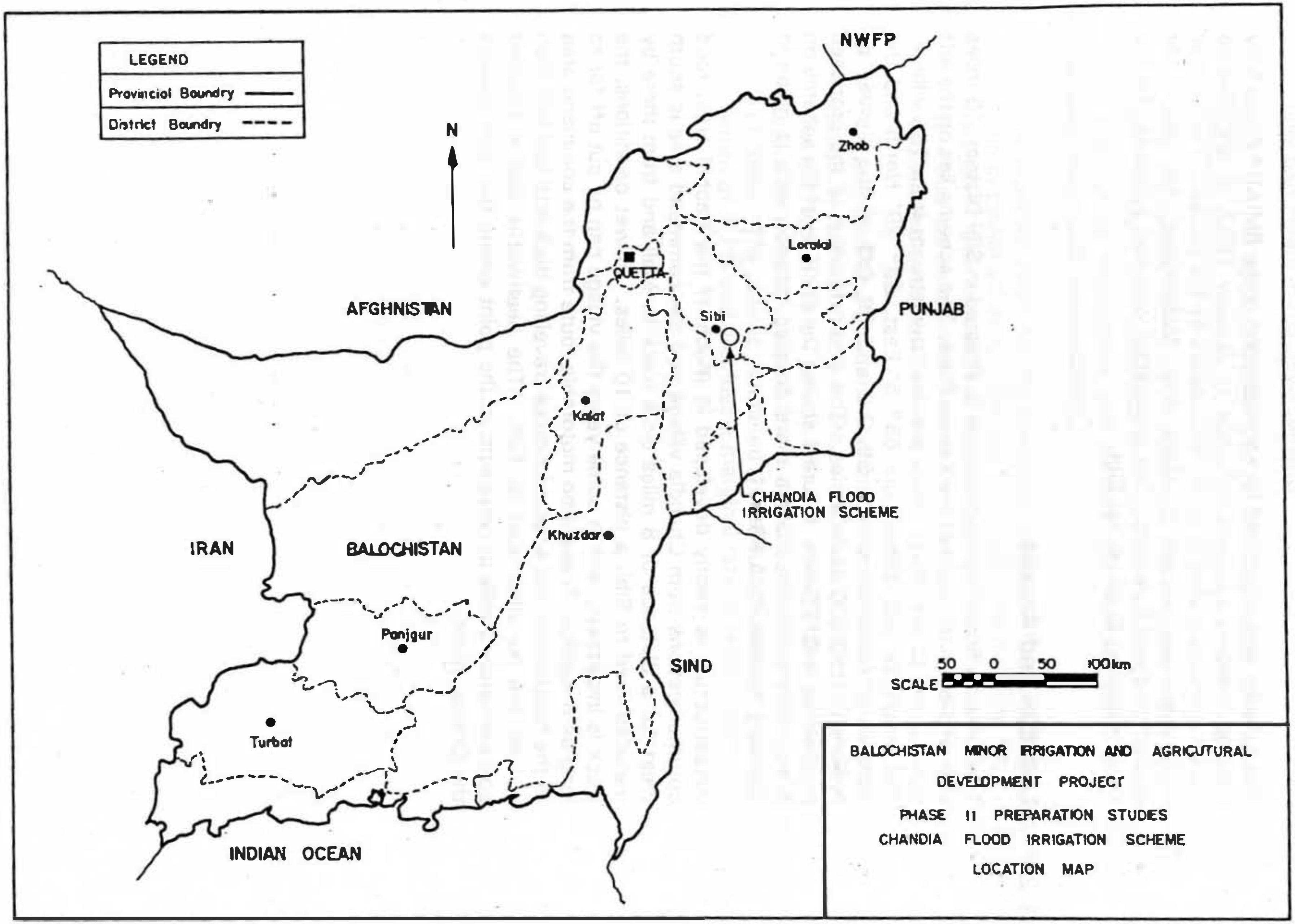
1.2 Location and Access

The Chandia flood irrigation scheme is situated in Sibi District, 13 miles east of Sibi on the edge of the Kachhi Plain. The scheme lies on the left bank of the Chakar River about 4 miles downstream from Talli village. The longitude and latitude are 68° 5′ East, 29° 29′ North and the scheme is found on sheets 39 C/2 and 39 C/3 of the Survey of Pakistan, 1:50,000 scale series. The grid reference of the proposed headworks is Q120400. Figure 1 shows the position of the scheme on a map of the Province and a more detailed location map is given in Drawing Number CHA/FS/001.

Infrastructure is poorly developed in much of the Kachhi area, road communications from Chandia village and the command area is south west for a distance of 8 miles on a track to Mall and from there by metalled road to Sibi, a distance of 10 miles. In wet conditions, the track is impassable and in some years the village can be cut off for as long as 6 weeks. There is no motorable route from the command area to the headworks and access involves travelling back into Sibi and then out on the metalled road to Talli. The headworks site is situated approximately a mile downstream of the point where the road crosses the Chakar River.

FIGURE 1

LOCATION MAP



BALOCHISTAN MINOR IRRIGATION AND AGRICUTURAL DEVELOPMENT PROJECT

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CHANDIA FLOOD IRRIGATION SCHEME

LOCATION MAP

1.3 Overview

The sailaba or flood irrigation sector of agricultural production in Balochistan has suffered from inappropriate interventions and under investment for many years. In many areas of Balochistan, sailaba irrigation provides the only form of agricultural production. This system of farming is important for the production of cereals, oilseed and fodder The uncertainties involved in flood irrigation and the difficulties in collecting data on the hydrology and predicting the flood volumes and benefits from the schemes, have all proved to be problematic in the past.

In addition, improvements to the traditional form of diversion structures, which are a very flexible form of diversion, have been difficult to justify on the basis of the cost of replacing them with a complex engineering structure. The proposed design adopts the traditional gandha approach by retaining the breachable bund, but introduces a much improved headworks and a short weir. This will allow a more controlled use of the available flood water, whilst retaining the desirable safety features of the traditional system.

By improving the control of the flood waters through an improved offtake, and by retaining the traditional breachable bund of the gandha system, the scheme aims to reduce the uncertainties associated with the availability and periodicity of sailaba irrigated agriculture. Moreover, the flexibility of the traditional system is retained with an appropriate improvement in the level of technology used to control floods. The improved supply of water will lead to improved risk management strategies being adopted by the farmers in what is a relatively harsh environment.

2 CLIMATE AND LAND RESOURCES

2.1 Climate

The scheme lies on the eastern edge of the Kachhi Plain and the climate is characterised by very hot summers and warm winters. Rainfall is very low and erratic with an annual median of only 4.9 inches, of which slightly more than half occurs during the summer monsoon.

The nearest meterological station with sufficient data for determining reference crop evapotranspiration (ETo) using the Penman method is Sibi, which is 13 miles east and at a similar altitude. The mean monthly temperatures at Sibi range from 38°C in June to 13.8°C in January. The long term rainfall data for Sibi has been analyzed by Kidd et al[1] and the median, 80 and 20% exceedence rainfall is summarized below in Table 1.

TABLE 1 MONTHLY RAINFALL FOR 80%, 50% AND 20% EXCEEDENCE PROBABILITIES (mm)

Month	80%	Median	20%
Jan	0	5	22
Feb	0	6	26
Mar	0	5	21
Apr	0	2	9
May	0	0	7
Jun	0	0	13
Jul	3	22	60
Aug	0	11	45
Sept	0	0	15
Oct	0	0	0
Nov	0	0	0
Dec	0	0	12

[1] Kidd, Rees, Keatinge, Rehman, Samiullah and Raza Meteorological Data Analysis of Balochistan 1988

2.2 Land Resources

2.2.1 Topography

The scheme is located in an extensive piedmont plain extending from Pakistan's western mountain ranges towards the Indus valley. The topography around Chandia is typical of the Kachhi Plain, flat and featureless. However, within the command area the natural topography has been extensively modified by the construction of level basins surrounded by bunds and the excavation of channels to divert the flood waters into the basins. The land slopes in a south westerly direction, but the actual slopes are less than 1 in 1000. During rain, runoff generally occurs as sheet flow, except where the land has been modified and then the flow tends to be concentrated in natural or man-made channels. The command area lies at an altitude of approximately 500 feet.

2.2.2 Current Land Use Pattern

Most of the command area has been modified by the construction of flood bunds and the subsequent levelling of basins over a period of time. Where land is out of command or at the end of the system and where it remains uncultivated, the natural vegetation comprises plants adapted to arid conditions and are typified by Tamarix. Within the command area the land is used for extensive flood irrigation of sorghum, mung, wheat and oilseeds. In any particular year the respective cropped areas depends on the availability and timing of flood water for irrigation.

3 SOILS AND SUITABILITY

3.1 Physiography

The soils are formed in river piedmont alluvium with the sediments originating from the surrounding hills, which consist of limestone, shale and sandstone of the Sibi Formation. Within the piedmont plain three subunits were identified.

The Recent piedmont plain (219 acres) has a lower physiographic position and is subject to most seasonal flooding. Lithology of the deposits is silty or loamy. The Late Subrecent piedmont plain (1773 acres) occupies the highest position and the lithology of the deposits is fine silt. Much of this unit lies uncultivated due to lack of water. The Late Subrecent piedmont basin (143 acres) occupies a relatively lower position within the Late Subrecent piedmont plain and as a result it captures more floodwater, the unit has a clayey lithology.

3.2 Soil Survey Methods

The soil survey fieldwork was carried out in December 1992, 1/12 500 scale sheets served as the base maps. The soils were examined in auger holes to a depth of 1.5m. The augerings were made at intervals varying with the complexity of the soil pattern, however, the average observation density was one auger hole per 50 acres. Representative soil profiles were studied in detail and sampled for laboratory analyses in 1.5m deep pits with augering to at least 2m depth. The soils were differentiated following the FAO Guidelines for Soil Profile Description (1977) and the Soil Survey Manual (USDA Handbook 18), on such characteristics as texture, structure, thickness of horizons, calcareousness, permeability, drainage class etc. The pH of the soil was estimated by thymol blue, an indicator suited for pH values between 8 and 9. Colour notations were based on Munsell Soil Colour Charts. Infiltration rates were measured using the double ring method.

Twenty two soil samples were collected and analyzed in the Soil Survey of Pakistan laboratory at Lahore, the analyses included:

- texture: sand, silt and clay (hydrometer method),
- organic carbon (Walkley-Black),
- available phosphorous (Olsen),
- soluble cations: Ca, Mg, Na,
- soluble anions: CO_3, HCO_3, Cl, SO_4
- pH,
- electrical conductivity (ECe)
- exchangeable sodium percentage (ESP) estimated by nomogram from sodium absorption ratio (SAR),
- $CaCO_3$

Soluble ions, pH, ECe and SAR were determined using the soil saturation extract. Available water holding capacity (AWHC) was estimated using the soil texture[2] and were estimated to be: 8% for sands, 12% for sandy loam, 17% for loam, 19% for clay loam, 21% for silty clay and 23% for clay.

3.3 Description of Soil Mapping Units

Four mapping units were recognized in the Chandia scheme, as shown in Figure 2 and were tentatively correlated with soil series established by the Soil Survey of Pakistan (SSP). The mapping unit symbols are based on the SSP name with the soil series names in brackets behind the mapping unit symbols. Detailed descriptions of representative soil profiles and their analytical data are given in Annex A.1.

3.3.1 Mapping Unit Bo-1 (Bolan series)

Mapping unit Bo-1 lies in the northern apex of the scheme in the Recent piedmont plain and covers 219 acres (10% of the survey area). The soils are characterised by being very deep and well drained, the texture is silt loam to very fine sandy loam, with thin laminations of fine sandy loam or silty clay loam. The soils still show the original sedimentation stratification. Colours are brown, ranging between 10YR and 2.5Y 5/3, with patches of 7.5YR 5/4. The soils are non-saline and non-sodic, the permeability and infiltration rates are moderate (0.36 inch/hour) and AWHC is estimated at 19% (by volume) to a depth of 80 inches. These soils are intensively cropped with sorghum and pulses as the main kharif crops and wheat or oilseed as the main rabi crops.

3.3.2 Mapping Unit Lu-2 (Luni series)

Mapping unit Lu-2 occupies a large tract of land in the eastern part of the scheme and a smaller one in the western part. This unit is in the Late Subrecent piedmont plain and covers 830 acres (39% of the survey area). The soils are deep and well drained, texturally they are silt loam, approaching silty clay loam. Colours are brown, ranging between 10YR 5/3 and 4/3, with faint patches of 7.5YR hue. Soil structure is weak coarse and medium angular blocky with in-ped laminations. Fine salt specks are scattered in the profile. At some places the soils are slightly saline in the upper portion of the substratum, but non-saline below. Permeability is moderate to slow, infiltration rates are slow (0.12 inch/hour) and the AWHC is estimated at 19% to a depth of 80 inches. The unit has minor inclusions of other soils, for example river bed deposits. About half the area is not cultivated due to scarcity of water, with sorghum being the main crop during the kharif season.

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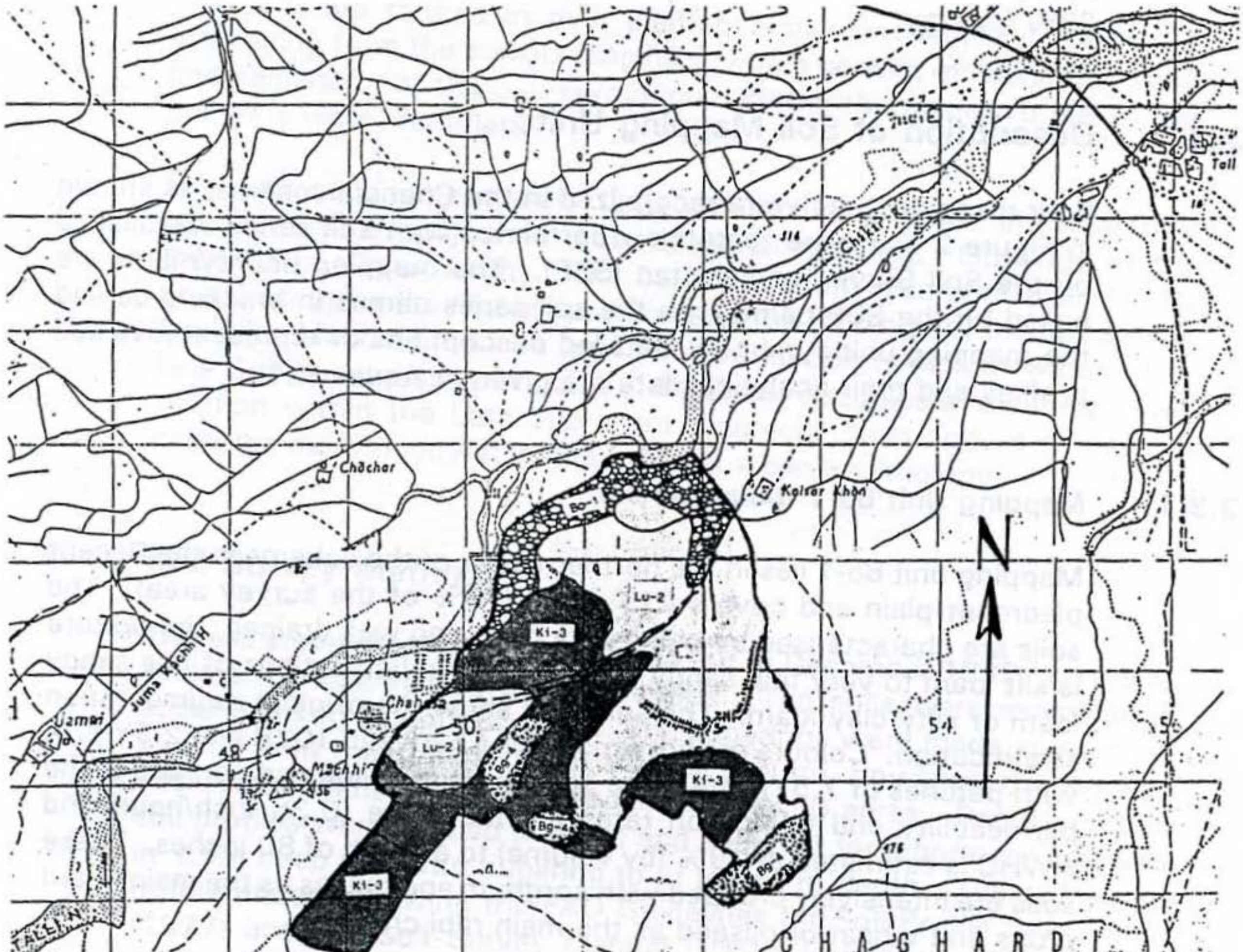
[2]Massoud F.I. Water Soil Plant Relationships 1979.

FIGURE 2

SOIL MAP OF CHANDIA COMMAND AREA



3.3.3 Mapping Unit Ki-3 (Kachhi series)

Mapping unit Ki-3 occupies a large stretch of land in the western half of the scheme and a small patch in the east. The unit is in the Late Subrecent piedmont plain and covers 943 acres (44% of the survey area). The soils are deep and generally well drained, but locally can be moderately well drained. The textures are silty clay loam and silty clay, and were more variable in the substratum, ranging from silt loam to silty clay. Soil structure is weak medium subangular blocky. Colours are brown (10YR 4-5/3), with or without faint to distinct specks of 7.5YR hue at places in the profile. In some places, the soils are slightly saline in the upper portion of the substratum, but non-saline below. Infiltration rates are slow (0.05 inch/hour) and AWHC is estimated at 20% to a depth of 80 inches. This mapping unit has about 15% inclusions of other soils, particularly the Bhag series. Only a small portion of this unit is not cultivated, with sorghum as the main kharif crop.

3.3.4 Mapping Unit Bg-4 (Bhag series)

Mapping unit Bg-4 occupies three small patches in the Late Subrecent piedmont basin and covers 143 acres (7% of the survey area). This series is characterised by soils which are deep and moderately well drained with a texture which is silty clay in the subsoil, but may approach silty clay loam above and below. Soil structure was found to be weak, fine to medium angular and subangular blocky. Colours are brown (10YR 4-5/3), with or without greyish brown (10YR 5/2) mottles indicating somewhat impeded drainage. Fine salt specks were found scattered in the profile. The substratum is slightly saline. Permeability and infiltration are slow (0.05 inch/hour) and AWHC is estimated at 20% to a depth of 80 inches. Crops found on this unit are sorghum and pulses during kharif, wheat and oilseeds during rabi season.

3.4 Soil Management Properties

3.4.1 Soil Fertility

All Chandia soils are very low in organic matter, hence also in nitrogen. Available phosphorous is similarly very low, also because the soils are strongly calcareous. Farm manure, nitrogen and phosphorous fertilizers would be expected to give a good response, provided water is sufficient. Irrigation water may give a modest supply of nutrients. Cations are in ample supply and potassium deficiency is therefore not expected.

3.4.2 Soil Water

All soils are at least 80 inches deep, medium or fine textured and virtually without coarse fragments. AWHC are therefore high (about 20%). However, in the heavier textured Kachhi and Bagh soils, this water may be released more slowly which may cause draught stress when plant water demand is high, and available water values are near wilting point. The Kachhi and Bagh soils have somewhat impeded drainage mainly due to slow permeability and the Bhag series are also prone to ponding. Ploughing to break up silt pans prior to irrigation will improve infiltration rates.

3.4.3 Soil Salinity and Sodicity

The soils show no surface salinity or sodicity, but Bg-4 and Ki-3 soils, and to a lesser extent also Lu-2 soils are slightly saline in the subsoil, which is probably related to their slow permeability. Below the slightly saline layers textures, however, are somewhat coarser allowing leaching of salts.

3.5 Land Capability Classification

In the land capability classification as applied by SSP, 49% of the land (Bolan and Luni series) is considered as very good agricultural land (Class ir I), provided the land is irrigated and properly fertilized.

The remaining 51% of the land (Kachhi and Bhag series) is considered as good agricultural land (Class ir IIs), with slight limitations by slow permeability, workability and salinity. The suffix 's' stands for limitations posed by soil properties.

3.6 Crop Suitability Ratings

Soil suitability evaluations were conducted for the main field crops sorghum (grain and fodder), mung beans, wheat and oil seeds under the present land utilization type and irrigation system.

The land utilization is characterised by the growing of fodder sorghum, with water being the limiting factor. It should be noted that in Chandia sorghum and pulses commonly receive only one flood irrigation, in the kharif period. Wheat and oil seeds (rape seed and mustard) are grown on residual kharif water and may receive additional water from spring floods. Soil and crop suitability ratings take these severe irrigation regimes into account. Besides irrigation water quantity, water quality is important for crop performance.

With the current practice of only one irrigation per crop and very little additional rainfall, yields of field crops in Chandia are below optimal. This is confirmed by the average yields in Chandia which are low, but within the ranges (0.5 to 1.2 tons of wheat per hectare) commonly encountered in Kachhi plain. Under such a severe irrigation regime, crop performance largely depends on the availability of soil water. This again depends on the AWHC of the soils and the rooting volume of the crops. Rooting volume depends on the maximum rooting depth a crop can attain, which depends on crop type and soil characteristics and plant density. Normal maximum rooting depths cited, Landon[3], are 80 inch for sorghum and wheat. For mung beans and oilseed no figures were found but depths are probably over 60 inch. However, the possibility that the crops manage to develop even deeper root systems under the extreme Chandia conditions should not be excluded. Plant densities are low, but are possibly optimal for the Chandia conditions.

In general, Chandia soils are all very deep (well over 100 inch) with a high AWHC of about 20 percent of volume. The heavier textured Kachhi and Bhag soils are somewhat more difficult for roots to penetrate than Bolan and Luni, but the soil profiles examined, all show very deep root penetration and sufficient porosity.

Apart from the limitation posed by the single flood water application and the earlier mentioned deficiencies in nitrogen and phosphorous, the salinity in some of the Chandia soils reduces the range of crops which could be grown and probably depresses the yields of the existing crops.

In an optimal fulfilment of all other crop requirements and taking the maximum salinity to 80 inch depth, the following yield reductions could be expected by soil salinity alone and is shown in Table 2.

TABLE 2 YIELD REDUCTIONS DUE TO SALINITY

Soil Series	Sorghum	Mung Beans	Wheat	Oilseed
Bolan	0-10%	25-50%	0%	0%
Luni	25-50%	>50%	10%	10%
Kachhi	25-50%	>50%	10%	10%
Bhag	25-50%	>50%	10-25%	10-25%

It should be noted that for sorghum as a fodder crop, salinity and water stress are probably less crucial than for grain production. In addition, it is difficult to predict what the exact reduction in crop yields is by water stress and salinity combined.

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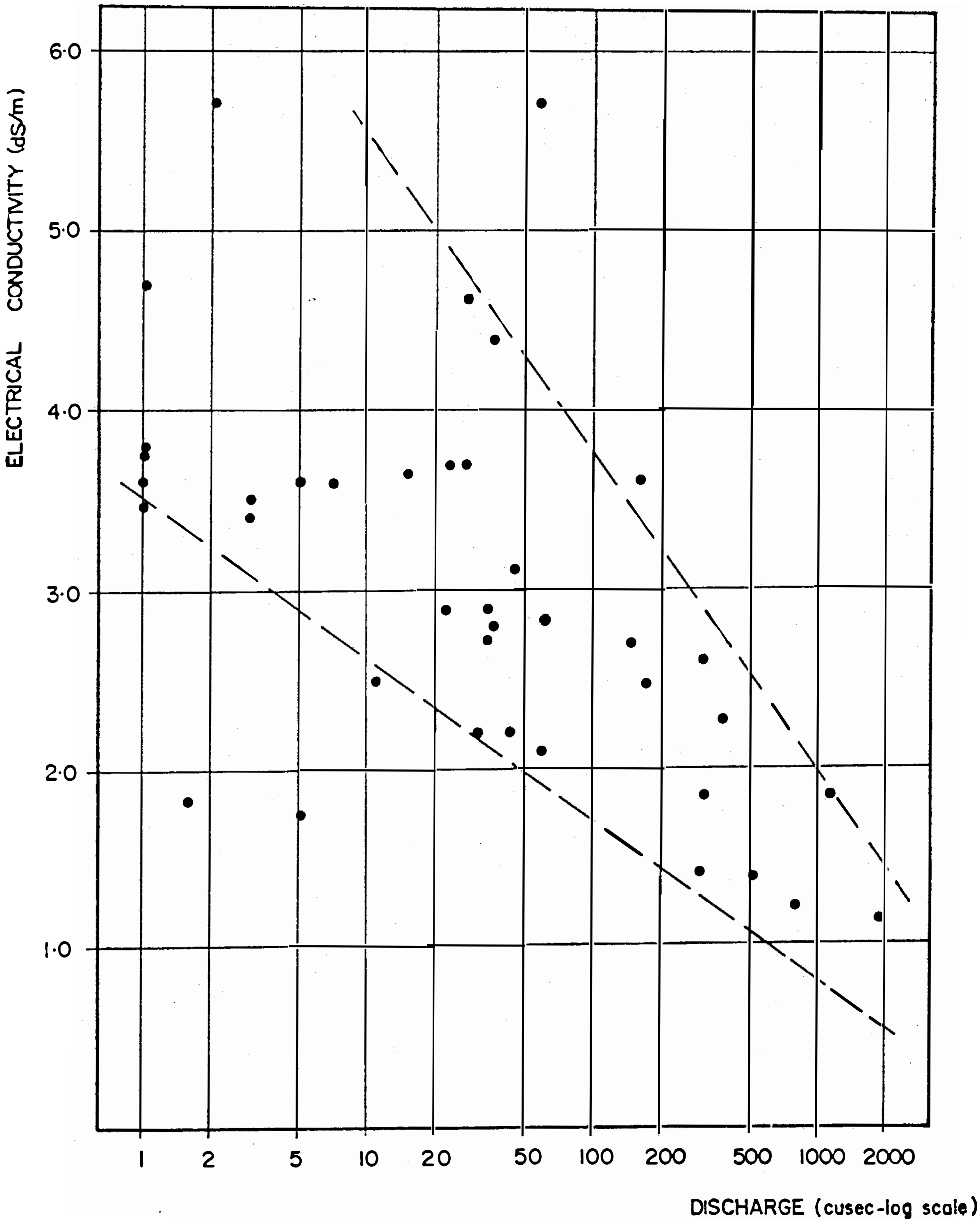
[3]Landon J. R. (ed) Booker Tropical Soil Manual 1991.

In Chandia irrigation water from the river is expected to have ECw values between 1 and 2 dS/m as shown in Figure 3, and these values indicate salinity levels that are more favourable for crop performance than those in the soils. At least 10% of this irrigation water, however, should be allowed for deep percolation to avoid salinity build-up in the soils. A water sample from a shallow well gave an ECw value of 2.4 dS/m, indicating moderate salinity ground water, and that the salts are being leached downwards under current practices. Other tests show less limitation for use of the water for irrigation.

FIGURE 3

ELECTRICAL CONDUCTIVITY VS DISCHARGE IN CHAKAR RIVER



BMIADP PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
ELECTRICAL CONDUCTIVITY AGAINST DISCHARGE
IN CHAKAR RIVER
(Ref WAPDA—River and Climatological Data Annual Reports)

4 WATER RESOURCES

4.1 Overview

Water resources assessment is a key input to both the engineering design and the economic appraisal of the flood irrigation scheme. Flood magnitudes and durations influence the design capacity of headworks structures. The reliability of a proposed scheme is a function of the distribution of flood magnitudes and the design capacity. Flood volumes and the seasonal distribution of flood delivery determine the potential for irrigation and hence the benefits of the scheme. In this section, the assessment of the water resources of the Chandia flood irrigation scheme is described and discussed.

The water balance of the Chakar River basin, which includes the Chandia flood irrigation scheme, is complex. In particular, the precise interaction between river flow, over-bank flow and ground water is unknown and likely to vary seasonally. Daily mean runoff data and annual maxima are available for only seven years for a site on the Chakar, together with a longer period of rainfall data for sites close to, but not within the Chakar catchment.

A flood generation model of the Chakar mountain catchment has been developed, calibrated and used to generate a 30 year synthetic time series of flood hydrographs for the Chakar River at the boundary of its mountain catchment, thus extending the short runoff data record for the site.

A water balance simulation model of the Chakar River flood plain has been created to represent the behaviour of flows in the Chakar between the mountain catchment boundary and the proposed diversion site. It uses as input data the 30 year synthetic time series of flood flows generated by the catchment model.

The calibrated flood plain model has been used to evaluate the diversion performance of alternative designs for the headworks of the Chandia scheme and thus assist in the screening of potential arrangements for further economic analysis.

An analysis of expected diversion flow availability at the headworks has been undertaken using the flood plain model with the 30 year synthetic time series of Chakar River flows. Two options for the improvement of the Chandia Flood Irrigation Scheme were considered, together with the existing situation.

4.2 Methodology

There are insufficient reliable rainfall and runoff data related to the Chakar River to enable an acceptable, direct data-driven analysis of water resources to be made. However, there is a considerable amount of rainfall and runoff data related to other river catchments in Balochistan. It has been possible to regionalize the runoff characteristics of these 18 rivers in terms of parameters in a truncated Fourier Series. This process will be described in detail in the BMIADP Flood Irrigation Manual, but is summarized in Annex B.1.

Use of the regionalization scheme offers two principal advantages over a direct data driven analysis, as follows:

(a) For ungauged rivers, the runoff characteristics of all adjacent rivers in the same region can be accounted for in estimating the runoff regime of the ungauged catchment.

(b) Where gauged rivers have poor or sparse data, the regionalized runoff scheme can be used to extend and rationalize the gauged data.

Therefore, the quantitative assessment of the water resources of the Chakar River has been based on the generation, calibration and analysis of a synthetic time series of hydrographs using a regional Fourier Series model.

An important feature of this process is the calibration of the models used in the assessment. Historical data, local observations, the experience of local farmers and the work of other consultants have been reviewed and accounted for in calibrating the results predicted at intermediate stages of the water resources analysis. Consequently, it has been possible to maximize the quality of the analysis by calibrating the predictions of models against estimated distributions of data, obtained by pooling the above information, rather than single unsubstantiated statistics.

The data used in the preparation and calibration of mathematical models of the Chakar system have been obtained through a comprehensive programme of:

- interviews with farmers, to establish cropped areas in previous years and high flood levels in the vicinity of the headworks;
- transect survey work, to establish the cropped area in the current year;

- detailed topographic surveys, to establish the levels and extent of the existing command area and of the river and canal; and

- sediment and soil surveys.

The assessment of Chakar River water resources has been carried out in four phases, the interrelationship of which is illustrated by Figure 4.

Chakar River Catchment Simulation

In the first phase, a catchment runoff model was developed and used to generate a synthetic time series of flood hydrographs for the Chakar River at the mountain catchment boundary. The flood magnitudes, volumes and delivery predicted by this model were calibrated against historical rainfall and runoff data and estimates of runoff.

Chakar River Flood Plain Simulation

In the second phase, a flood plain model was used to simulate the water balance and flood attenuation of the Chakar River between the mountain catchment boundary and the Chandia headworks site. The flood magnitudes, volumes and delivery predicted by this model were calibrated against local information.

Design of Chandia Headworks

In the third phase, a diversion model was used with the generated flood time series data at the Chandia headworks site to determine the optimum configuration for the headworks and to predict the reliability of the headworks.

Chandia Yield Analysis

In the fourth phase, the diversion model was used to estimate the volumetric yield associated with two options for improving the Chandia scheme, together with the existing without project situation.

4.3 Characteristics of the Chakar River Basin

The Chakar River emerges from a mountain catchment on the north-eastern edge of the Kachhi Plain. The area is illustrated in Figure 5.

FIGURE 4

PHASES IN ASSESSMENT OF WATER RESOURCES

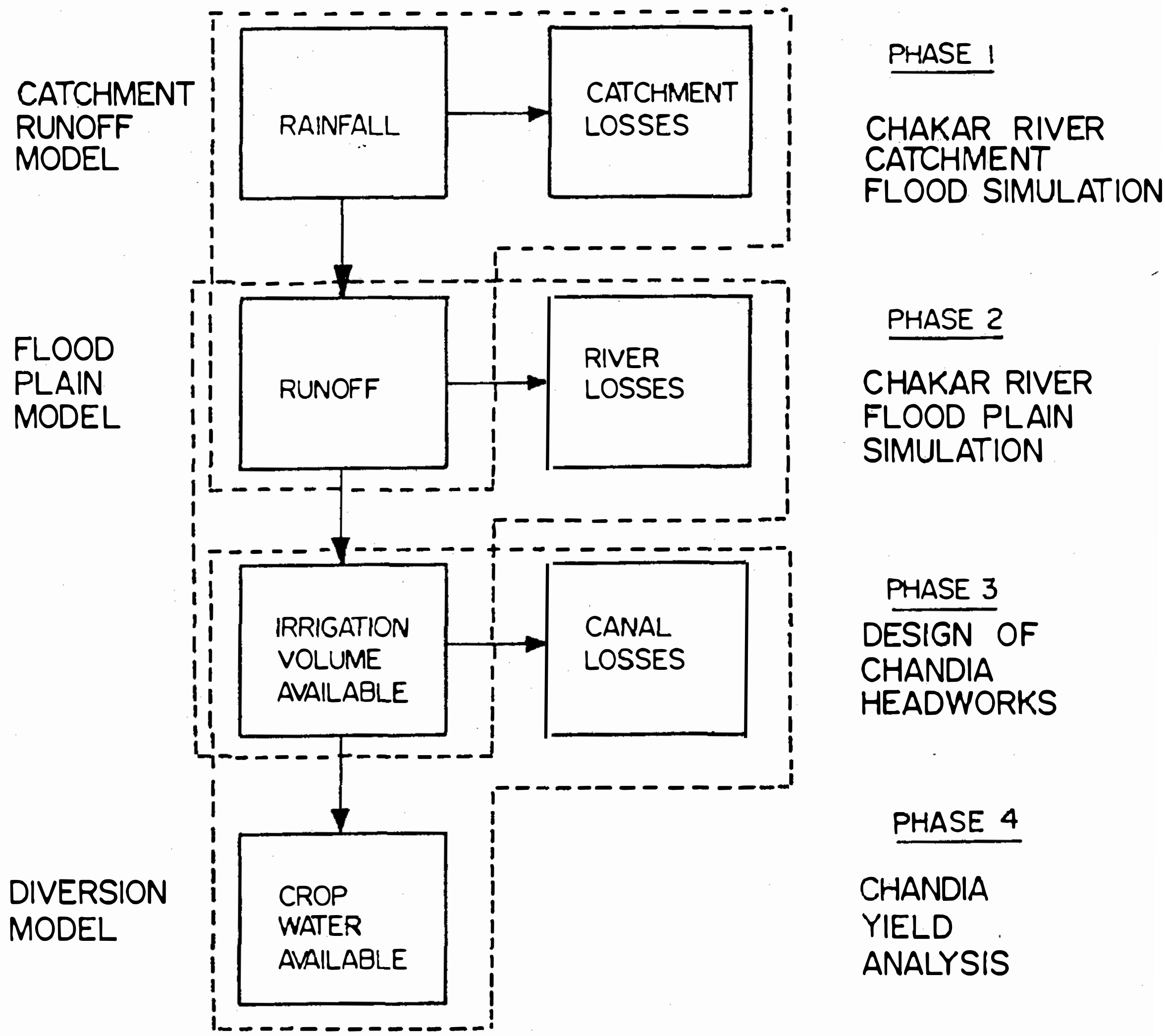
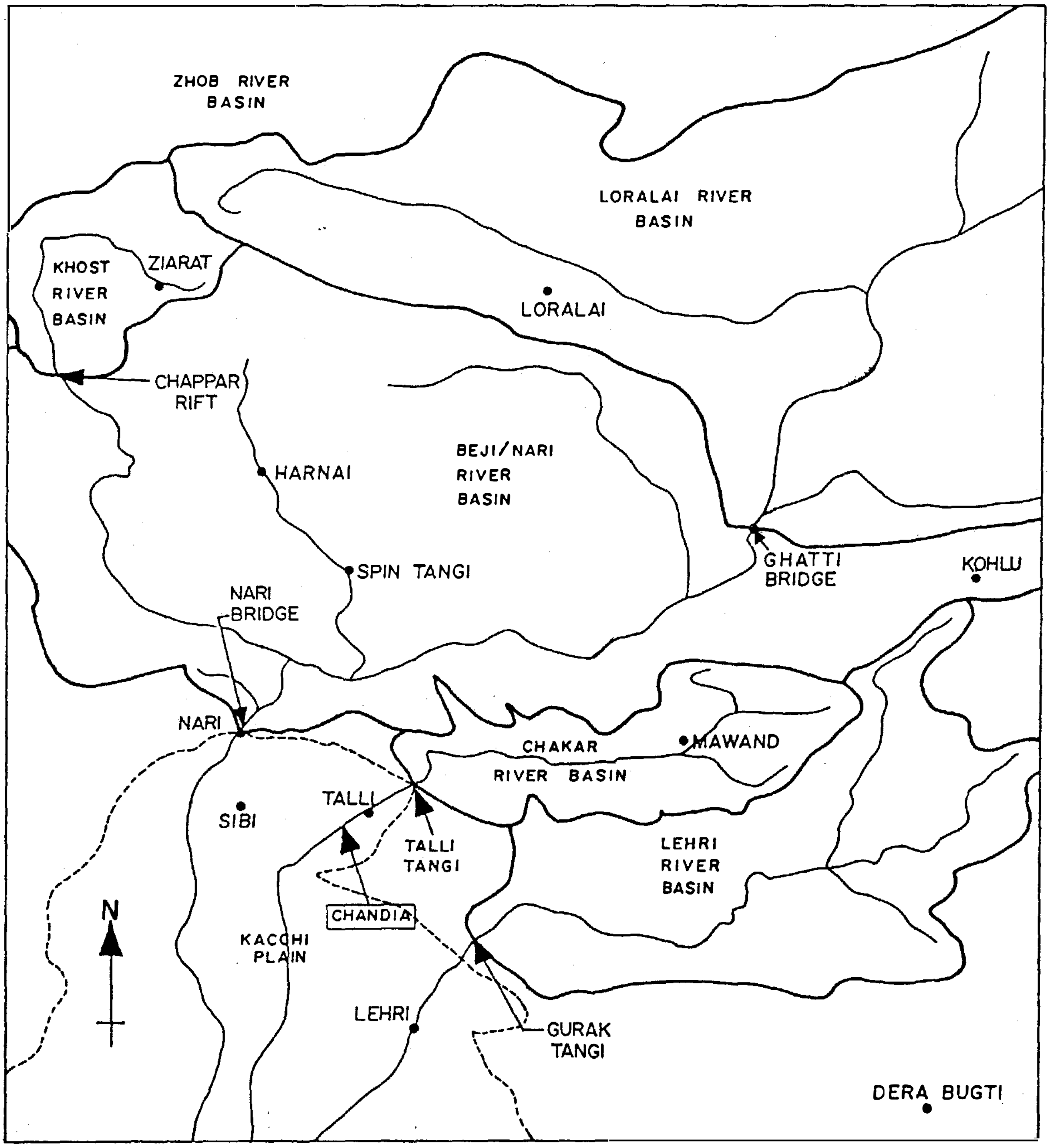


FIGURE 5

CATCHMENT LOCATION MAP



Scale 1 : 1,000,000

4.3.1 Catchment

The catchment of the Chakar River runs roughly east to west from Kohlu to Talli Tangi before joining the extensive Kachhi Plain river system. It lies between the Beji River basin to the north and the Lehri River basin to the south.

The measured and calculated characteristics of the Chakar River catchment are summarized in Table 3.

TABLE 3 CHAKAR RIVER CATCHMENT CHARACTERISTICS

CATCHMENT CHARACTERISTIC	VALUE
Mountain catchment area	570 sq miles (1480 sq km)
Proportion of area:	
mountain	70%
alluvial	28%
valley	2%
Fall	3720 ft (1130 m)
Length	53 miles (85 km)
Time of concentration	10.7 hrs

4.3.2 Rainfall

Rainfall in the Chakar catchment is dominated by summer monsoonal incursions which arrive from the south east. Winter rains are unreliable, and are thought to originate in the highlands of northern Afghanistan and Pakistan.

There are no rain gauges in the Chakar catchment. Rain gauges adjacent to the catchment are listed in Table 4, together with the periods for which daily rainfall data have been made available by the Pakistan Meteorological Department (PMD) and WAPDA's Surface Water Hydrology Project (SWHP). Some of the data are of doubtful quality.

TABLE 4 RAINFALL DATA AVAILABILITY

RAIN GAUGE	DATA SOURCE	DATA PERIOD
Talli	SWHP	1962-1966 1988-1991
Ghatti Bridge	SWHP	1962-1967 1988-1991
Kohlu	PMD SWHP	1911-1946 1962-1964 1967-1971 1973-1974
Spin Tangi	PMD SWHP	1891-1946 1964-1986 1988-1991
Lehri	PMD SWHP	1923-1946 1965-1970 1988-1991

Figures 6 (a) and 6 (b) show the seasonal distributions of average rainfall depths over the catchment at Kohlu and at Ghatti Bridge respectively. These stations, some 25 miles (40km) apart and in the same orographic region, show almost identical seasonal delivery characteristics, with a small difference between the seasonal volumes.

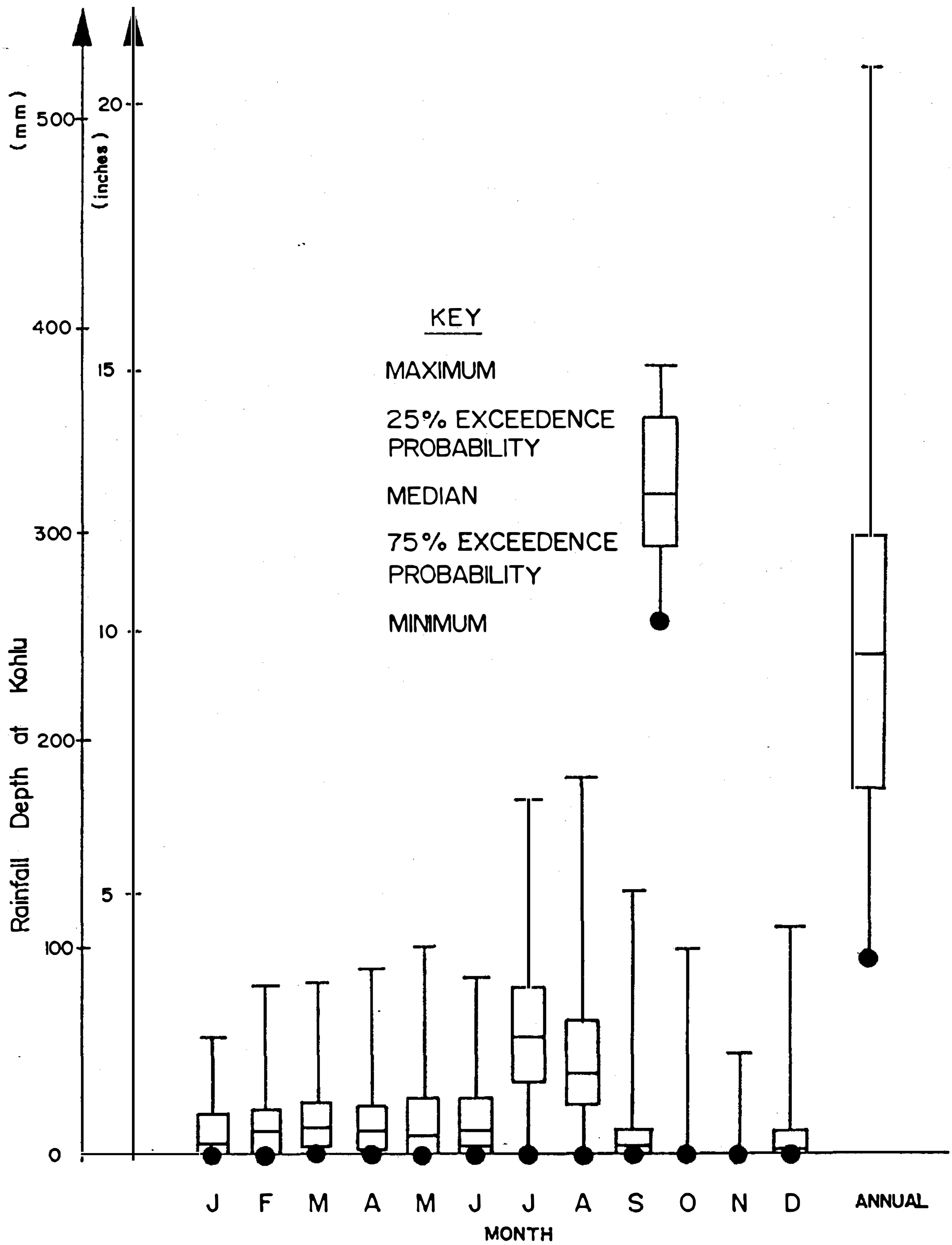
4.3.3 Runoff

Runoff at Talli Tangi is highly ephemeral. Seven years of daily average flow records for Talli Tangi have been processed and published by SWHP for the period 1961 to 1968, but excludes 1966. The data are of reasonable quality, although relatively few stage-discharge measurements were made in this period. In addition, the annual maximum discharge has been published for each of the seven years. It has not been possible to obtain the original gauge records nor the rating curves for the site, which would have enabled a time series of peak flows to be derived.

Several other rivers in the region have also been gauged by SWHP. Those which exhibit a similar delivery characteristic to the Chakar River are listed in Table 5. The assessment of hydrological similarity has been made as part of the development of the catchment runoff generation software. The details of this assessment will be described in detail in the BMIADP Flood Irrigation Manual. A summary of the process is included in Annex B.1.

FIGURE 6 (a)

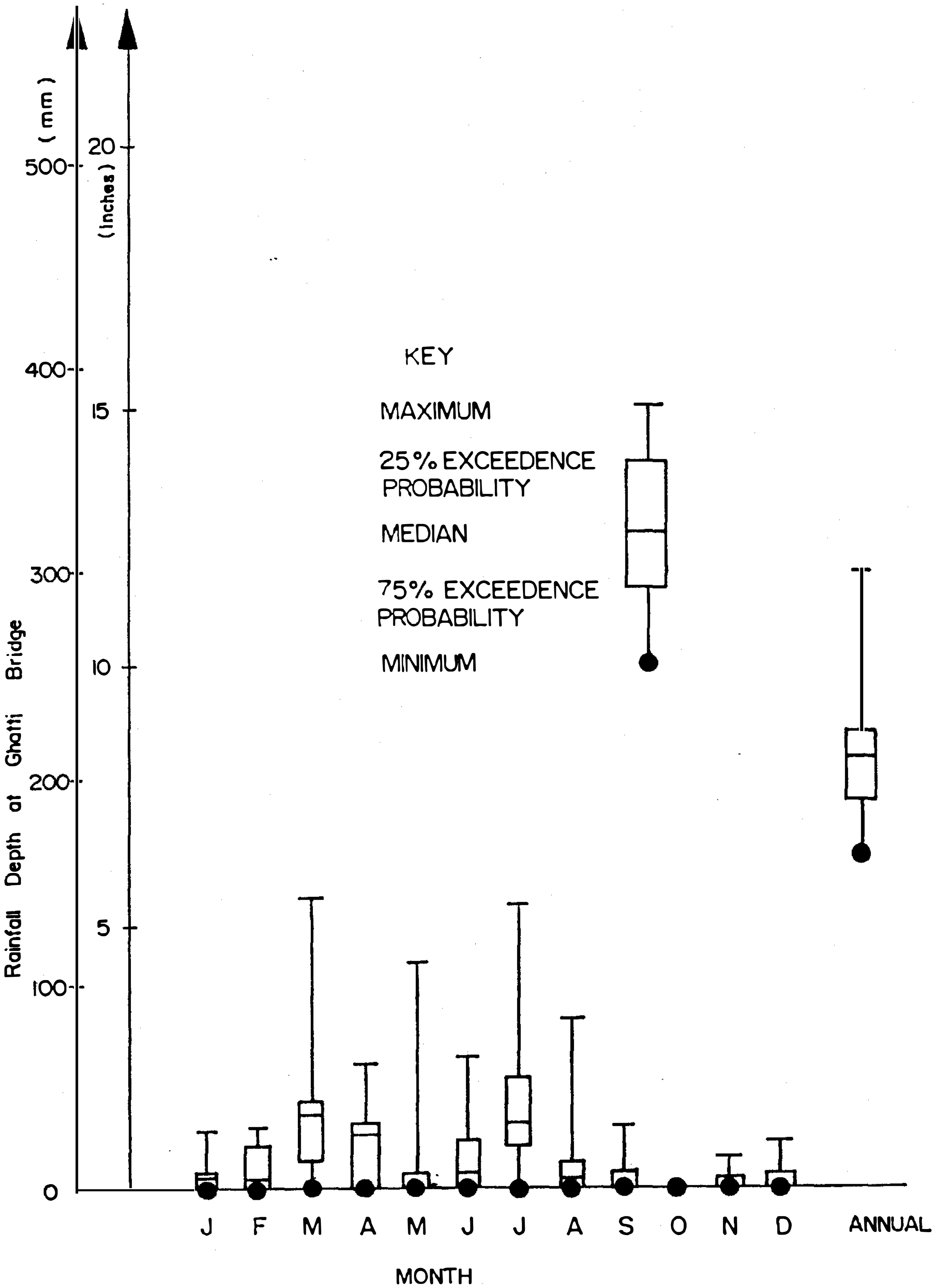
RECORDED SEASONAL DISTRIBUTION OF RAINFALL AT KOHLU



NOTE: Analysis based on 41 year of data.

FIGURE 6 (b)

RECORDED SEASONAL DISTRIBUTION OF RAINFALL AT GHATTI BRIDGE



NOTE: Analysis based on 8 years of data.

TABLE 5 REGIONAL RUNOFF DATA AVAILABILITY

RUNOFF GAUGE	DATA PERIOD
Chakar at Talli Tangi	1961-1965 1967-1968
Lehri at Gurak Tangi	1963-1965
Beji at Ghatti Bridge	1961-1967 1987-1988
Khost at Chappar Rift	1961-1982 1986-1988
Nari at Nari Bridge	1961-1971 1987
Zhob at Sharik Weir	1976-1988

Runoff hydrographs for all magnitudes of flood events tend to rise far more rapidly than would be expected from the calculated time of concentration of the catchment (see Table 3). This may be due to the angle at which the catchment lies to the summer monsoons. The upper part of the catchment is effectively protected from the full monsoon activity by a series of mountain ranges, whilst the lower part of the catchment is directly exposed to the Kachhi Plain. This is likely to result in rain falling predominately in the lower catchment, causing runoff to build up more rapidly than would be predicted by normally accepted formulae (see Annex B.2).

4.3.4 The Flood Plain

The Chakar River flood plain is effectively unbounded in its upper reaches, being wide and gently sloping down from east to west following a short, steep section close to Talli Tangi.

The river channel has shifted by up to 1600 feet (500m) in the 35 years since the Survey of Pakistan maps of the area were last updated. It has moved closer to Talli and has reduced the area of cultivatable land on the left bank. The proposed road bridge to Talli and its associated bank protection works will fix the position of the river in this area, thus minimising future movements of the river in the Chandia area.

4.3.5 Existing Irrigation

Between Talli Tangi and the site of the Chandia Wah headworks, a distance of 8.5 miles (13.6 km), there are five other identifiable offtakes. These irrigation offtakes are detailed in Table 6. The canal capacities have been estimated from local survey information.

TABLE 6 IRRIGATION OFFTAKES FROM THE CHAKAR RIVER

OFFTAKE	DISTANCE FROM TALLI TANGI miles (km)	TYPE OF OFFTAKE	CANAL CAPACITY [cusec(cumec)]
Bala	0.6 (1.0)	chab	n/a
Shewarhi	0.7 (1.2)	chab	n/a
Saafi	0.9 (1.5)	chab	n/a
Sultan Kot	3.7 (6.0)	gandha	530 (15)
Kaisar	6.0 (9.7)	gandha	3880 (110)
Chandia	8.5 (13.6)	gandha	880 (25)

The capacities of the three gandha offtakes detailed above are not proportional to the land holdings of associated villages. Thus, although the Kaisar scheme would appear to dominate the Chakar irrigation system, the flows taken off here are limited by the modest size of the Kaisar area. The influence of the upstream offtakes on the water availability at Chandia is discussed in Section 4.6.

4.3.6 Local Flood Flow Characteristics

Limited information concerning the characteristics of floods at the site of the Chandia headworks has been obtained by local survey. Local estimates of flood levels, have been used to calibrate the flood plain routing model.

Estimates of areas irrigated by the Chandia Wah, provided by local farmers and by transect survey of the command area, have been used to calibrate the volume delivery predicted by the model. The farmers' estimates are likely to be biased by experience of recent exceptionally good years. However, in detailed interviews information was obtained concerning the occurrence of good, bad and indifferent years. This information has been accounted for in the calibration of the flood plain model.

The gandha located at the head of the Chandia Wah has not been required for the diversion of flows in the last two years due to the advantageous position of the low flow channel of the Chakar River at this point. Since it has not been possible to observe the failure mechanism, the behaviour of the existing headworks has had to be assumed. Nevertheless, this element of the model has been carefully considered since it is a key factor in determining the volume of water available in the Chandia Wah. This is discussed further in Section 4.6.

4.4 Preliminary Studies

The following preliminary studies were carried out in order to improve understanding of the behaviour of the Chakar catchment and to check the validity of the rainfall and runoff data:

(a) rainfall-runoff correlation, using contemporary data;

(b) flood estimation using the BMIADP Flood Estimation Manual;

(c) unit hydrograph analysis; and

(d) a review of hydrological studies involving the Chakar River by other consultants (notably Lahmeyer[4]).

4.4.1 Rainfall-Runoff Correlation

Rainfall-runoff correlation proved to be inconclusive using the limited period of contemporary data for rainfall stations local to the Chakar catchment. Annex B.2 describes the analysis.

Of those rainfall stations identified in Table 4, the volume distribution and delivery recorded at Ghatti Bridge between 1962 and 1967 gave the best correlation with the contemporary runoff at Talli Tangi. However, the correlation coefficient in both summer and winter was only 0.44.

Thus, it has not been possible to estimate real-time runoff for the Chakar River catchment from local rainfall records, nor to use this technique to validate estimates of runoff produced by other means.

The poor correlation between rainfall and runoff can be explained by:

- the complexity of rainfall patterns in the mountainous areas bordering the Kachhi Plain;
- the spatial separation of gauges; and
- the dubious quality of some of the data.

4.4.2 Flood Estimation

Peak flow data for the Chakar River at Talli Tangi are only available as annual maxima for the period 1961 to 1968. Independent estimates of flood magnitude were obtained in order to validate this data for use in calibrating the catchment runoff model.

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[4]Lahmeyer International Consulting Engineers: Talli Flood Irrigation Project, Water Resources Appendix B 1989.

The BMIADP Flood Estimation Manual was used to provide an estimate of the magnitudes of floods of high return period. These estimates have been used in the calibration of the flood generation model (see Section 4.5.2).

Several other organizations have studied the hydrology of the Chakar catchment. Lahmeyer Consultants estimated the flood flows in the Chakar River as part of their study for the proposed Talli diversion weir, since abandoned. Their estimate has also been used in the calibration of the flood generation model (see Section 4.5.2).

4.5 Chakar River Flood Simulation

A software suite has been developed by the Technical Assistance (TA) Team for the estimation of ephemeral flows in gauged and ungauged catchments. The design of this facility will be described in detail in the BMIADP Flood Irrigation Manual, but is summarized in Annex B.1. Figure 7 illustrates the procedure used to model the behaviour of spate catchments.

The software has been used to extend the period of data for the Chakar River from 7 to 30 years. The Chakar River flood generation model uses original runoff and rainfall data from a number of rivers in the region to define a formal statistical representation of the phase and amplitude of the runoff process. By using the extended data base provided by these similar rivers, it is possible to overcome the problems caused by the short period of runoff data for the Chakar River itself. The Chakar River lies in Region 1 of the flood generation regionalization scheme, described in Annex B.1.

4.5.1 Calibration of the Catchment Runoff Model

In using the flood generation software to define a statistical model of the Chakar River runoff, some facets of the model are assumed whilst others are adjusted as part of the calibration process. The assumptions made in the catchment model will be described in detail in the BMIADP Flood Irrigation Manual, but are summarized in Annex B.1. The assumptions which have been made in the definition of the flood generation software have been tested very carefully to ensure that they do not restrict the use of the software unduly whilst enabling robust analyses of flood flows to be undertaken.

The 30 year synthetic time series of flood hydrographs has been calibrated against:

(a) the flow delivery distribution suggested by historical runoff and catchment rainfall records;

(b) the seasonal distribution of flood volumes derived from historical runoff data; and

(c) the distribution of flood magnitudes derived from historical runoff data and other studies of the Chakar River basin.

Table 7 summarizes the principal assumptions and calibrated parameters of the catchment runoff model.

TABLE 7 CALIBRATED CATCHMENT RUNOFF MODEL PARAMETERS

ASSUMED FACET	CALIBRATED PARAMETER	CALIBRATED VALUE
Hydrograph shape	Time to peak	1 hour
	Time to recede	4 hours
	Base flow recession time	4 hours
	Base flow	zero
Hydrograph peak truncation at 260000 cusec (7500 cumec)	Coeff of variation of peaks	2.00
Regional phase definition	Region 1C assumed	
Local amplitude definition	Values in Table 3 assumed Variation in rainfall within Region 1 accounted for	

In generating runoff data for the Chakar River at Talli Tangi, regional data for Region 1 of the flood generation scheme were used to define the phase of flood events, whilst data for the Chakar River catchment were used to scale the magnitude of events. The Chakar-specific data included rainfall at Kohlu and Ghatti Bridge. These data were compared with those for reference rainfall stations related to other gauged rivers in Region 1 and used along with ratios of catchment area to establish scaling factors for flood magnitudes.

The approximate shape of the flood hydrographs in the Chakar River was calculated using unit hydrograph theory. A small proportional adjustment to the estimated time to peak, time to recede and base flow recession constants was allowed during the calibration process. The resulting hydrograph shape is illustrated in Figure 8.

The model scales generated flood peaks to preserve the correct distribution of volumes, defined by the Chakar River data. Excessively large flood peaks are truncated to ensure that these very rare maxima do not distort the predictions of the runoff model. The level of truncation is arbitrary.

The flood generation software ensures that the volumes of generated hydrographs equate with those of the original data. Thus, calibration of the model is a process of matching the distribution of event magnitudes to the original data, whilst confirming that the generated volumes and delivery are accurate.

Table 8 presents details of the quality of the calibration of the catchment runoff model.

Figures 9 (a) and 9 (b) display the observed and modelled distributions of flow volume and magnitude at Talli Tangi respectively.

4.5.2 Comments on the Catchment Runoff Model

The quality of the calibration of the catchment runoff model, summarized in the above statistics, is good. Specific points are raised as follows:

(a) Figure 9(a) demonstrates that the bimodal distribution of flow delivery, reflecting kharif and rabi season rainfall and runoff, is modelled accurately.

(b) The means and medians of seasonal and annual flow volumes are also accurately modelled, as shown by Figure 9(a). However, the maximum predicted flood volumes considerably exceed the recorded values at Talli Tangi. This is a result of the greater length of time series generated by the model (30 years) and used to produce the calibration statistics. The maxima for the observed data are approximately 1 in 7 year events, whilst those for the generated series are approximately 1 in 30 year events.

(c) The distribution of flood magnitudes is reasonably closely modelled, as displayed by Figure 9(b). The calibration, of modelled flood peaks against observed and estimated data, appears to become less accurate for floods of high return period. This can be explained by:

- the approximate nature of calculation of magnitudes of the historical floods, local observations and estimated data; and

- approximations and distortions introduced by the flood generation process, such as the arbitrary truncation of extremely large flood peaks.

FIGURE 7

CATCHMENT RUNOFF MODELLING

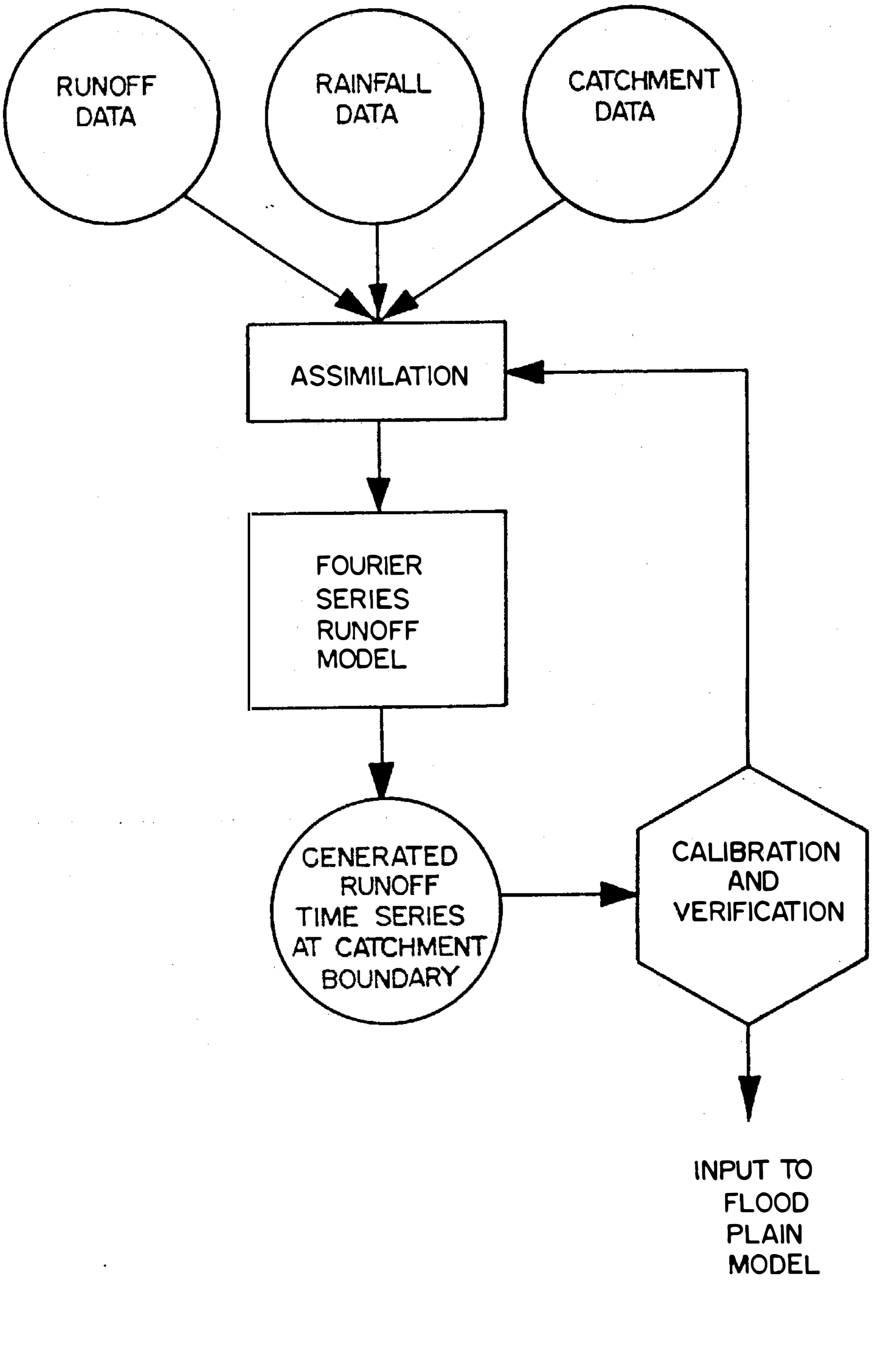


FIGURE 8

SAMPLE OF GENERATED RUNOFF TIME SERIES FOR CHAKAR RIVER AT TALLI TANGI

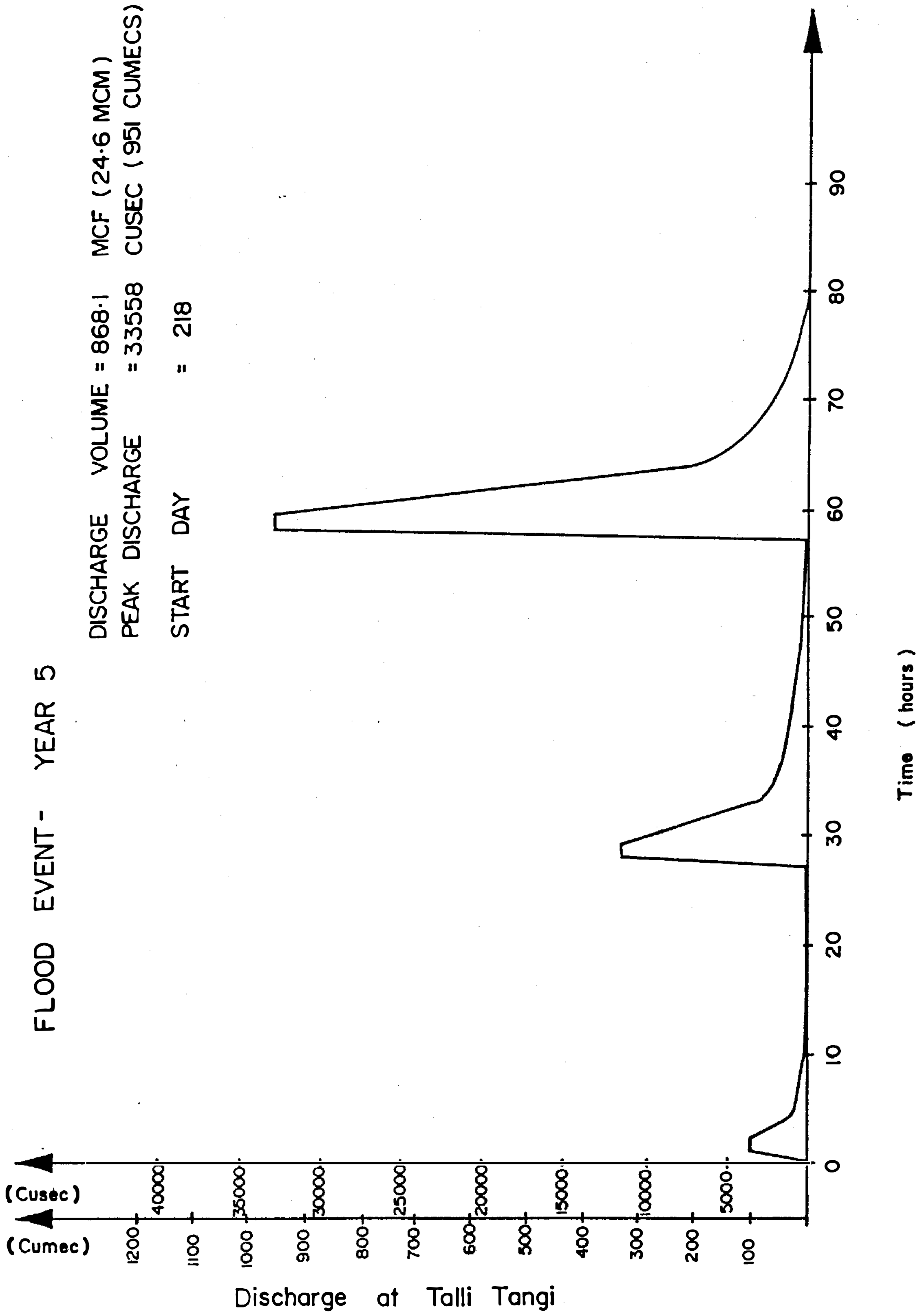


FIGURE 9 (a)

ESTIMATED vs MODELLED DISTRIBUTION OF RUNOFF VOLUME AT TALLI TANGI

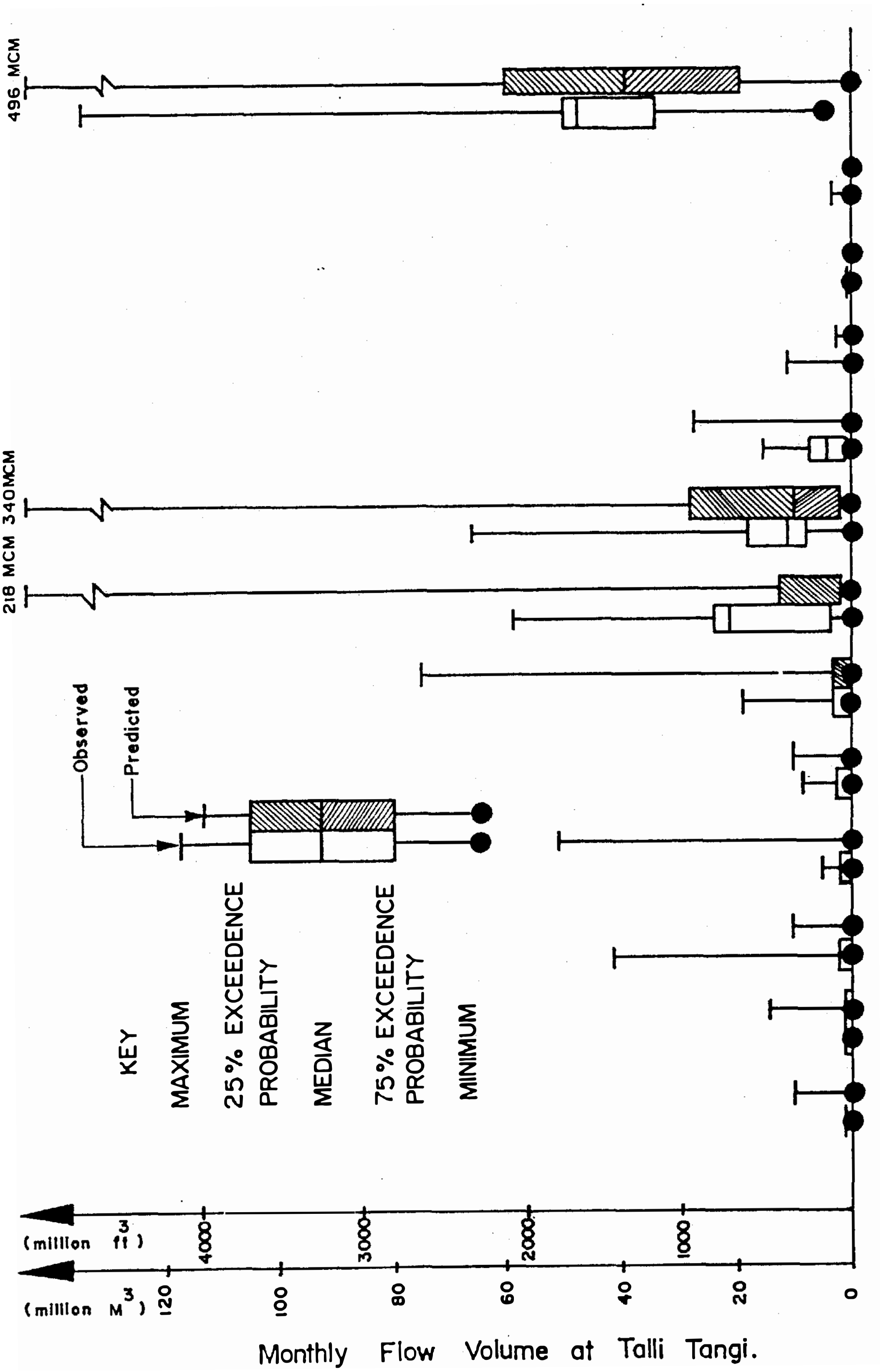


FIGURE 9 (b)

ESTIMATED vs MODELLED DISTRIBUTION OF FLOOD MAGNITUDES AT TALLI TANGI

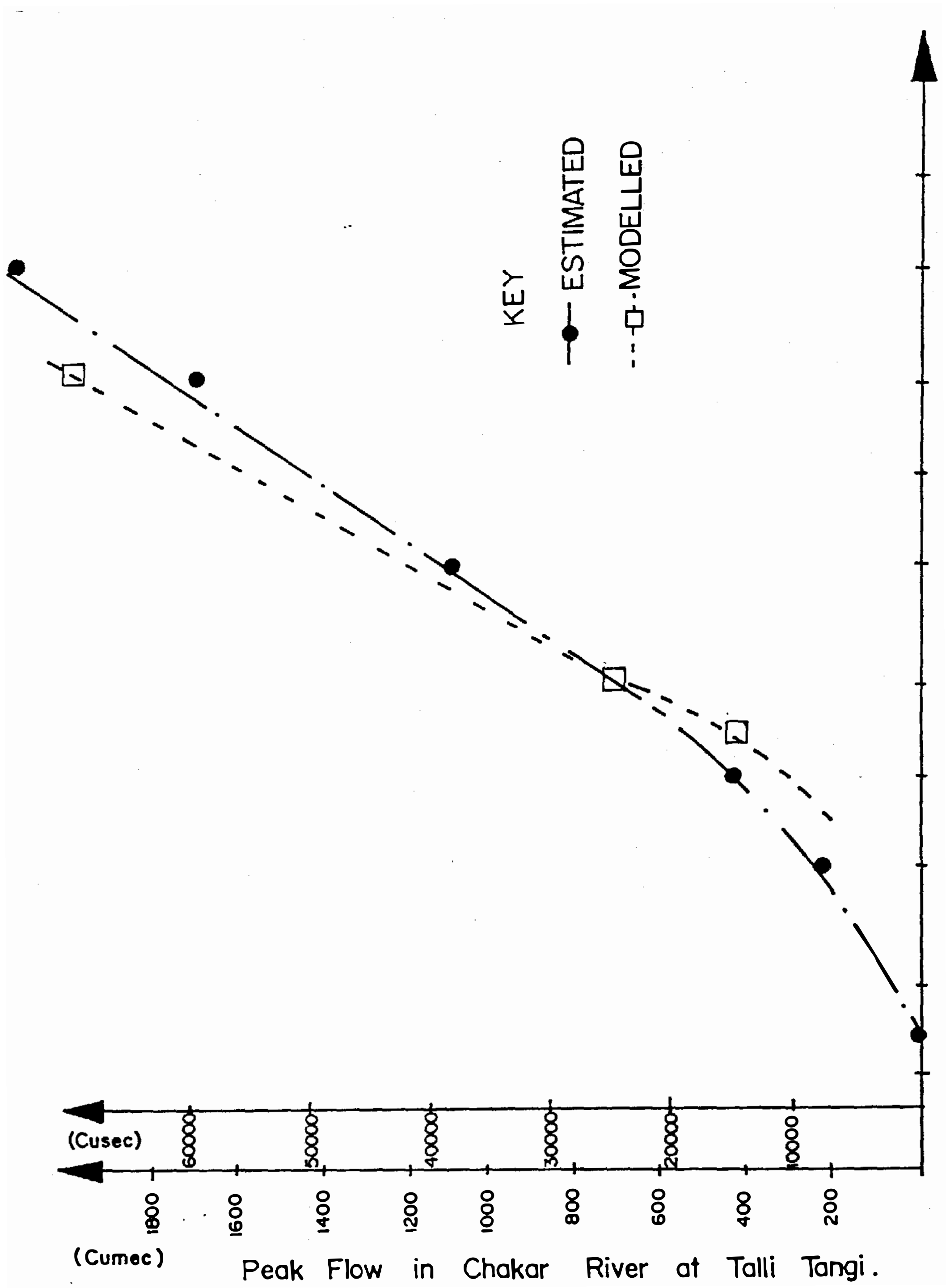


TABLE 8 CALIBRATION OF CHAKAR FLOOD GENERATION MODEL

STATISTIC	VALUE AT TALLI TANGI	
	OBSERVED	MODELLED
DELIVERY		
month with max delivery	JUL/AUG	JUL/AUG
month with min delivery	NOV/DEC/JAN	OCT/NOV/DEC
FLOOD VOLUMES	Mcf (Mcm)	Mcf (Mcm)
KHARIF: minimum	35.3 (1)	35.3 (1)
median	1164 (33)	1200 (34)
mean	1870 (53)	2082 (59)
maximum	4658 (132)	15668 (444)
RABI: minimum	0 (0)	0 (0)
median	282 (8)	212 (6)
mean	565 (16)	282 (8)
maximum	2188 (62)	1835 (52)
ANNUAL: minimum	141 (4)	35.3 (1)
median	1659 (47)	1376 (39)
mean	2188 (62)	2364 (67)
maximum	4764 (135)	17503 (496)
FLOOD MAGNITUDES	cfs (cms)	cfs (cms)
1:1 year	15000 (425)	11000 (312)
1:2 year	25000 (708)	25000 (708)
1:5 year	38000 (1077)	42000 (1190)
1:10 year	50000 (1417)	55000 (1559)
1:20 year	59000 (1672)	69000 (1955)
1:50 year	-	-
1:100 year	-	-

In this study, we are concerned with floods of magnitude less than say 50 years. By tending to overestimate flood peaks, the modelled flood bunds will breach slightly prematurely, thus ensuring that estimates of offtake volumes are conservative. Consequently, the influence of any inaccuracy in predicting flood magnitudes is reduced.

4.5.3 Flood Hydrograph Generation

The calibrated flood generation model has been used to generate a 30 year synthetic time series of flood hydrographs for the Chakar River at Talli Tangi, thus extending the short runoff data record for the site. A sample of the generated time series is given previously in Figure 8.

4.6 Chakar River Flood Plain Simulation

A water balance simulation model of the Chakar River Flood Plain has been developed. It uses as its input data the 30 year synthetic time series of flood flows generated by the catchment model.

The functions defining the model, illustrated in Figure 10, account for:

- the operation of the various existing irrigation offtake structures in the flood plain (water rights, intake capacities, river flood rating curves);
- infiltration of flood flows into ground water (flood plain soils series);
- river recharge from over-bank storage;
- routing of flood flows along the Chakar River; and
- the behaviour of the Chandia headworks bund and the engineered headworks structures.

The information required to define the system functions has been obtained from local site surveys and interviews carried out by the TA Team (see Section 4.2).

4.6.1 Calibration of the Flood Plain Model

In creating and calibrating the flood plain model of the Chakar River, as with the catchment model described in Section 4.5, it has been necessary to make certain assumptions regarding the behaviour of the real system whilst other parameters have been allowed to vary to facilitate calibration.

The flood plain model has been calibrated against:

(a) the probability distribution of offtake volumes at Chandia, estimated from the areas irrigated by local farmers in recent years; and

(b) the probability distribution of flood magnitudes derived from flood marks adjacent to the Chandia headworks site.

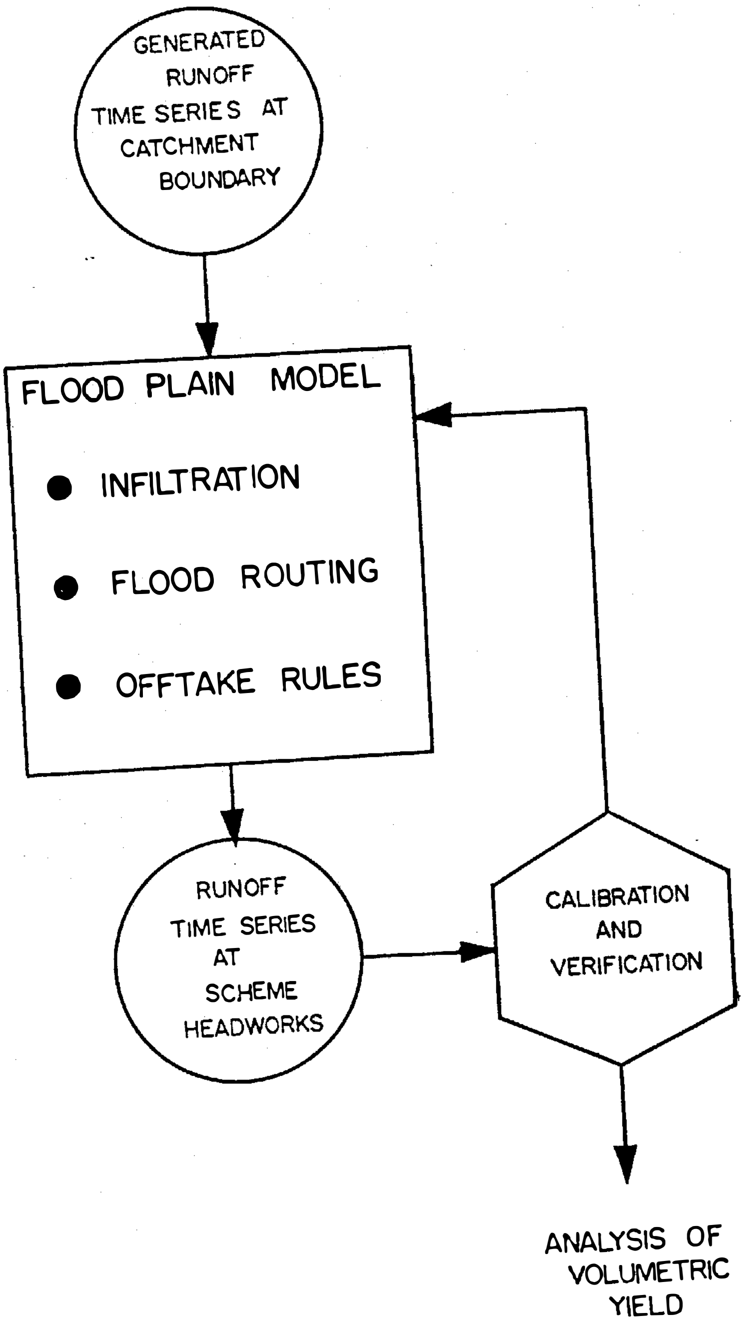
Table 9 summarizes the principal details of the calibrated flood plain model, including assumptions made and calibrated parameters.

TABLE 9 ASSUMED AND CALIBRATED FLOOD PLAIN MODEL PARAMETERS

ASSUMED FACET	CALIBRATED PARAMETER	CALIBRATED VALUE
Chakar River in regime	River bed infiltration	
	Surface evaporation	
	Over-bank spillage flow from river	Balance between infiltration, evaporation, spillage and recharge
	Recharge of river from local runoff and over-bank storage	
Influence of upstream chab structures insignificant	Offtake capacity of upstream gandhas: Sultan Kot	530 cusec (15 cumec)
	Kaisar	3880 cusec (110 cumec)
	Chandia	880 cusec (25 cumec)
Offtake efficiency simplified (defined by Figure 11)		
Gandha repairs by oxen or by tractor	Time taken to repair breached gandhas	10 days
Efficiency of transmission and distribution is 48%		
Depth of application of water on fields is 2ft (0.6 m)		

FIGURE 10

FLOOD PLAIN MODELLING



The Chakar River is in regime. This has been confirmed by comparison of surveyed river cross sections with theoretical channel shapes in sand presented by Simons and Albertson[5].

The apparent balance which has resulted during the calibration process, on average, between river bed infiltration, surface evaporation, losses to over-bank storage and recharge from local runoff and over-bank storage could not have been predicted due to a the complex nature of the mechanisms of the local water balance. The precise nature of these interactions, however, is not required to be specified in a water balance model which is finally calibrated utilising local information at the Chandia inlet site.

Offtakes controlled by chab headworks are excluded from the model. Such headworks are washed away by relatively modest floods in the Chakar River, and are reinstated only when flood levels have receded. Consequently, they have very little influence on the performance of the three existing gandha structures.

Capacities of upstream gandha offtakes are substantial in comparison with that of the Chandia offtake. The influence of these offtakes on the availability of water to the Chandia scheme is assessed indirectly in Section 4.8, where volumetric yields are predicted for both of the proposed options for improvement of the Chandia scheme.

Figures 11 (a), (b) and (c) show the assumed relationships between river flow, offtake flow and offtake volume for the cases where, respectively:

(a) the gandha remains intact;

(b) the gandha fails during a flood; and

(c) the gandha has not been rebuilt following a previous flood.

These functions have had to hypothesized, since it has not been possible to undertake detailed field studies by which to evaluate them. However, it is known that a gandha is breached rapidly when the river flow exceeds the capacity of the inlet canal. Following breaching of the gandha, flow diversion into the canal is controlled by the stage of the river. This is related to the flow in the river by a simple rating curve. The top level of a gandha is typically set at or above the full supply level of the inlet canal.

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[5]Simons D.B. and Albertson M.L. 1960 Uniform Water Conveyance Channels in Alluvial Material.

The time taken to rebuild a gandha across the full width of the river is estimated to be 10 days on average using bullock teams with drag scoops, a figure supported by interviews with local farmers. This period includes an allowance of several days for the river to dry out sufficiently to permit access to the site. When the damage to the breach is substantial or when the river does not dry out between floods, a tractor is used. There is often a considerable delay before it is made available, so that the average time to rebuild the gandha sufficiently high to divert water is still approximately ten days.

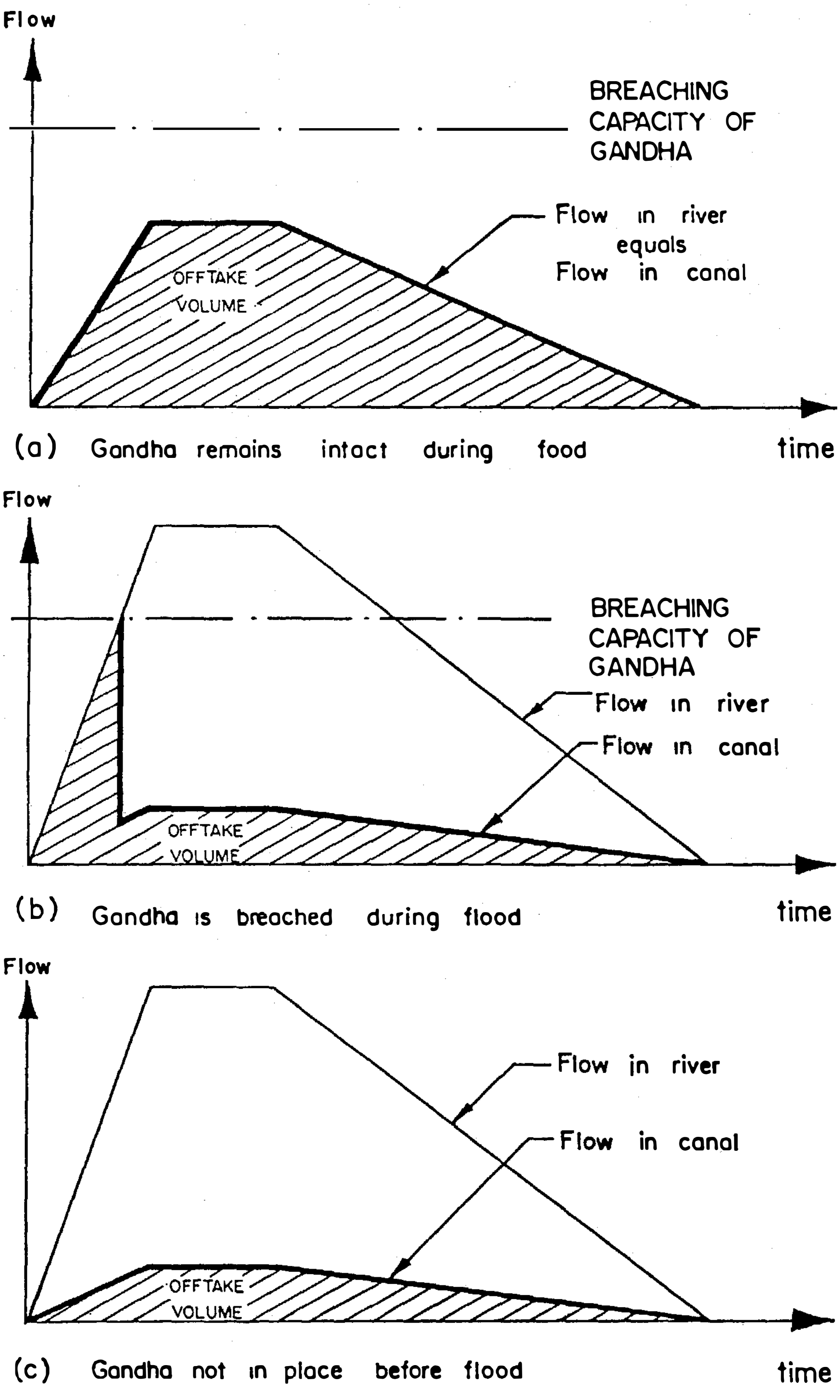
It has been observed that field bunds in the Chandia command area are approximately 2ft (0.6 metres) high on average. According to local farmers, only a single irrigation is applied to the fields in a season. The combined efficiency of transmission, distribution and application has been estimated at 48% using the method set out in FAO publication 24[6]. This information has been used to convert predicted delivery volumes into irrigated areas in the calibration process.

Table 10 illustrates the accuracy of the calibration of the flood plain model in terms of the criteria set out at the start of this section.

[6]Guidelines for Predicting Crop Water Requirements, FAO Irrigation and Drainage Paper 24 1984.

FIGURE 11

MODELLING OF BREACHING BEHAVIOUR OF GANDHA



(a) Gandha remains intact during food

(b) Gandha is breached during flood

(c) Gandha not in place before flood

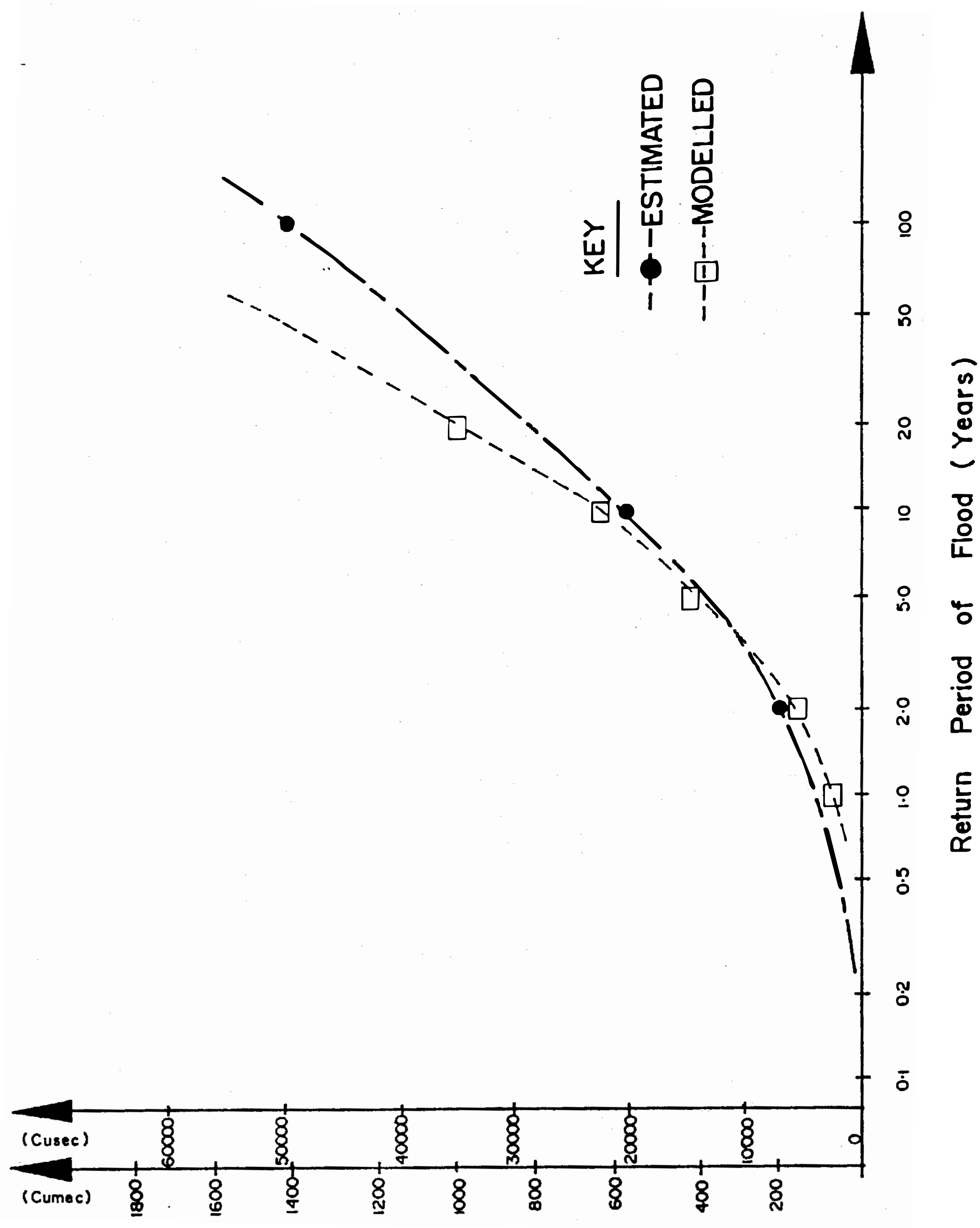
TABLE 10 CALIBRATION OF THE CHAKAR FLOOD PLAIN MODEL

STATISTIC	VALUE AT CHANDIA HEADWORKS	
	OBSERVED	MODELLED
FLOOD VOLUMES	Mcf (Mcm)	Mcf (Mcm)
KHARIF:		
minimum	n/a	0 (0)
median	n/a	31.8 (0.9)
mean	n/a	63.5 (1.8)
maximum	n/a	498 (14.1)
RABI:		
minimum	n/a	0 (0)
median	n/a	3.5 (0.1)
mean	n/a	7.1 (0.2)
maximum	n/a	56.5 (1.6)
ANNUAL:		
minimum	n/a	0 (0)
median	n/a	38.8 (1.1)
mean	81.2 (2.3)	70.6 (2.0)
maximum	367 (10.4)	558 (15.8)
FLOOD MAGNITUDES	cfs (cms)	cfs (cms)
1:1 year	3800 (108)	2500 (71)
1:2 year	7000 (198)	5800 (164)
1:5 year	13000 (368)	15000 (425)
1:10 year	20000 (567)	22500 (638)
1:20 year	28000 (793)	35000 (992)
1:50 year	40000 (1134)	-
1:100 year	50000 (1417)	-

Figure 12 shows the observed and modelled distributions of flood magnitude at the Chandia headworks site.

FIGURE 12

ESTIMATED vs MODELLED DISTRIBUTION OF FLOOD MAGNITUDES AT CHANDIA HEADWORKS



Peak Flow in Chakar River at Chandla Headworks.

4.6.2 Comments on the Flood Plain Model

The quality of the calibration of the flood plain model is satisfactory, and is discussed as follows:

(a) The model produces realistic estimates of offtake volumes at the Chandia headworks. Since the mean predicted offtake volumes appear to be slightly less than observed reality, it is reasonable to conclude that over the long term true volumetric yields will exceed the predicted values.

(b) As was noted with the calibration of flood magnitudes at Talli Tangi, the model tends to overestimate the magnitude of rare floods, but to predict more common floods with greater accuracy. This explains why predicted maximum offtake volumes are larger than expected and why predicted average offtake volumes are slightly low.

The overall effect of the above is a slightly conservative estimate of the volumetric yield of the existing scheme and other options examined using the model. The calibration exercise has emphasised the influence of the two gandha intakes upstream on the water availability at the Chandia headworks. Although it is likely that any significant improvement in the reliability of these intakes would have a serious effect on the viability of the Chandia scheme, in their present condition they will never cause the economic failure of the scheme (see section 4.8.2).

4.7 Design of Chandia Headworks

An important element of the engineering design of any scheme is the screening of potential solutions, such that:

- all viable alternative designs are considered; and
- only the most efficient design of any type is put forward for detailed design and economic analysis.

An outline arrangement of the Chandia headworks was put forward in the Flood Irrigation Mission Report[7]. The proposal was for an engineered canal head regulator to be built together with a sand sluice and a short weir, incorporating a traditional gandha between the weir and the far river bank. Full diversion of river flows would be achieved for flows up to the capacity of the canal, weir and sluice prior to the progressive failure of the gandha.

[7]Camacho R.F. 1992 BMIADP Phase II Flood Irrigation Mission Report.

The consideration of alternative designs for the Chandia headworks involved:

(a) optimizing the total capacity of canal, weir and sluice (the flow above which the gandha would fail);

(b) optimizing the relative capacities of canal, weir and sluice; and

(c) establishing the relative reliability of the preferred engineered scheme and the existing gandha-only farmers' scheme.

The calibrated flood plain model has been used to evaluate the diversion performance of a number of alternative designs for the headworks of the Chandia scheme, and to compare this with the estimated performance of the existing farmers' scheme. By using the model to evaluate a range of essentially similar options, considerable analytical time has been saved and the full range of possibilities has been considered.

The most favoured engineering solution for the headworks for Chandia consists of a weir, sluice and canal with a combined capacity of 6,700 cusec (190 cumec). The full supply level of the Chandia canal would be as existing, estimated to be 880 cusec (25 cumec).

Table 11 summarizes the relative reliability of the preferred engineered and the existing system, in terms of predicted bund breaching frequencies. The predictions are conservative, as they consider only breaches where the gandha was fully intact before the breaching flood. In practice, over the long term a number of floods would occur during the rebuilding period (see Section 4.8 for a discussion of this point).

TABLE 11 PREDICTED ANNUAL FREQUENCY OF HEADWORKS FAILURE AT CHANDIA OFFTAKE

BREACHES PER YEAR	TRADITIONAL GANDHA	ENGINEERED HEADWORKS
minimum	0	0
median	3	1
mean	2.8	0.8
maximum	7	3

Thus, the threshold of river flow at which the gandha breaches would be greatly increased if an engineered headworks arrangement were to be adopted.

In addition to a full engineering solution to the improvement of the Chandia headworks, a further technical solution was proposed. This consisted of a canal head regulator with a capacity of 880 cusec (25 cumec) as per the full engineered scheme, but omitting the weir and sand sluice. The reliability of this scheme would not increase from that of the existing arrangement, since no increase in the capacity of the headworks would be involved.

Both of the proposed schemes for the improvement of the Chandia headworks require the use of a bulldozer to reinstate the gandha as quickly as possible during the recession of a flood causing a breach. This does not affect the intrinsic reliability of the proposed schemes in terms of the expected number of floods per year which would cause failure of the gandha, but greatly improves access to low flows and to floods which follow quickly on from previous bund breaching flows.

4.8 Chandia Yield Flow Analysis

4.8.1 Yield Flow by Scheme Option

The calibrated flood plain model has been used to predict a 30 year time series of volumetric yields associated with two options for the improved headworks of Chandia and the existing without project situation. These options, described in detail in Section 9.3, are outlined in Table 12.

TABLE 12 SUMMARY OF SCHEME OPTIONS

FEATURE	Without Project	OPTION 1	OPTION 2
Traditional Gandha	yes	yes	yes
Weir and Sluice	no	no	yes
Dedicated Plant for Gandha Repair	no	yes	yes

The principal features of the flood plain model which are varied to represent each option are:

- the time taken to repair the gandha following failure (see Section 4.6.1); and
- the breaching capacity of the headworks (see Section 4.7).

Table 13 summarizes the flood plain model parameters relating to the hydraulic behaviour of the headworks for each option.

TABLE 13 CHANDIA HEADWORKS MODEL PARAMETERS

PARAMETER	Without Project	OPTION 1	OPTION 2
gandha repair time [days]	10	3	3
canal capacity [cfs(cms)]	880 (25)	880 (25)	880 (25)
breaching capacity of headworks [cfs(cms)]	880 (25)	880 (25)	6700 (190)

These factors in turn are the primary determinants of volumetric yield derived using the flood plain model.

4.8.2 Distribution of Volumetric Yield

The monthly, seasonal and annual distributions of volumetric yields predicted by the model for without project and with project Options 1 and 2 are shown in graphical form in Figure 13(a), (b) and (c) respectively. The kharif season is defined as June to September inclusive; the rabi season covers October to May.

Table 14 presents the summary statistics of volumetric yield for each option.

FIGURE 13 (a)

WITHOUT PROJECT PREDICTED DISTRIBUTIONS OF VOLUMETRIC YIELD

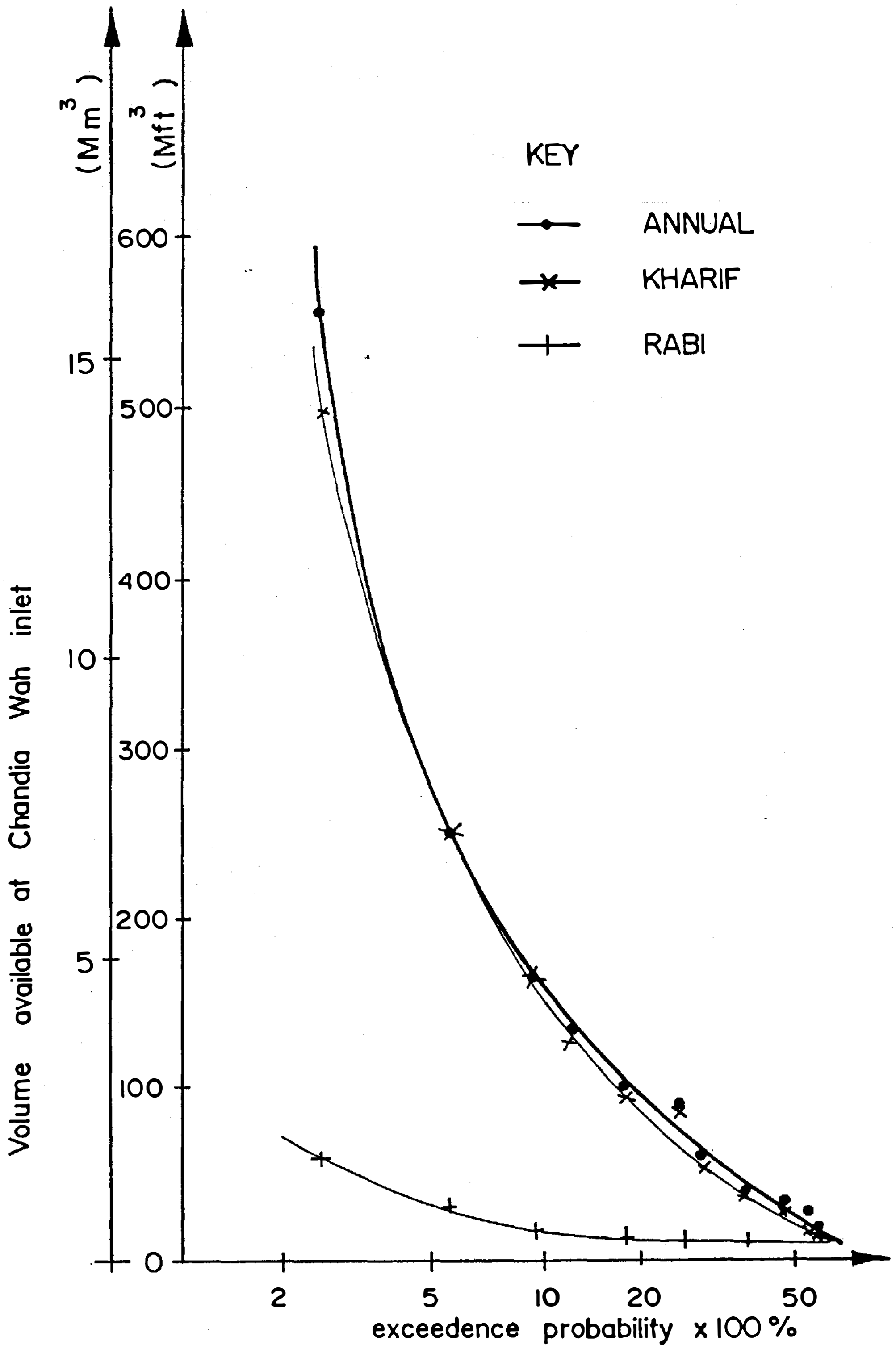


FIGURE 13 (b)

WITH PROJECT OPTION 1 PREDICTED DISTRIBUTION OF VOLUMETRIC YIELD

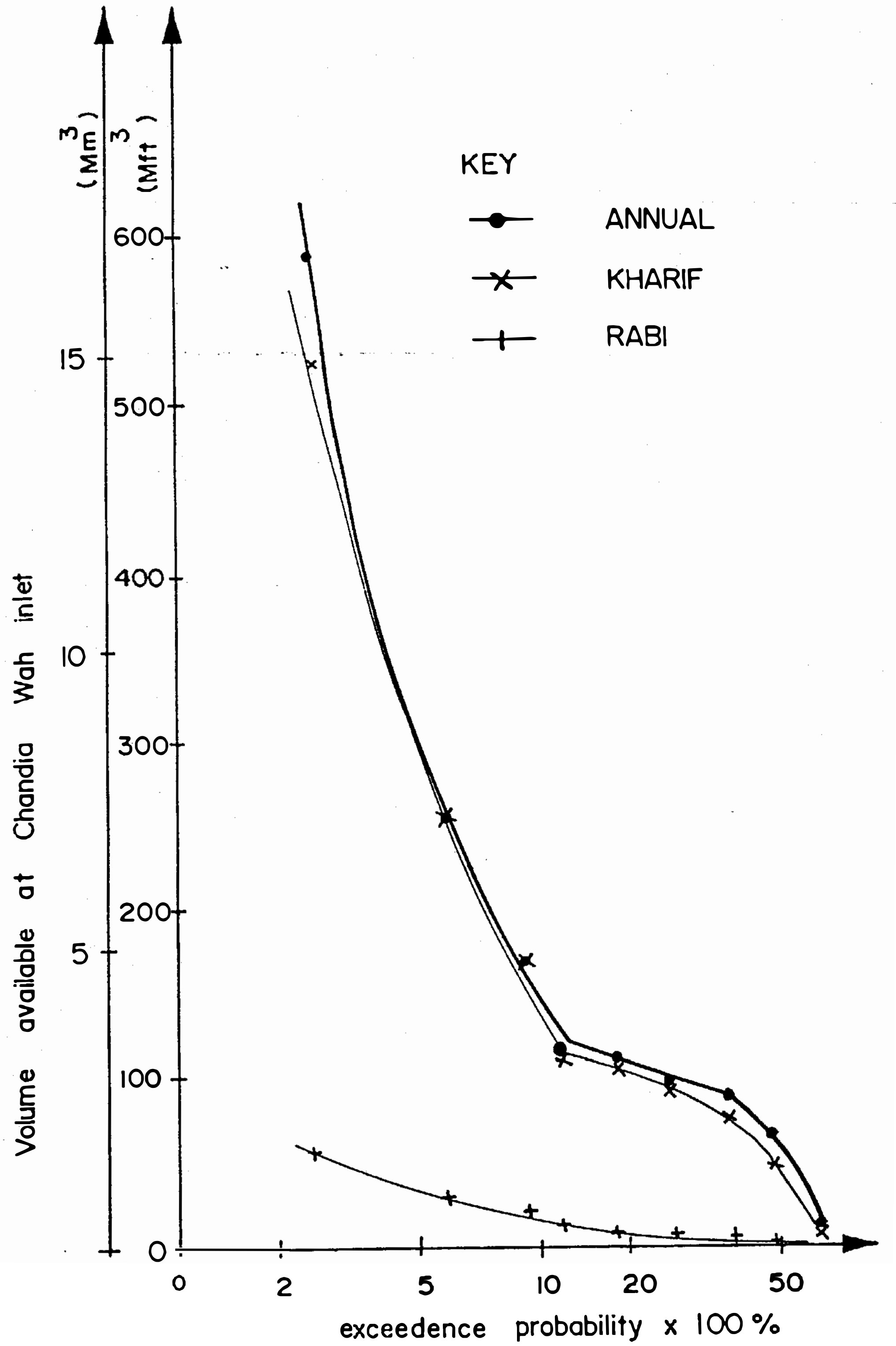


FIGURE 13 (c)

WITH PROJECT OPTION 2 PREDICTED DISTRIBUTION OF VOLUMETRIC YIELD

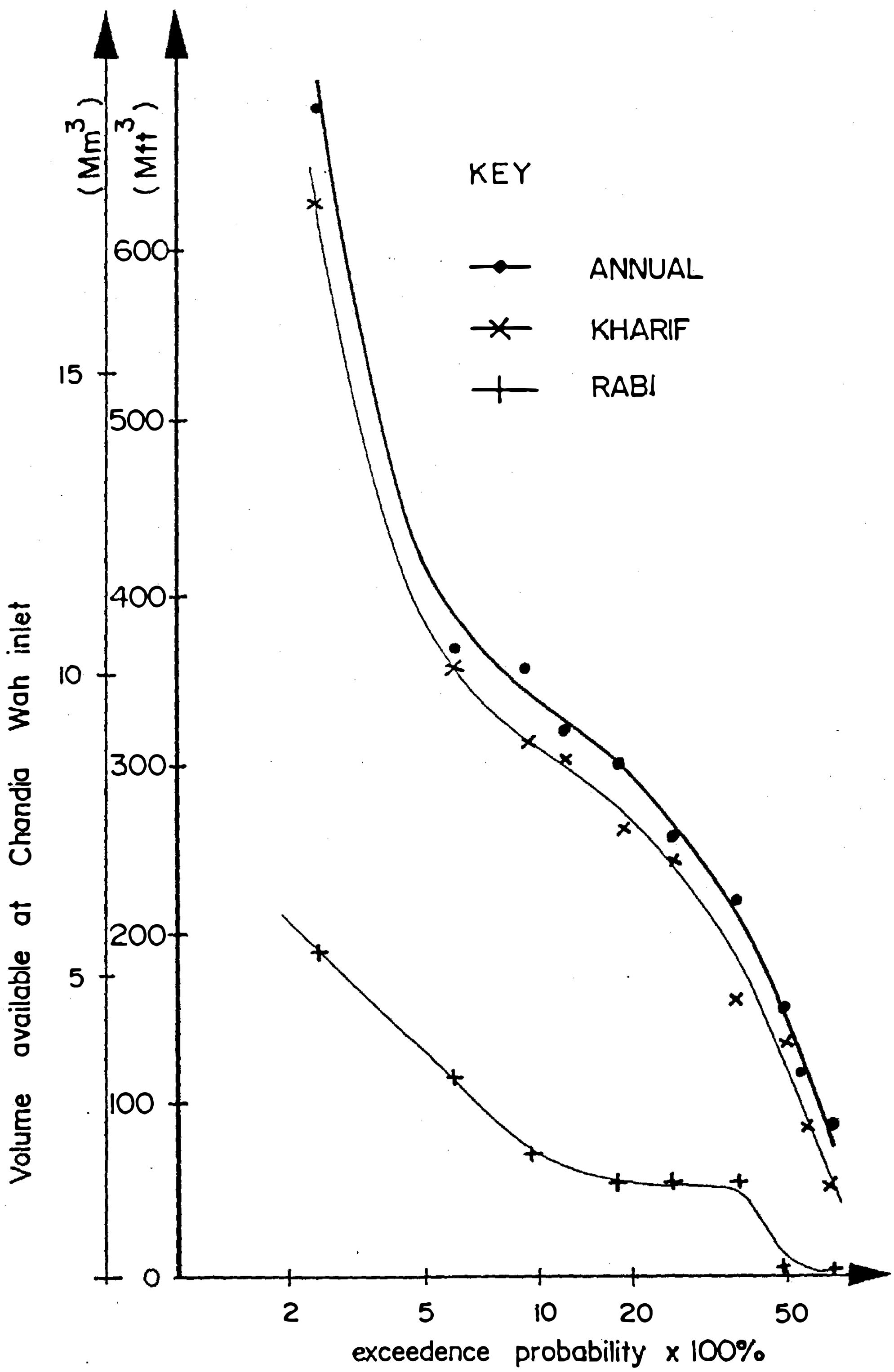


TABLE 14 SUMMARY OF PREDICTED VOLUMETRIC YIELD AT CHANDIA HEADWORKS SITE

SEASON	PREDICTED VOLUME STATISTIC [Mcf(Mcm)]					
	MIN	75% EP	MEDIAN	MEAN	25% EP	MAX
Without Project						
KHARIF	0(0)	9.1(0.3)	30.1(0.9)	62.4(1.7)	89.6(2.5)	498(14)
RABI	0(0)	0(0)	3.6(0.1)	7.2(0.2)	10.3(0.3)	57.9(1.6)
ANNUAL	0(0)	13.9(0.4)	37.3(1.1)	69.5(2.0)	92.3(2.6)	556(16)
OPTION 1						
KHARIF	0(0)	9.1(0.3)	53.1(1.5)	75.3(2.1)	97.1(2.8)	526(15)
RABI	0(0)	0(0)	3.6(0.1)	7.6(0.2)	10.3(0.3)	57.9(1.6)
ANNUAL	0(0)	13.6(0.4)	66.3(1.9)	82.8(2.4)	100(2.9)	584(17)
OPTION 2						
KHARIF	0(0)	57.2(1.6)	139(3.9)	153(4.3)	241(6.8)	625(18)
RABI	0(0)	0(0)	5.4(0.2)	31.5(0.9)	57.2(1.6)	187(5.3)
ANNUAL	0(0)	71.9(2.0)	160(4.6)	185(5.2)	252(7.2)	682(19)

4.8.3 Comments on Predicted Volumetric Yields

Table 14 illustrates the following points:

(a) Only a small proportion of the flow volumes available at Talli Tangi are utilised by the existing Chandia scheme. This is due to:

- the dominance of the two upstream gandha offtakes, which effectively block a large proportion of the potential flow; and
- the poor reliability of the existing Chandia headworks.

(b) Significant improvements in volumetric yield, based on median yield volumes, over the without project situation at Chandia are available through Option 1 (80% improvements) and Option 2 (330% improvement).

4.8.4 Over-Year Extreme Value Analysis of Predicted Volumetric Yield

Table 15 shows calculated multi-year extremes of volume availability for the without project case and the two with project options. These figures represent the best and worst N-year sequences of volume availability. For example, the 1-year minimum annual average volume is the worst figure which could be expected to occur in any given year, whilst the 10-year minimum is the worst annual average which could be expected over any given period of 10 consecutive years.

TABLE 15 EXTREME VALUE ANALYSIS OF VOLUMES

PERIOD (years)	1	2	3	4	5	10
MINIMUM ANNUAL AVERAGE VOLUME [Mcf(Mcm)]:						
Without	0(0)	3.4(0.1)	16(0.5)	16(0.5)	26(0.7)	33(0.9)
OPTION 1	0(0)	3.4(0.1)	16(0.5)	16(0.5)	35(1.0)	45(1.3)
OPTION 2	0(0)	29(0.8)	48(1.4)	50(1.5)	97(2.7)	121(3.4)
MAXIMUM ANNUAL AVERAGE VOLUME [Mcf(Mcm)]:						
Without	556(16)	299(8.5)	209(5.9)	175(5.0)	148(4.2)	128(3.6)
OPTION 1	584(17)	325(9.2)	230(6.5)	192(5.4)	162(4.6)	133(3.8)
OPTION 2	682(19)	463(13)	365(10)	312(8.8)	283(8.0)	261(7.4)

5 EXISTING IRRIGATION INFRASTRUCTURE

5.1 Overview

Flood irrigation (sailaba) based on the gandha system is a flexible traditional method of flood diversion and consists of earth diversion and impounding bund constructed across rivers. The bunds are communally made, but have short comings, such as the low level of technology used in the design and construction of the bund, the lack of control of the flood, the time taken to rebuild the main bund and consequent reduction in the amount of available water taken from the river. The lack of any structure limiting the flow can also result in large floods causing erosion within the command area. In extreme cases, the river has changed course to flood the diversion channel with major erosion consequences for the command area.

5.2 Existing Irrigation Infrastructure

The existing irrigation infrastructure comprises:

- diversion works on the left bank of the Chakar River, approximately one mile downstream of the Talli-Sibi Road crossing;
- a flood channel, 16,400ft long from the river to the start of the command area;
- 13 flow division structures and;
- a 2,100 acre command area, most of which has been developed with level, bunded basins and distribution channels.

The layout of the diversion works varies from year to year depending on the position of the low flow channel within the overall width of the river. During 1992, the channel followed the left bank of the river and consequently flood water flowed into the flood channel without the need for any additional works. This ideal situation reportedly occurs only on average once every five years, and in other years, when the low flow channel is in the middle of the river, the Chandia farmers construct an earth bund diagonally across the river to divert all the flow into their flood channel. No attempt is made to restrict the diversion flow and as a result the discharge into the flood channel frequently exceeds the bank capacity causing damage and flooding. Once the bund across the river fails, flow into the flood channel only continues during the period of high flow or if the low flow channel is on the left bank of the river. In any other position, the bed level at the entrance to the flood channel is above the water level.

The volume of water diverted during a season depends to a large extent on when the bund fails, if for example, it is breached during the first flood and the residual position of the low flow channel is not on the left bank, then there is little chance of any further water being diverted until the bund can be reinstated. The government normally provides a bulldozer to rebuild the bund once a year, but any subsequent rebuilding or remedial works to the flood channel are undertaken by the farmers using oxen and by hiring tractors. The river bed material consists mainly of silt and fine sand and is very difficult to work when saturated.

The existing flood channel has a capacity of approximately 880 cusecs and the distance from the offtake to the first flow distribution point is 16,400ft. There are reportedly 13 secondary canal offtakes from the main flood channel, these are nominally flow division structures, but there is no hard sill across the channel and as a result the division depends on the relative bed levels of the main flood channel and the secondary canal.

5.3 Water Distribution and Water Management

The Chandia bund and flood channel forms an integral part of a far larger flood irrigation system on the Chakar River. There are nominally 12 offtakes in the system and Chandia is the sixth (see Figure 14). The first three are free intakes, constructed from brushwood and stones and divert the base flow. They are not intended to divert flood flow, and are usually washed away during quite small floods. The remaining offtakes, including Chandia, involve the construction of a bund, known locally as a gandha, across the river channel which diverts all the flow down the flood channel until the bund breaches. This releases all the flow down to the next gandha. Traditionally, the gandhas were constructed using bullocks and drag scoops which effectively limits their height, therefore down stream users could be reasonably confident that they would breach. However, with the increasing use of mechanical plant, there is a possibility that bunds are likely to be built increasingly higher. As a result they are less likely to breach thus depriving downstream users of their share of the flood water. However, this tendency to raise the height of the bund is expected to be curtailed by the possible serious erosion which will occur when a large flood is diverted into the diversion channel.

The customary rules governing the use of the gandhas are not well-defined. The Chandia water users have the right to divert as much water from the present location of their bund near Kaisar Village. The only restriction is that they are expected to break the bund, once their land is irrigated, this applies to all bunds on the Chakar River. However, it is not always followed and much controversy is generated by the Chacar Bund, located downstream from the Chandia intake. The Chacar Bund was not broken for a number of years, the result being that its excess water is diverted to an area to the west, draining into the Nari

River. This latter area is not supposed to be irrigated from the Chakar River.

The main area commanded from the Chandia Wah diversion channel is located in the downstream section of the channel. This downstream area has prior rights to the flood water. The farmers whose land is situated along the upper reaches of the flood channel, are not allowed to construct small bunds in the Chandia Wah. Consequently, where the invert of the branch channel is higher than the bed level in the main channel, water is only diverted during high flow. After the flood and water users have irrigated all their land, the upstream users are permitted to construct bunds to divert the flow into their channels.

The main downstream command area is served by three main branch channels, Kach Wallah, Shaher Wallah and Kand Wallah. These branch channels are further subdivided into a total of 12 branch channels and when a flood comes, it is allowed to flow into all 12 channels simultaneously. However, if the water level is very low, it will only flow in the lowest channels which are presently located at the tail of the Shaher Wallah. The water distribution, automatically adjusts to the flood discharge in the Chandia Wah, the distribution of water is a variable of the capacity and depth of the respective branch channels. These parameters are flexible, and landowners on any of the branch channel are allowed to deepen their channel, thus increasing the probability of a larger supply by their own effort. This option is not always as attractive as it seems, as it involves a substantial amount of work and the erection of higher, and hence more vulnerable bunds in the channels to divert the water to the fields. Similarly, widening of the headreach of the channel is usually not preferred, since it would attract a flow larger than the fragile channels can handle.

Within each branch channel the water is utilized field by field, in a relatively controlled fashion. Small bunds of soil, erected in the channel network, divert all the water to one field at a time. Once the field is fully flooded to the required depth, the small bund is broken and the next field is served. The amount of water applied to a plot depends on the height and strength of the bunds (laths), surrounding the plot. There are no restrictions on the height of these field laths, but again making them higher might increase the chance of breaking before all impounded water is infiltrated and therefore they are normally 2ft high. When all fields on a branch channel are irrigated, the branch channel is closed off.

In flood irrigation, second waterings by upstream land owners are often a source of friction. In Chandia, however, clear rules have been formulated. In the monsoon, which is the main flood season in Chandia upstream land owners are not allowed to use water for a second time if there is still downstream land that is yet to receive its first irrigation. Only upstream plots, of which the laths were broken in the first irrigation, and hence were not inundated properly, are entitled to divert water for a second time; before all the downstream land is served.

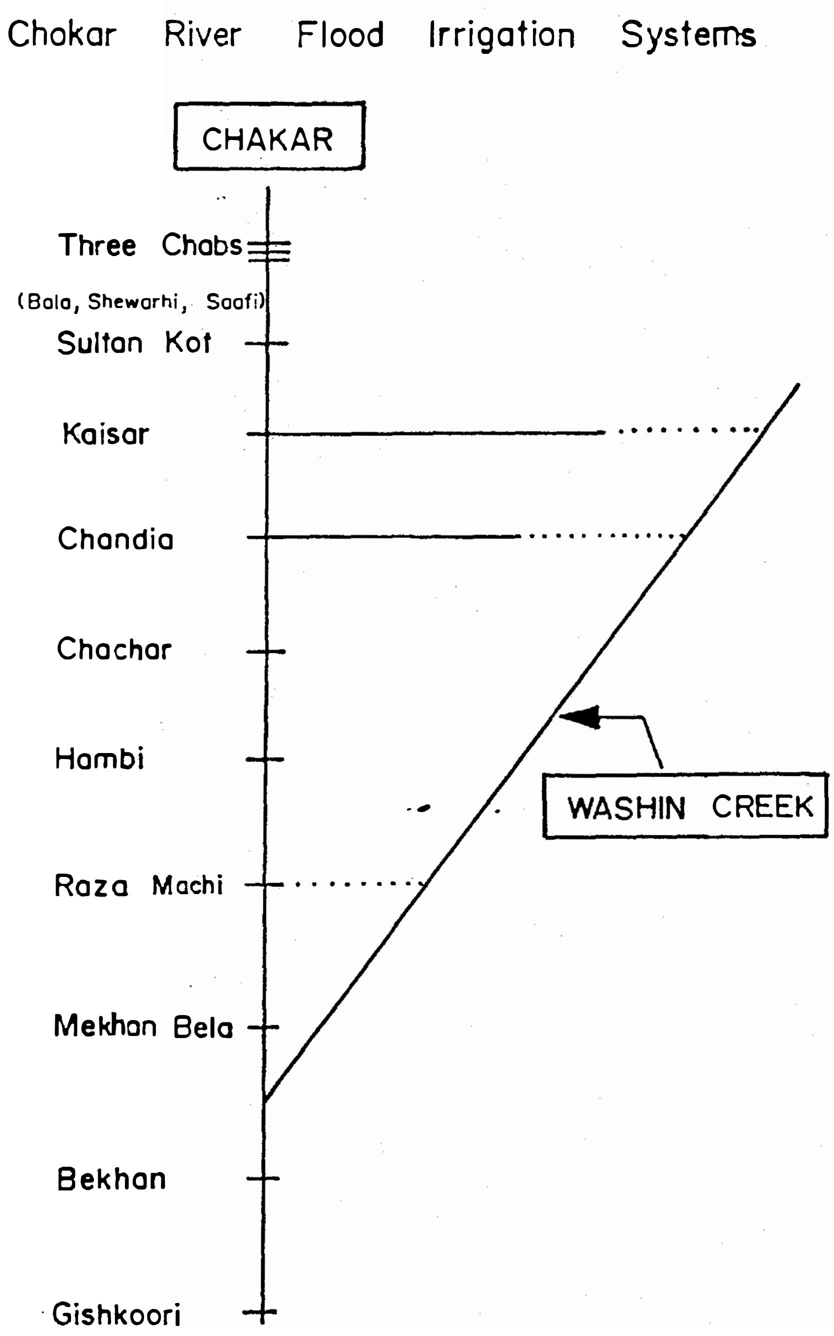
For the floods in the spring season slightly different rules apply. At this time, the small area of wheat sown on the residual moisture from the late monsoon floods is already on the land. Preference is sometimes given to irrigating the area under wheat for a second time, before other land is irrigated.

Excess water from Chandia is passed on to two other areas, to Raza Machi lying immediately south of Chandia village and to the Washin creek, that runs in an east-west direction, further south of Chandia. A number of bunds are sometimes constructed on the Washin creek. After these bunds, the Washin creek joins the Chakar River, the combined flow irrigating the villages of Gishkoori, Goramzai, Mall and Gorkeech.

The acceptability of the proposed improvements at Chandia were tentatively discussed with some of the downstream landowners. The landowners at the tail of the Chakar River, in particularly at Bekhan and Gishkoori were unconcerned, since, if from Chandia the flood water is diverted and would not reach them through the Chakar River, it would still do so from the Washin creek. The landowners on the four bunds, immediately downstream of Chandia (Chacar, Hambi, Raza Machi and Mekhan Bela), however, initially expressed doubts about the proposed project, as they were under the impression that the whole of the Chakar River would be blocked off. When explained that the weir and sluice gate would allow floods to pass downstream during and after the Chandia command area had been irrigated, a major source of concern was removed. It is proposed to prepare a model of the headworks for discussion with Chandia landowners as well as landowners served by the downstream bunds.

FIGURE 14

FLOOD IRRIGATION SYSTEMS ON CHAKAR RIVER



5.4 Existing Operation and Maintenance

Mirroring the clear rules of the water distribution system within the command area, there is a well-defined system for the maintenance of the Chandia flood irrigation system. The main recurrent tasks are the construction of the bund, the repair of the main flood channels and their surveillance at the time of floods.

The basis by which the landowners of Chandia are organized to undertake these tasks is an intricate system of 24 shares, locally called jora. The 24 shares are divided into four groups of six shares, each group originally related to one of the four constituting clans in Chandia.

Within each clan, the maintenance obligation was distributed proportionally to the land owned by each member of the clan (Annex C.1). The land commanded from each flood channel, however, differs and hence there is a discrepancy between land owned and the maintenance obligation. This discrepancy was further compounded by the practice of selling land without the corresponding obligation to provide labour and cash for the maintenance of the system. As a result, different plots of land carry different obligations.

Whereas the 24 shares relate to the main command area, and cover the recurrent maintenance costs throughout the year, there are six more jora shares that are expected to make a contribution to the upkeep of the system once a year. The persons responsible for these additional six joras, are the same people responsible for the 24 main joras, but the proportional distribution under the two regimes is different. Reportedly, the people responsible for the six joras have to contribute one-sixth of the maintenance costs at the end of the year, but in practice the collection of this share has been difficult.

The actual maintenance of the system is undertaken by a combination of self-help and government assistance. The government assistance consists of the subsidized provision of a bulldozer. The present allocation of bulldozers is made exclusively from the political funds of the Members of the Provincial Assembly. The Members of the Provincial Assembly are expected to deposit Rs300 per hour for each allocated hour of usage from their discretionary fund into the bank account of the Agricultural Engineering Department. Out of this sum, Rs30 per hour has to be recovered from the receiving farmers[8]. The allocations are usually given to one of the village leaders, who was instrumental in collecting votes for the particular politician. If farmers obtain bulldozers directly from the Agricultural Engineering Department, they have to deposit Rs250 per hour of usage with the department. These payments cover only part of the running costs, these are estimated at Rs800 per hour without depreciation. With depreciation the hourly rate would be

[8] There is a limited trade in bulldozer allocations, with people who were given bulldozer allocations in excess of their requirements offering them for sale for Rs80 per hour.

Rs1100. Most bulldozers used by the Agricultural Engineering Department were provided through grants from the American and Japanese Governments.

Last year the bulldozer allocation for Chandia from the local Member of the Provincial Assembly was 150 hours, which according to informants is an average figure. In addition, some 100 hours more were obtained directly from the Agricultural Engineering Department. For 1991, the Chandia land owners obtained 200 hours of bulldozer usage directly. A total of Rs19,200 and Rs38,400 was collected in these years. In practice, one bulldozer is permanently stationed in mouza Raza Chandia which consists of two other flood irrigated areas apart from Chandia. The bulldozer is at present broken down.

There are a number of additional costs borne by the farmers when the government bulldozer is used:

- an obligatory gratuity to the bulldozer operator of Rs20 per hour and the provision of a meal for him;
- the transport charges of the bulldozer at Rs10 per kilometre;
- the provision of four helpers to assist the bulldozer operator;
- occasional minor repairs, if not undertaken by the government.

The government bulldozer is mainly employed on the reconstruction of the bund in the Chakar River and the repairs to the Chandia Wah flood channels. The amount of work depends on prior flood damage. In normal years, however, the bund will be erected twice; once before the monsoon and again before the spring flood season. If the allocation of bulldozer hours is insufficient, farmers will use tractors and bullocks, provided in accordance with the jora system.

Surveillance of the system and organization of the annual repairs is the responsibility of the water bailiff (mir-i-aab). His function is hereditary and he is compensated for his services in kind. His main role during floods is to watch for any breaches in the channel and to mobilise a repair gang if necessary. He is assisted by four tohas, these people also work with the bulldozer operator when necessary and are provided under the 24 jora system.

6 SOCIOLOGY

6.1 Overview

The land owners, served by the Chandia flood irrigation system, live mostly in the modest-sized settlement of Chandia. Though the distribution of land and water is reasonably egalitarian, varying access to non-agricultural sources of income has resulted in a marked economic differentiation within the community. There are a number of landowners who are very poor and have difficulty in affording the basic expenditures of hiring draft animals or tractors or even the purchase of seed.

A consequence of this economic differentiation is that leadership in Chandia is not based on traditional tribal roles, it is based more on economic position. The community operates in a democratic manner and pride is taken in the absence of pronounced tribal leadership.

The returns of flood irrigation vary greatly between years. A number of mechanisms have evolved to offset these fluctuations. The most important of these is the access to government jobs, which act as a buffer in the economic base.

6.2 Population and Community Structure

The people of Chandia are Baloch, belonging with a few exceptions to the Chandia tribe. They settled in the area in the remote past, and then outmigrated to later come back again.

Within the Chandia tribe in Chandia village four lineages, called thala, exist:

- Turkalizai
- Dostalizai
- Bahadurzai
- Chakrani

There have been no disputes of any importance between these lineages in living memory. Each of the lineages has a nominal leader, who represents the interests of his group in village politics. The head of the senior lineage (Turkalizai) carries the title of malik, village headman.

Real leadership, however, differs from the ascribed leadership in Chandia. The two key men in the village are Mir Muhammad, whose hospitality is proverbial, and Haji Sulaiman, who has attained this standing by virtue of being employed in the Department of Irrigation and is well versed in dealing with government departments. The people of Chandia do not recognize the power of a sardar.

In total, 67 households, consisting of 897 persons, own land, commanded from the Chandia flood channel. A significant portion of them, 19 households (28.3%), live outside Chandia village; most of them in nearby Sibi, where they have found permanent employment. They ask one of their family members to look after the landed property in Chandia village.

In addition to the 48 land-owning families residing in Chandia, there are 10 landless families, consisting of 74 persons, living permanently in the village. Some of these hold government posts, such as teachers, and others work as tenants and agricultural labour. A special category is the village artisans, supposedly from lower social status, who are paid annually in kind, their remuneration is donated from designated persons, following the lines of the 24 jora system, described in section 5.4.

An overview of the households resident in Chandia is given in Annex C.1.

6.3 Socio Economic Status

A substantial number of the land owning families in Chandia are economically dependent on non-agricultural sources of income, the most important one being employment in one of the government departments in Sibi. A total of 89% of the families have one or more family members in the civil service, this figure is based on an inventory undertaken during the social survey and is summarised in Table 16. In the majority of cases, this concerns low-ranking jobs, such as messengers and workmen. This access to a secure source of income for some of the families has given rise to a marked economic differentiation in the village.

TABLE 16 NON AGRICULTURAL SOURCES OF INCOME OF LAND-OWNING FAMILIES

Activity	Total	Percentage
Government/pension	60	89
Trade	2	3
Others	4	6

An effort was made to assess the comparative socio-economic status of the Chandia community. Wealth indicators were collected, a summary of which is given below:

- Housing: Houses in Chandia are small, particularly when the relatively large average household size of 12.9 is considered. This is larger than any other scheme for which a Phase II study has been undertaken. On average, houses in Chandia have 2.3 rooms. Most houses are built of adobe.

- Domestic appliances: Considering the availability of electricity, ownership of electric appliances is not widespread. Radio's are owned by 23% of the households. In 8% of the households there is a television. The most common electric device is a fan, reflecting the high summer temperatures of the area, 54% of the households own an electric fan. None of the households in the sample owned a refrigerator or cooker..

- Transport: Private means of transport are unusual. Only 8% of the sampled households owned a motorbike and 23% owned a bike. None of the sampled households owned a tractor or a truck, though some of the household, not included in the sample, posses a tractor.

- Livestock: Livestock ownership is moderate in Chandia, although the draft animals represent a sizeable investment and are significant in terms of agricultural production in the area. The average number of chicken, sheep, goats and cattle is 1.2; 4.7; 5.5 and 1.8 respectively. The category of cattle includes the ownership of draft bullocks, however, only 31% of the sampled households owned bullocks.

Based on these indicators, the community of Chandia would be classified as poor within the context of rural Balochistan. However, Chandia is slightly better off in terms of economic indicators than that of some areas that have access to perennial water. A comparison with the poorest perennial irrigation schemes, for which Screening Reports have been prepared recently, show that the people of Chandia have a higher level of income than those of Lakharo or Kunara. This is explained by the access to government employment.

This general picture of poverty, however, hides the significant economic differentiation that exists in Chandia. Some families were encountered that were financially unable to cultivate their own land. They did not possess their own bullocks, and could not afford the expenses of hiring a tractor either to repair their field bunds or prepare the land. Instead, they rented out their land to a tenant, who owned his own draft animals, underlining the importance of this asset vis-a-vis the ownership of land. In cases, where poor landowners did not manage to secure the help of tenants, they would just cast seed in the inundated part of their fields.

6.4 Wealth Redistribution and Risk Coping Strategies

A number of traditional solidarity mechanisms are in place in Chandia. These appear more to help people in need or people struck by calamity, than to help persons whose crop failed. When asked for a definition of 'poor', the villagers would point to either landless people or old-aged persons, without adult sons to take care of them. People facing a crop failure, a common phenomena in flood irrigation, were not included in this category, probably because its occurrence is so frequent and systematically affects some land owners more than others.

The solidarity mechanism most prevalent was the islamic duty to give part of the crop as alms to the needy (zakat). The prescribed amount is one-tenth of the harvest; or one-fortieth of the livestock. When given, it is given to poor fellow villagers and the mullah of the village mosque.

With the establishment of the Zakat and Ushr Ordinance in 1980, the Government of Pakistan also established a formal welfare redistribution mechanism, with ushr being levied on the crop, replacing the land revenue previously collected. The performance of this mechanism has been abysmal, the main problems being the underestimation of crop yield and the poor collection of ushr by revenue officials. In the years since the Ordinance came into force in 1983, the maximum assessment for the whole of Chandia was just Rs4,824 (rabi 1984-1985). The poor performance of revenue officials follows that of the country as a whole, where collection of ushr is estimated to be only 7% of potential.

Another type of assistance to the poor is to allow them to cut mustard leaves as vegetables and provide them with limited supplies of fodder.

Assistance to the poor is not limited to the consumptive sector. A common practice is for a bullock-owner to lend his draft animals to a person who does not own any. There is a limitation to this practice and bullocks are usually only lent for one or two days. Another practice, which is far less widespread, is to give some land in usufruct to a poor relative.

In addition to this redistribution of wealth, there are other traditional support mechanisms, that assist people at critical stages in the life cycle. As each person will at one time face these crisis, these mechanisms are reciprocal and do not entail a one-sided transfer of surplus assets or possessions from rich to poor, therefore they have more the form of mutual insurance. One of the main systems is the bijar or mookh, consisting of a small contribution to a fellow villager's cost in arranging a wedding, although this system is not uniformly applied. Another system is the help, provided if a family faces a death case. In these circumstances fellow villagers arrange food for the first three days of the condolence period.

6.5 Risk Sharing Strategies

As mentioned, the risk of a failed crop is not covered by any insurance or solidarity mechanism at village level. Instead, the variation in returns from flood irrigation are absorbed at family level. There are several strategies adopted simultaneously. One that is particularly important in Chandia is to settle a family member in a secure government job, thus guaranteeing a basic income for the family.

These opportunities are not available for all farm households, for those less fortunate, another strategy is to cover the deficits of a bad year with the surpluses of a good year. This entails saving seeds for several years if necessary, consequently the traditional clay grain storage bins are quite large, some being over 8ft high. How viable these seeds are is difficult to determine as storage conditions are not ideal. Inconsistency in the harvest also poses a problem for another critical input, draft power. In bad years, farmers are sometimes forced to sell their bullocks, providing necessary cash; they then buy the bullocks back at the start of a good season. If a farmer does not have the cash, he will buy the bullocks on loan, paying the sum after the harvest, at 25% higher prices. Similarly other farmers take loans for seeds with Hindu shopkeepers in Sibi, paying 5-10% interest monthly.

Labour mobility is another response to a dry year. Farmers will go to Sibi or to Sindh in pursuit of an income to bridge a dry year.

A final method of spreading risk occurs at family level. It consists of a family not dividing the landed property on a permanent basis, but to review after the floods which lands were watered. Those lands are then distributed among the various family members to cultivate individually in that particular year.

6.6 Land Rights

In similarity with other schemes, the land rights in Chandia differ from the land rights officially recorded in the cadaster. Despite its imperfections, the existence of a cadastral record does provide a measure of security to land rights.

The land rights from Chandia predate the land settlement, first recorded in 1902 during the colonial period. According to an official document of this period, the Chandia people were given land rights by the Barozai rulers of Sibi as a reward for their services. With the passing of a number of generations, three-quarters of the land was sold to another party. This transaction apparently invited the wrath of the Marri tribesmen, living in nearby hills and their constant harassing forced the Chandia people to leave their land. The land was then occupied by Gohramzai Brahui, who in due course also vacated the land, after being attacked by the Marri's.

At the time of pax Britannica the Chandia people moved back to the area, but they found their land title disputed by the Gohramzai. Initially all land was allocated to the Gohramzai, but in an appeal to the Political Agent at the time, a portion of the landholding of the Gohramzai was allocated to the Chandia people and entered accordingly in the first settlement.

A second settlement was made in 1958. The Record of Rights[9], is based on this occasion and is administered in the Sibi Teshil Office under the name of Mouza Raza. This Mouza consists of two more villages, apart from Chandia village, Raza and Jagir. In the Record of Rights, a separate entry is made for each combination of land owner and tenant, it mentions the parcels of land owned and cultivated, their size and source of water. Copies of this record are kept with the District Commissioner Sibi and the Naib Teshildar Thalli. Though the record is open for consultation, its formulation is rather esoteric, with parcel sizes, for instance, noted down in a special version of the Hindi script.

The Record of Rights of 1958 mentions the Chandia people as being both the landlords and the hereditary tenants (lathband)[10] to the land. For several plots, different persons are being mentioned as landlord and as hereditary tenant.

However, in the field no evidence was found of hereditary tenancy arrangements. When questioned, the villagers were aware of this discrepancy between cadastral record and field situation, but they had never taken the considerable effort to correct the record of land rights.

Another source of confusion regarding the land rights, concerns the position of the Gohramzai. Some people say that officially they were obliged to pay a tax (topa), being equal to one-twentieth of the crop, to the Gohramzai. The background of this payment is probably the period before 1958, when some Gohramzai were in charge of collecting land tax from the area and in return could keep one-twentieth of the crop. The Martial Law Ordinance 64 of 1958 abolished this system, but it seems to have continued to some extent until the seventies, when the then President Zulfikar Ali Bhutto announced the termination of all such payments.

A third point of controversy is that the Chandia people claim that some of the land, which is currently registered as government property, actually belongs to them. This particularly concerns a tract of land in the downstream part of the flood channels. This occurred in 1958

[9] Land Revenue Act 1967 Section 39

[10] Hereditary tenancy is very common in flood-irrigated and rain-fed areas in Balochistan. In the past owners of large tracts of land gave the land to other persons to develop, i.e. to level and to prepare field bunds (laths). In return the tenants acquired a partial ownership in the land and a permanent occupancy right. These rights of the hereditary tenant were, however, contingent on his constant care of the land.

when village leaders, afraid of being taxed on this land, did not enter it in the Record of Rights. At the moment there is no land, with individual title, which has not been developed. Any large scale expansion of the command area would require a transfer of land title from the government. The scheme concept, however, envisages a more intensive utilization of the existing command area, instead of the development of additional land.

TABLE 17 DISTRIBUTION OF LAND RIGHTS

Ownership	Total fields owned	Total fields irrigated in 1992/1993
First Quartile	7.3%	6.6%
Second Quartile	14.8%	13.2%
Third Quartile	23.1%	25.2%
Fourth Quartile	54.7%	55.0%

Table 17 above gives an overview of the distribution of land rights. It is based on recall of key-informants in Chandia, as given in Annex C.1. Farmers in Chandia tend to measure a persons property in terms of the number of 'fields' owned. The table above does account for the different field sizes, but there is no indication to assume that these vary systematically between small and large landowners. An analysis of the land rights, as recorded in the Record of Rights, was not possible at this stage, since - in addition to the ambiguities mentioned above - the Record of Rights does not distinguish between land within and outside the command area of the Chandia flood channel. To establish this difference would require consultation with topographic and cadastral maps, this would be a time consuming exercise with little immediate benefit. An analysis of the Record of Rights for Chandia, however, is proposed at a later stage.

The distribution of land, as apparent from the table, is fairly egalitarian. The 25% largest landlords own 54.7% of the total number of fields. Moreover, between large and small landlords, there was no difference in the likelihood of receiving irrigation water, at least not in the past flood season. This egalitarian picture is confirmed by the distribution of maintenance obligations, which as explained in section 5.4, is related, though not exactly similar to, land holdings.

6.8 Water Rights

Table 17 gave an overview of land resources. This gives only a partial indication of the distribution of productive resources, since without irrigation water, the land has little value. An assessment of the fairness and robustness of the rights to the flood water needs to be made to complement an analysis of land titles.

The distribution of flood water in Chandia follows a well-established pattern. Part of the existing practices are confirmed in the misl-e-hakyat, which is part of the Record of Rights and registrars:

- the right to operate two flood channels in this mouza, the upstream one being the Chandia Wah (also called Nulla Tumni), the lower one being Raza Machi Wah;

- the distribution of flood water over three branch channels in Chandia with no permanent division between the branch channels; and

- A rule that in the monsoon, all land has to be irrigated once, before a second irrigation can be applied from the flood water.

Even with this reference in the Record of Rights, rights to the flood water are generally understood to be subject to customary law, and the misl-e-hakyat has little practical legal value. This is illustrated by the court case between the landowners of the downstream Gishkoori and the upstream Chacar. The Chacar land owners constructed a very strong bund with the aid of a bulldozer; for three years this bund did not fail nor was it broken, depriving the downstream landowners of flood water. The Chacar land owners allegedly managed to acquire more water for their area, in contravention of customary law and the Record of Rights and were utilizing it on land previously not under cultivation. In the court case, however, the Gishkoori land owners did not manage to enforce the demolition of the Chacar bund[12].

Whereas flood water rights at the level of the Chakar River are prone to different interpretations, the water distribution within the Chandia command area is relatively robust, its robustness guaranteed by the fragility of the channels, as explained in 5.3.

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[12] The details of the case were as follows: the Gishkoori landowners protested to the District Commissioner against flood water being wasted from the Chacar bund. The background was the damage to the Chacar flood channel, causing part of the diverted water to spill away. The District Commissioner ordered the Chacar landowners to destroy the present bund and build it at a location slightly downstream, digging a new link to the flood channel (beyond the damaged reach). The Chacar landlords protested against this order in court and were reinstated in their right to build the gandha at any location they desired.

Moreover, a number of practices are in place, that ensure that the distribution of flood water is fairly equally distributed and that it is not monopolized by upstream land owners:

- the practice of irrigating the whole command area, before allowing a second irrigation in the monsoon season;

- the liberty of all land owners to further excavate their channels to attract more water, however, they are constrained by the physical difficulty of doing so and the level of their land;

- the practice of families to keep land in joint ownership and distribution of lands for cultivation to individual family members, only after it has been irrigated;

- the fact that most land owners have plots in different parts of the command area, thus preventing a segregation of downstream and upstream landowners; and

- the ban on making channel bunds in the upstream section of the flood channel.

6.9 Village Amenities

Chandia village is well provided with social amenities. The village, despite its modest population size, is endowed with a number of educational facilities: a boys high school, as well as boys and girls primary schools. The total number of students is just above 100. There are 12 teachers in total giving a favourable student teacher ratio. The schools in Chandia apparently have a particularly good reputation in the area.

There is also a government appointed paramedic in Chandia, operating a small dispensary, however, for major health problems, the Chandia villagers visit doctors in Sibi. Telecommunications are well arranged, with the presence of a public call office and a small post office.

The village is also provided with electricity, there are 40 houses with electricity connections. Repairs to the wires from the transformer onwards are undertaken by the community.

Water supply is not always reliable. The water comes from a government tubewell in Talli village. The history of this drinking water supply system is interesting: it was developed by the army during the military operations in Marri territory in 1973. Afterwards it was converted for civilian use. In the flood season, however, the water supply system tends to get disrupted. During this period villagers dig fifteen feet deep wells in the bed of the Chakar river for domestic purposes.

The main shortcoming, in terms of village amenities is the access to the village. There are two dirt tracks to the village, the first from the Sibi-Talli road and the other from the Sibi-Mall road. Some work has been done by the government on the last connection, but work was never finished. In the flood season both tracks become very difficult to traverse and the area sometimes isolated for one to four weeks. In normal times, however, one daily bus operates on the route to Sibi.

7 AGRICULTURE

7.1 Overview

The existing agriculture in this area of the Kachhi Plain is based on fodder sorghum and livestock. The system that has developed is flexible and has evolved over time to account for the uncertainties of the flood water from the river. At Chandia, in addition to the fodder sorghum , mung, wheat and oilseed form important crops; sorghum has a high value when grown for fodder. Cropping intensity is very much a factor of the extent, size and number of floods and these vary from year to year.

7.2 Farm System

The basic farm system of the area is fodder sorghum and livestock. At Chandia this is combined with, pulses, oilseeds and wheat. The sorghum has high value when grown for fodder and is often inter-planted with pulses, mainly mung. Minor crops that are grown include coriander, radish and melons. Most families have a moderate number of livestock and in general, livestock are of considerable importance in the whole of the Kachhi Plain with sorghum being the major source of fodder in the summer.

The farmers follow a very basic rotation of the crops, for example; sorghum, fallow, oilseed and then frequently the first crop again. All crops are grown by deficit irrigation. The rotation will vary and in certain instances no rotation is observed. Table 18 summarises the main crops and areas and reflects a favourable year under the existing system.

The farmers of Chandia have developed a number of agricultural and household practices to reduce risk associated with subsistence farming in what is a relatively harsh environment. The simplest strategy is the diversification of crops, most landowners and tenants grow a mixture of cereal, pulses, cash and fodder crops throughout the year. Additional cropping strategies include the selection of fodder as the main crop, which has good marketing prospects and attracts less risk than producing a grain; intercropping the fodder crop with pulses also spreads risk. Land and water management strategies to manage risk, include fragmentation of land holdings, this is an important consideration in obtaining access to water and different soil types; soil texture is used to determine crop type. Cultivation strategies include farmer preference to irrigate increased areas, the use of hand drills to facilitate deep sowing of seeds. Poor landlords without draft animals and adequate access to credit will prefer to use tenants with access to animal traction.

TABLE 18 MAIN CROPS IN THE EXISTING SCHEME

CROP	AREA* (acres)
Sorghum	231
Sorghum and Mung	131
Oilseed	94
Wheat	71
Fallow	299
Sub-total Irrigated Land	826
Bunds or Irrigation Structures	70
Total Area	896

* These areas represent a favourable year, estimated to be a 1 in 10 year event

Sorghum is grown primarily as a fodder crop and is ratooned, the first cut green, with the second crop grown for the grain with the stalks cut as dry fodder. A third crop is sometimes possible which is allowed to grow again for green fodder, this last crop being dependent on the availability of spring rains which are very variable. As the sorghum is ratooned the crop gives a high rate of return on investment. Some sorghum grain is retained for home consumption, in particular to make bread.

Sorghum and Mung The sorghum is frequently interplanted with a pulse crop which is normally mung or moth, the haulm of which is used for, and sold as fodder. This combination of crop is attractive in terms of return on investment, risk spreading and use of available water. Second irrigations are rare as the farmers perceive there is a risk of damaging the crop. Farmers view the mung crop favourably.

Oilseed The main rabi cash crop is oilseed, which is mainly mustard with some rapeseed. The mustard leaves are used as a vegetable and if crop development is very poor the crop may be turned into fodder.

Wheat Farmers traditionally plant the wheat on the finer textured land and this is often reserved specifically for the crop; farmers will often plant in the same place for many years. Farmers are aware of improved varieties, but as these are difficult to obtain, tend to use traditional varieties. Much of the wheat is sold and in the case of richer farmers and villagers, a superior tasting wheat is purchased as a replacement. Most farmers take the view that wheat was their riskiest crop.

Minor crops grown in the area include coriander, melons, and vegetables.

Livestock form an important enterprise in the area although the livestock holding is moderate at Chandia with animals kept for home consumption and draft. There is a large demand for fodder in the surrounding area and most crops are grown to satisfy this demand or have a dual purpose. Livestock form an important source of income and food, but also represent an area of risk, particularly associated with draft animals which represent a significant investment and are at risk in time of drought. In dry years, bullocks are moved to other areas where fodder is available. The risks associated with keeping these animals is also managed by renting and through other exchange mechanisms. Most farmers will keep goats, and sheep for home consumption and for an occasional sale. The main draft animals are bullocks and following the normal course of events they are bred. The importance of this activity is difficult to establish in detail as often bullocks are bred for use in the family farm enterprise. In addition, this activity is mainly managed by the women of the village. Some donkeys are kept for carting and milling wheat grain for flour. One or two milk cows are often kept for butter and milk. Livestock also provide an important source of fuel as the dung is dried and burnt, and as a consequence, very little farm yard manure (FYM) is applied to the land.

7.3 Agricultural Inputs

Inputs are limited to supplies of traditional seed, although some certified rape seed is used. No fertiliser is used as the farmers are convinced that the soil does not require fertiliser, little FYM is used, being mainly burnt or used on the vegetable crops. The wheat variety has been developed locally and the farmers are happy with the performance of the crop. When rape is grown the seed is nearly always certified and is brought from Sibi. The crop calender is shown in Figure 15 (a). The crop calender follows the kharif and rabi plantings, the dates of the plantings will vary slightly and are dependent, to an extent, on farmer perceptions on the arrival and the amount of flood water.

The control of pests and disease is limited to intervention at minimal cost by the Department of Agriculture (DoA) when there is a problem.

Farm mechanisation is limited to a small number of tractors with limited tackle; the bulk of the land is prepared using bullocks. Normally, one ploughing is performed, this is occasionally followed by a planking to level the land. Most drilling is undertaken with the use of a hand drill or sown behind the plough to ensure deep sowing which is an important feature of farming in the area.

Post harvest threshing mainly follows the traditional methods of using draft power to assist the removal of the grain or pulse from the head or pod and hand winnowing is performed for the removal of the chaff. Chandia village does have one mechanical, tractor driven thresher.

Labour

The family provides the main source for farm labour and there are no shortages of labour, the demand during harvest and other peaks being met through the hiring of labours. There are no changes in the rate of remuneration. The marked seasonal labour peaks at Chandia are shown in Figure 15 (b) and correspond to the planting and harvesting times.

Credit

Credit is a feature of the economic system of Chandia and surrounding area. Credit is obtained from Hindu traders, although the existence of this practice is frequently denied, but its importance to the local economy and in particular, the poorer part of the community, should not be underestimated. The credit is often advanced in the form of seed provided to the farmers. The interest charged is often very high (see section 6.5). One explanation for this would be that the lenders are also the risk taker and depend very much on the season for the return on their investment. The traders will also exercise considerable caution in lending when assessing the ability of the farmers to grow a satisfactory crop and therefore a return on their investment. Unfortunately, with the vagaries of the climate and the flood irrigation practised, it is not unknown for the very poor farmers to be refused credit which directly impacts on their ability to feed themselves.

FIGURE 15 (a)

CROP CALENDER

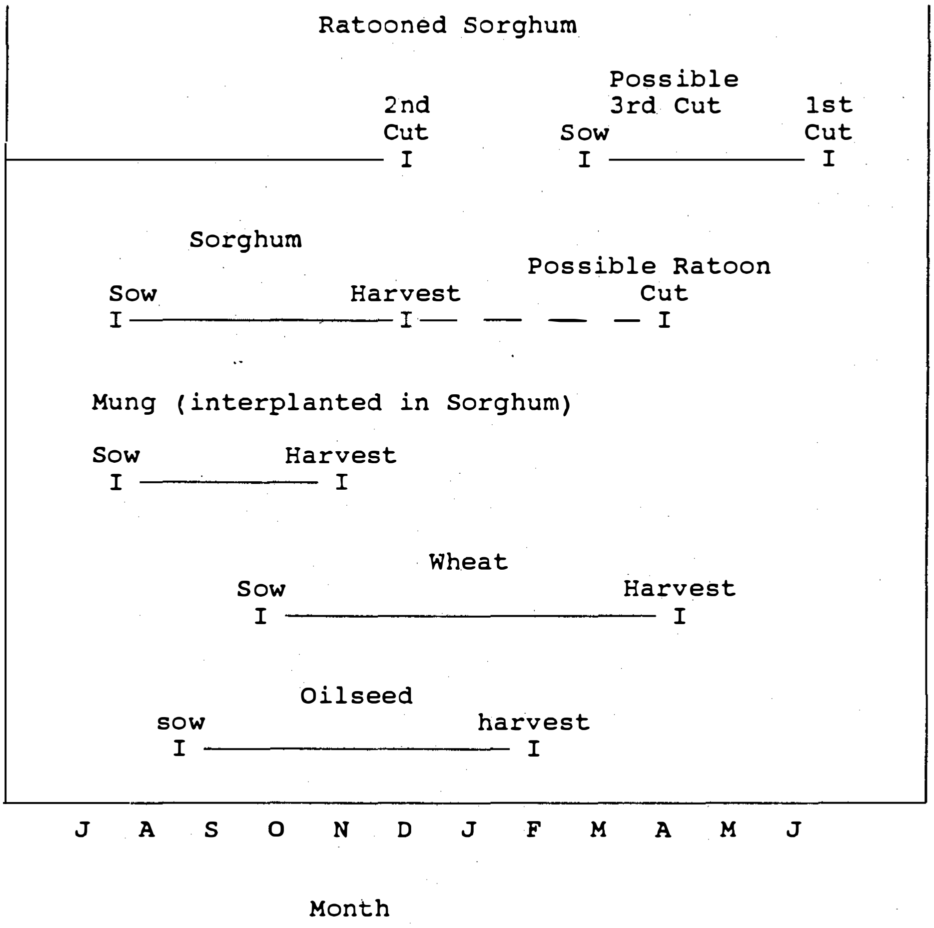
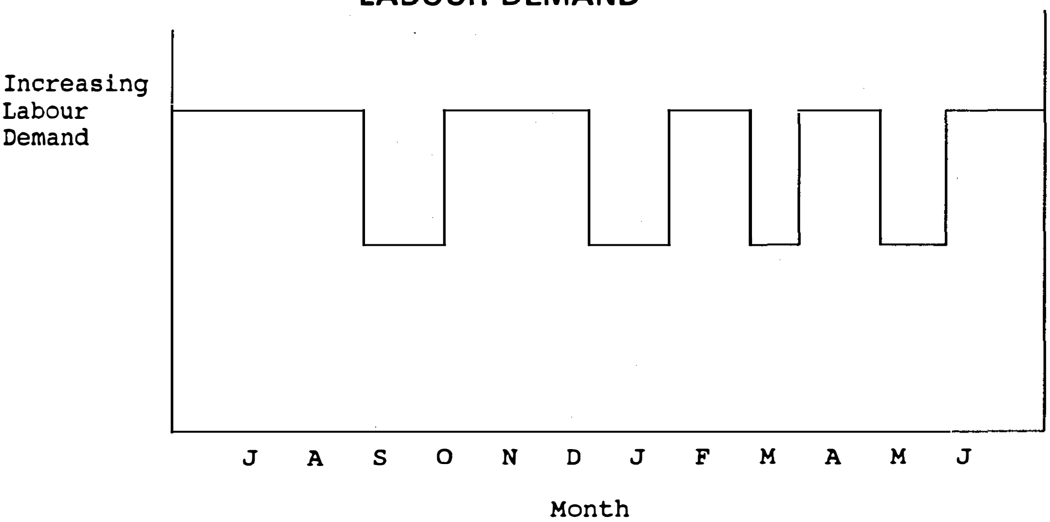


FIGURE 15 (b)

LABOUR DEMAND



7.4 Farmer Priorities

The farmers were interviewed to asses their priorities and these were found to differ with their income status. The richer farmer's priorities were for a dam to store water and the poorer farmers for easier access to a bulldozer to repair the existing bund more quickly. Both types of farmers perceived the need for a second irrigation and improved water availability to achieve this. Conversely, most farmers also stated they would prefer to irrigate a larger area rather than put on a second irrigation. This, in general terms, would be associated with their apparent risk reduction approach to farming and would be unlikely to change in the foreseeable future. All farmers perceived the need for land saving technology and most stated they would use improved varieties of seed if they became more freely available and would use fertiliser if they could see the benefits of its use.

7.5 Markets

The main market for produce from the scheme is Sibi which handles all fodder and grains, with the other market for the area being Quetta. Access to the markets is restricted in times of poor weather, although little marketing activity would occur during this period as land preparation would be the farm priority.

The Sibi junction is an important railway station for the transport of grains from the Kachhi area to the markets of Punjab.

There is a substantial market for fodder in Sibi where the majority of public transport is horse drawn and from urban dairy cows. In addition, the surrounding villages have considerable numbers of livestock and the town lies on the traditional route of the nomads which pass from the winter grazing in the Kachhi Plains to the summer grazing in the mountains. They frequently buy fodder to supplement the range grazing.

Currently, there are ten Commission Agents dealing in fodder, and approximately 200 tonnes of green wheat and barley fodder are sold every day during the early part of the year when these crops are cut. This volume of trade is said to be repeated during the sorghum fodder season. The price of fodder is currently regulated by the District Commissioner, as a result of pressure from local farmers. When this occurs, which is said to be most years, a standard price is applied to all types of fodder and is the same whether it is being bought or sold. The Commission Agents then take their percentage from the seller in the form of fodder, for example 10kg in 50kg. Farmers normally transport the fodder to Sibi themselves. Some fodder is grown on a contract basis, this fodder (wheat, barley or oats) is then normally taken to Quetta.

Much of the grain grown in Chandia is handled by Hindu traders who purchase the grains from the farmers. In addition, some grain traders also cart the grain from the village back to Sibi and supply the necessary labour, reducing the inputs from the farmers. The grains and pulses grown at Chandia are sometimes stored for a period before the traders arrive to purchase the grain. This can often be 1 to 2 months and the grain is stored in large (6-8 feet high) clay bins. The grains may also be stored by commission agents, but for a shorter period, often only 10-15 days. This is done to try to catch any rise in price, as there can be fairly wide fluctuations in the market price, in particular the price of sorghum grain. Market information is obtained on a daily basis by telephone from contacts in the main markets the traders sell to.

7.6 Existing Constraints

The continuous practise of using self produced seed does lead to problems of disease and viability. In addition, the use of one area continually for one crop, according to farmers, has led to an increase in the incidence of disease and pest attack. Demonstration plots could be used to improve knowledge on planting density and could also be used to good effect to demonstrate the impact of improved varieties, importance of good seed and the effect of fertilisers.

7.6.1 Soil Management

There are a number of management improvements which would be expected to have a significant impact on the crop production in the project area, these include:

- Land levelling is currently poor which leads to patches of uneven local relief and unequal distribution of water;

- The soils are highly susceptible to erosion due to their textures and weak structures. Structures could be improved by an increase in the organic matter by manuring;

- Workability of the heavier Kachhi and particularly Bhag soils is reduced by the presence of swelling clays, which crack and become very hard when dry and plastic and sticky when wet. Ploughing should be performed at an appropriate soil moisture content. In Bhag soils, cracking can become serious with crops suffering some root damage; and

- All soils are highly calcareous, which may contribute to surface crusting. This can be overcome by using acidic nitrogen and phosphorous fertilizers and appropriate ploughing.

7.7 Data Collection Methodology

Data on farmer practices, yields and estimates of cropped area were collected by farmer interview and by transect survey to establish the area of existing crops. The transect data was collected following existing methodologies developed for the Phase I Monitoring and Evaluation exercise[13]

Yield data was based on farmer recall and cross questioning with follow up visits, however, yields directly related to area were difficult to establish and published data was also taken into account. This method has been used successfully elsewhere in Pakistan[14].

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[13] Field Manual for Transect Survey of Crop Area Estimation, Impact Evaluation Study Number 15, BMIADP, Government of Balochistan, 1991.

[14] Crop Yield Estimation Methodology Study Rabi 1986-87, Planning and Investigation Publication No. 315, Watercourse Monitoring and Evaluation Directorate, Planning and Investigation Organisation, Planning Division, Water and Power Development Authority, Pakistan, August 1987.

8 OBJECTIVES

8.1 Scheme Goal

The goal of the development is to contribute to the economic growth of the village, through the development of sustainable irrigated agriculture by reducing the uncertainty of the source of flood irrigation water and contributing to sustainable self sufficiency by encouraging farmer participation and enabling land users to improve crop production.

8.2 Scheme Objectives

The objectives of the scheme are to improve the availability and control of flood water for irrigation, improve the delivery of agricultural inputs and services, encourage farmers to participate in the development of their land, improve the maintenance of the irrigation infrastructure, and stimulate the entrepreneurial and communal activities at the village level through a Water Users Association (WUA) and extension activities. The scheme will have a high degree of financial and institutional autonomy.

8.3 Scheme Outputs and Indicators

The proposed development improves the reliability and availability of water. The median water availability should improve from 855 acre ft (1.1 Mcm) to 3683 acre ft (4.6 Mcm) and will result in an increase in the median cropped area from 205 acres, in the without project situation, to 883 acres in the with project situation. The WUA is expected to facilitate and improve the distribution and management of water and agricultural inputs. Recurrent maintenance will follow the existing organisation but will be based on the WUA which will have improved access to capital via their maintenance fund to facilitate satisfactory operation and maintenance.

9 PROJECT IMPLEMENTATION

9.1 Overview

The development will result in the establishment of an improved water supply to an existing traditionally developed scheme. Land users will be encouraged and enabled to expand and diversify crop production and will fully participate in the development. The development initiative aims to augment the incomes of the farmers to assist them to develop the proposed increased command area. Implementation will focus on improving the availability of water and providing extension and institutional support to facilitate improved crop production techniques and will stimulate entrepreneurial activities at the village level.

A summary logical framework of the proposed project and its implementation is shown in Figure 16.

9.2 Links to the Main Project

The implementation of the scheme will be managed through the Project Management Unit and implementation will be coordinated through the Farmer Support Unit (FSU) which will be able to draw on project and Government of Balochistan (GoBAL) resources.

Funds to cover the capital cost for implementation of the scheme will be made available through the Flood Irrigation sub component of the Infrastructure Development Component. The resources required for the agricultural development of the scheme will be channelled through the Farmer Support Unit from the Agricultural and Social Development Component. The component will provide the foundation for sustainable development through the provision of scheme extension inputs, training, opportunities for business development, encouragement of farmer participation and improved water management and agricultural practices. The principle unit directing resources at scheme level will be the Field Services of the FSU (Figure 17).

Assistance for the development of the WUA will be delivered through the Field Development Organiser of the Field Services section of the Farmer Support Unit. This will aid the development of the WUA committee and improve the maintenance of the scheme.

FIGURE 16 LOGICAL FRAMEWORK

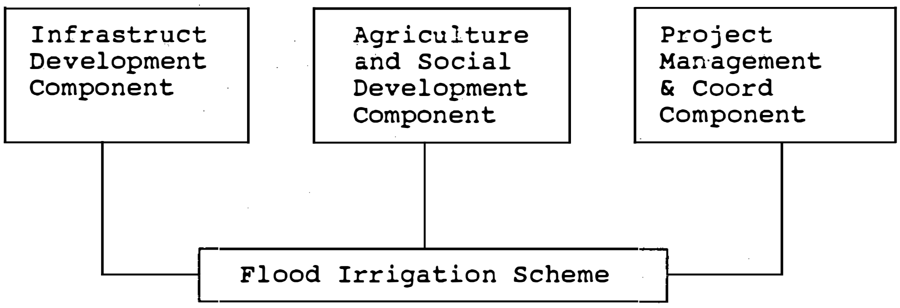
CHANDIA FLOOD IRRIGATION SCHEME LOGICAL FRAMEWORK SUMMARY

Narrative Summary	Indicators	Assumptions	Process	Inputs
Goal				
To contribute to economic growth through increased economic productivity from irrigated land (by reducing uncertainties of water availability and improving sustainability) and by farmer participation.	Uncertainties associated with water availability are reduced, incidence of poor years reduces	Proposed scheme is socially acceptable	Landowners are encouraged and enabled to improve flood irrigation systems.	Project assistance to develop the scheme.
		Farmers are willing and able to participate	Landowners and water rights holders form Water Users Associations to gain access to the project.	Assistance from Field Development Organisers of Farmer Support Unit.
	Increased area of crop production	Farmer uptake of improvements in technology	Land users receive advice to improve irrigation and agricultural practices.	Field Services and Field Services Support from project.
Objective				
a) Improve existing traditional flood irrigation system to improve water availability to the scheme and allow more controlled use of the floods.	Median water availability increases from 855 acre ft to 3683 acre ft. Median crop production area increases from 205 acres to 883 acres.	Water is available, scheme is socially acceptable and economically viable	Identify soil and water resources, conduct social and economic surveys.	Planning, design and construction, assistance in extension and after care programme.
b) Encourage land users to actively participate in the development of their own land and contribute to the sustainability of the scheme.	WUA and other interest groups formed are effective; maintenance is effective and contributions to maintenance funds are kept up.	Land and water users are involved in all levels and are part of the decision making process, and the WUA is representative of the community.	WUA formed and assisted, contributions to design and construction, development of command area.	Training and assistence through Farmer Support Unit.
		Women are willing and able to take part in the decision making process.	Women's Self Help Group formed to facilitate their input as water users into the WUA and scheme development.	Assistance from W&D team
c) Improve the delivery of agricultural and irrigation inputs and services to farmers and land users, improve farm practises and economic efficiency of the scheme.	Use of inputs such as fertilisers, pesticides improved varieties, improved farm practises, improved production, an additional acres of land are brought into production.	Awareness of benefits of improved inputs are available and the required quantity, farmers have the finances and ability to use the inputs, the WUA and extension services are effective.	Identify constraints, source inputs, involvement of WUA, awareness programme.	Input and Marketing support to facilitate as necessary improved delivery of inputs.
d) Encourage business development opportunities that sustain the development initiative.	Commercial activities of the farmers increase and benefit from the scheme.	Market for produce continues, effective extension process.	Extension work and possible follow on project to develop improved marketing or supply of improved inputs.	Business development assistance and market information.
e) Conduct a pilot study to establish a strategy to reduce the incidence of malaria.	Introduction and use of bed nets, reduction in the incidence of malaria.	Villagers willing to use bed nets. Blood film slide facilities available.	Women & Development team to introduce study.	Impregnated bed nets.

It is anticipated that the WUA will initially be involved in organising extension advice, marketing of produce and bulk purchase of supplies and that, with assistance from the Field Services and Field Services Support sections, this role will eventually be taken over by a farmers organisation. The initial provision for technical advice on extension will be provided by the Field Services Support section through the Field Services of the project and the Agricultural and Social Development Component, which will provide advice and training via a Field Extension Organiser. The main point of contact at scheme would be the Village Development Agent appointed by the WUA.

FIGURE 17

MAIN PROJECT COMPONENTS



The presence of an identifiable WUA that represents the village will improve project links and project accountability to the scheme. The WUA should also enable the village community to directly participate in the design and facilitate contributions to the implementation of the scheme.

9.3 Proposed Irrigation Improvements

The objectives of the proposed rehabilitation of the Chandia Flood Irrigation Scheme are summarized below:

- to enable the farmers to utilize the small and medium floods in the Chakar River more efficiently, whilst the high floods are allowed to pass virtually unchecked;
- provide sediment control measures;
- regulate flows into the flood channel to prevent flood damage in the command area and;
- ensure existing downstream users continue to receive their share of the flood waters.

These objectives will be achieved by the construction of a permanent headworks structure and the provision of equipment for re-building the breachable bund. There are no plans at this stage to modify the main flood channel or the infield distribution system, though by limiting the diversion flows, the incidence of flood damage to channels and other infrastructure will be reduced and also the amount of sediment entering the system will be less; thus making it easier for the farmers to distribute the flood water.

The proposed offtake structure is on the left bank of the Chakar River on the same site as the existing free intake to the Chandia flood channel. The position of the offtake on the outside of a gentle bend is ideal for sediment control. The nominal design capacity of the regulator at the head of the flood channel is 500 cusecs, when the upstream water level is at weir crest level.

Two alternative levels of intervention have been considered; the first involves the construction of a regulator at the head of the flood channel to prevent high flood flows entering the system, river training works to reduce the incidence of widespread flooding, the construction of a breachable bund across the river and the provision of a bulldozer to facilitate the timely re-building of the bund. This option represents the minimum level of development that is likely to offer any improvement over the existing system.

The second, preferred, option provides greater control over the flood flows and reduces the annual maintenance requirements. In addition to the components listed in Option 1, it also includes the construction of a 150ft long concrete weir and a gated sand sluice.

Preliminary designs have been prepared and costed for both options in order to compare the rates of return.

9.4 Minimum Intervention Option 1

This minimum intervention option would comprise the following components:

- a regulator at the head of the flood channel to restrict the diversion flows;
- a breachable bund extending across the river;
- river training works and flood protection bunds and ;
- the provision of a bulldozer to facilitate the re-building of the breachable bund.

The general arrangement of the diversion works is shown in Drawing Number CHA/FS/101/1.

The flood channel head regulator is designed to limit offtake flows using a double orifice arrangement, which increases the head loss across the structure once the flow exceeds the design discharge of 500 cusecs. The sill level on the regulator is 492.1ft, which is 2ft above the nominal river bed level and the maximum flood level is 500.1ft. The stage/discharge relationship for the structure compared with an open flume arrangement with no head wall is given in Table 19. Sections through the proposed structure are shown in Drawing Numbers CHA/FS/102/1 and 103/1.

The breachable bund extends from the abutment wall on the head regulator across the river to the flood protection bund on the right bank. The length is approximately 900ft and the nominal top level is 500ft. The bund would be formed from the in situ bed material, which is pushed up using a bulldozer with nominal compaction, thus ensuring that it fails before the flood protection bunds down either side of the river.

The existing flood protection bunds would be raised and strengthened. Upstream of the headworks the top level would be 503ft and downstream it would be reduced to 497ft. Additional protection would be provided at vulnerable points by the construction of spurs to deflect flood flows away from the toe of the bunds and the strategic planting of indigenous vegetation such as tamarix aphylla. The use of tamarix for flood protection is well documented and has been used in similar situations as is proposed for the Chandia Flood Irrigation Scheme, notably in the Republic of Yemen and it is proposed the concept be adapted and developed further at the detailed design level. An extract from The World Bank Staff Appraisal Report for the Second Land and Water Conservation Project detailing the use of tamarix for flood protection is included as Annex D.1.

TABLE 19 **COMPARATIVE STAGE/DISCHARGE FOR DIFFERENT HEAD REGULATORS**

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGAION SCHEME
COMPARITIVE STAGE/DISCHARGE CHARACTERISTICS FOR DIFFERENT HEAD REGULATORS
(File ref: CHANOFF)

1. Double orifice (heights 3 and 2ft) canal head regulator
2. Single orifice (height 2ft) canal head regulator
3. Canal head regulator with no head wall

Characteristics		
Total width		33 ft
Sill level		492.1 ft
Flume coeff		3
Orifice 1 -	Coeff	.8
	Height	3 ft
Orifice 2 -	Coeff	.7
	Height	2 ft

Stage	U/S Depth (ft)	Double Orifice Discharge (cusecs)	Single Orifice Discharge (cusecs)	No Head Wall Discharge (cusecs)
492.1	0	0	0	0
492.6	.5	35	35	35
493.1	1	99	99	99
493.6	1.5	182	182	182
494.1	2	280	280	280
494.6	2.5	391	391	391
495.1	3	514	514	514
495.6	3.5	506	586	648
496.1	4	555	642	792
496.6	4.5	599	694	945
497.1	5	641	742	1107
497.6	5.5	679	786	1277
498.1	6	716	829	1455
498.6	6.5	751	869	1641
499.1	7	785	908	1834
499.6	7.5	817	945	2033
500.1	8	847	981	2240

The bed material in the Chakar River at the proposed headworks site is comprised almost entirely of fine sand and silt. In wet conditions, it is impossible to use wheeled plant in the river and since the timely reinstatement of the bund is essential, a small low ground pressure (LGP) bulldozer would be provided as part of the project to ensure that the bund can be re-built after each flood.

The performance of the diversion works described in Option 1 does not differ significantly from the existing system, except that the offtake flows are controlled and equipment is made available for re-building the breachable bund quickly. During small floods, up to a flow rate of 500 cusecs, the entire discharge in the river would be diverted down the flood channel. As the flow in the river increases further, the water level upstream of the headworks would rise until it overtops the breachable bund. At this point the flow down the flood channel would be 847 cusecs. Once the bund overtops, it would breach and the water level in the river would drop rapidly, though so long as the level remained above 492.1ft some water would still flow into the flood channel. However, once the river level falls below the regulator sill level, it is essential that the breachable bund is re-built as quickly as possible. Initially it would not have to be to its full design height, but just enough to divert all the flow back into the flood channel. On average the bund is likely to be breached 2.8 times during the year and if the potential benefits are to be realized, it is essential that the bund is repaired as quickly as possible.

Although Option 1 represents a relatively inexpensive solution, there are a number of shortcomings with the design and operation of the headworks which are summarized below:

- there is no provision for sediment control;
- the breaching of the bund occurs so frequently that the incremental flows into the flood channel are only marginally better than the without project situation;
- there is no facility for releasing water to downstream users without destroying the bund and;
- there is a high maintenance requirement involving not only the re-building of the bund, but also the removal of accumulated silt from the flood channel and the approach to the head regulator.

The river channel and different designs of offtake have been modelled in order to predict the likely diversion flows. In the case of Option 1, the increase in the volume of water is only sufficient for irrigating an additional 73 acres of land annually and as such the incremental crop production benefits cannot justify the high capital investment. For this reason Option 1 is not recommended.

9.5 Preferred Option 2

The civil works for this option comprise the following:

- a 150ft long weir with a design discharge equivalent to a 1 in 2 year flood;
- a gated sluice channel to reduce the ingress of silt into the flood channel and prevent the accumulation of sediment in front of the flood channel intake;
- a breachable bund extending across the remainder of the river;
- a double orifice head regulator to restrict the flow into the flood channel during high floods;
- settling basin at the head of the flood channel;
- river training works and flood protection bunds and ;
- the provision of a bulldozer to facilitate the re-building of the breachable bund.

A layout plan of the river and headworks area for Option 2 is given in Drawing Number CHA/FS/101/2 and a more detailed general arrangement of the weir and diversion structure is shown in Drawing Number CHA/FS/102/2. The main difference between Options 1 and 2 is the provision of the weir and sluice channel which significantly improves the performance of the headworks.

The proposed concrete weir is 150ft long and extends about a third of the way across the nominal width of the river. The high flood level is 5ft over crest level and the corresponding discharge is 5,200 cusecs. The flow characteristics over the weir provide good energy dissipation and a short USBR Type III stilling basin is proposed. The right bank abutment of the weir is situated in the main river channel and as such is vulnerable to scour when the breachable bund fails. The foundations of the abutment have been set 21ft below the nominal bed level.

A sluice channel between the weir and the canal head regulator is provided for sediment control. The configuration of the converging approach channel, skimming weir intake into the head regulator and sluice channel are based on model tests undertaken previously for another project. The skimming weir is set 2ft above the invert of the approach channel, so that during floods the bed load material is carried past the intake and through the sluice channel. The converging approach channel also induces a helicoidal current in the flow through the sluice, which tends to carry sediment away from the intake. After floods which have not caused the breachable bund to fail, the sluice channel would flush out any sediment that has accumulated in front of the intake and ensure that the low flow channel is maintained on the left bank of the river. The sluice channel is 9ft wide and the invert level is 5ft below the weir crest level. The flow is controlled by a manually operated steel gate, though as part of the detailed design, consideration would be given to the use of automatic or semi-automatic gates which open automatically when the water upstream reaches a predetermined level, but they would have to be re-set manually. An angled head wall is provided immediately upstream of the gate to limit the flow through the sluice during high floods; protect the gate lifting mechanism and also deflect floating vegetation through a 20ft wide spillway in the guide pier. The side spillway will adversely effect the performance of the sluice channel as a means of sediment control and the relative benefits of providing this facility will be investigated during the detailed design stage. The top level of the guide pier is 497.1ft, and during high floods water will pass over the top of the pier.

Even with the proposed sediment control measures, a certain amount of sediment is still expected to entre the flood channel and in order to trap the coarser material, a settling basin would be provided at the head of the canal. The provisional dimensions of the basin are: length 492ft, width 62ft and depth 8.5ft.

The design of the head regulator is identical to Option 1, though because of the weir and sluice facility the operation and performance will be improved.

The design and specifications of the flood protection bunds, spurs and other river training works are identical to those proposed in Option 1. Similarly the breachable bund will have the same top level and cross section, though it will be slightly shorter because of the concrete weir.

Preliminary design details for the headworks Option 2 are given in Drawing Numbers CHA/FS/103/2, 104/2, 105/2 and 106/2. The stage/discharge relationship for the various components of the diversion works are given in Table 20. The system capacity at the high flood level of 500.1ft is 7600 cusecs, which is slightly greater than a 1 in 2 year flood, thus the breachable bund is expected to fail once in two years. The performance of the diversion during a flood event is summarized in Table 21 for different flow rates in the river.

TABLE 20 STAGE/DISCHARGE RELATIONSHIP FOR HEADWORKS

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
STAGE/DISCHARGE RELATIONSHIP FOR HEADWORKS
(File ref: CHANHWK)

Weir Characteristics	
Weir length	150ft
Weir coeff	3.1
Crest level	495.1ft
Sluice Channel with Head Wall	
Sluice width	9ft
Flume coeff	3
Orifice coeff	.7
Invert level	490.1ft
Head wall soffit	495.1ft
Side Spillway	
Spillway width	20ft
Spillway coeff	2.8
Crest level	495.1ft

Double Orifice Canal Head Regulator	
Offtake width	33ft
Flume coeff	3
Orifice 1 coeff	.8
Orifice 2 coeff	.7
Invert level	492.1ft
Orifice 1 soffit	495.1ft
Orifice 2 soffit	494.1ft
Flow over Guide Pier	
Length	36.5ft
Flow coeff	2.2
Top level	498.1ft

Stage (ft)	Sluice Discharge (cusec)	Weir Discharge (cusec)	Channel Offtake (cusec)	Side Spillway (cusec)	Guide Pier (cusec)	Total Discharge (cusec)
490.1	0	0	0	0	0	0
490.6	0	0	0	0	0	0
491.1	0	0	0	0	0	0
491.6	0	0	0	0	0	0
492.1	0	0	0	0	0	0
492.6	0	0	35	0	0	35
493.1	0	0	99	0	0	99
493.6	0	0	182	0	0	182
494.1	0	0	280	0	0	280
494.6	0	0	391	0	0	391
495.1	0	0	514	0	0	514
495.6	348	164	506	2	0	1021
496.1	397	465	555	11	0	1428
496.6	447	854	599	31	0	1932
497.1	500	1315	641	63	0	2519
497.6	555	1838	679	111	0	3183
498.1	593	2416	716	291	0	4016
498.6	619	3045	751	367	28	4810
499.1	644	3720	785	448	80	5677
499.6	669	4439	817	535	148	6606
500.1	692	5199	847	626	227	7592

Note: Sluice gate remains closed until upstream water level reaches weir crest level (495.1ft), it is then fully opened.

TABLE 21 PERFORMANCE OF OPTION 2 DIVERSION FOR VARIOUS RIVER FLOW RATES

River Discharge (cusecs)	U/S River Stage (ft)	
0 - 500	490 - 495.1	All flow diverted into flood channel
500 - 802	495.1	Stage maintained constant by progressively opening gate on sluice channel
802 - 7600	495.1 - 500.1	Flow over weir and side spillway, also increasing flow through sluice channel and canal head regulator
7600	500.1	Breachable bund overtops and fails
> 7600	variable	Water level drops as bund fails, but if flood continues to rise the river level will also increase

Once the breachable bund has failed, the water level in the river would drop rapidly and as the flood recedes the level would fall below the sill on the head regulator. Consequently it is essential that the breachable bund is repaired as quickly as possible. Since the bed material is unsuitable for wheeled equipment when saturated, the intention is to provide the farmers with a small LGP bulldozer which can operate in muddy conditions. In order to prevent the low flows hindering the re-building of the breachable bund, the flow would be funnelled through the sluice channel, until the bund was sufficiently high to divert all the flow into the flood channel, then the sluice gate would be closed. It is essential that the breachable bund is then reinstated to its design height. The design philosophy for Option 2 is given in Annex D.2.

The Option 2 diversion has a number of advantages over Option 1 and these are summarized below:

- on average, the breachable bund will only fail once in two years;
- there is provision for releasing water to downstream users;
- the by-pass facility provided by the sluice channel will make it easier to reinstate the breachable bund;
- the system will continue to perform at optimum level until such time as the bund fails;
- the volume of water diverted and thus the potential irrigable area is considerably greater than option 1; and

- the measures to prevent sediment deposition in front of the intake and in the flood channel will significantly reduce annual maintenance.

In view of these advantages, and the fact that Option 2 offers a substantially higher rate of return it is recommended that the diversion Option 2 be adopted.

9.6 Crop Water Requirements

The conventional method of estimating the project irrigation water requirement is not applicable to flood schemes where in most years, irrigation water is applied only once. The availability of irrigation water is normally less than optimum and the main factors affecting the amount of water available for plant growth are the depth of water applied during the initial irrigation and the depth and moisture holding characteristics of the soil. In order to give an indication of the deficit and hence the likely crop yields, the optimum crop water requirements have been compared with the actual soil moisture available.

The mean daily reference crop ETo, has been calculated using the mean monthly climatic data for Sibi, which is 13 miles west and at a similar altitude to the scheme. The mean annual ETo is 91.26 inches (2318mm), with peak daily values ranging from 0.11 inches (2.8mm) in December to 0.46 inches (11.7mm) in June. The mean monthly climatic data for Sibi, together with the mean monthly ETo and for comparison peak daily reference crop evapotranspiration, defined as the maximum value that is likely to occur in 3 years out of 4 are given in Table 22.

For the purposes of assessing the crop water requirement, the contribution from rainfall is so low and erratic that it has been ignored. The crop water requirements, for the various crops included in the proposed cropping programme, have been derived by applying the crop factor Kc for the different growth stages, to the mean daily reference crop evapotranspiration ETo. The crop factors are based on the values given in FAO Publication 24[15] for optimum plant populations, but with modifications to take account of mid-month planting. However, in practice, the planting density is likely to be less than the optimum and since the ground is kept reasonably weed free, the moisture available to individual plants will be greater than predicted. The net crop water requirements in terms of depth of application and volume per acre (acre ft) are given in Table 23.

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[15] Guidelines for Predicating Crop Water Requirements; FAO Irrigation and Drainage Paper 24 1984.

TABLE 22 REFERENCE CROP EVAPOTRANSPIRATION (ETo) FOR SIBI

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
MEAN MONTHLY CLIMATE DATA AND MONTHLY REFERENCE CROP EVAPOTRANSPIRATION (ETo) FOR SIBI
(File Ref: CLIMCHA)

Latitude: 29.55 deg North
Altitude: 436ft

	Mean Daily Temperatures Maximum (deg C)	Minimum (deg C)	Mean Relative Humidity (%)	Mean Daily Sunshine (hrs)	Mean Wind Speed (m/s)	Mean Monthly ETo (mm)	Peak Monthly ETo (mm)
Note	1	1	1	1	1	2	3
January	21.5	6.1	46	7.4	.77	80	88
February	24.7	9.6	40.5	7.9	1.03	105	116
March	30.6	15.4	43.5	8.4	1.24	163	179
April	37.5	21.6	27	9.1	1.37	223	245
May	43.3	27.4	25	9.6	1.71	295	325
June	45.3	30.8	31	11.8	2.01	319	351
July	42.3	30.8	45.5	10.1	2.18	295	325
August	40.8	29.6	50	10.2	1.88	263	289
September	40.1	26.5	42	10.9	1.33	221	243
October	36.8	18.8	30.5	10.3	.94	169	186
November	30.5	12.1	35	8.9	.68	106	117
December	24.3	7.2	41.5	7.7	.6	79	87

Notes:
1. Mean monthly climatic normals (Ref: Meteorological Department - Karachi)
2. Mean monthly ETo determined using CROPWAT 5.2 program based on Penman Method (Ref: FAO 24)
3. Corrected peak daily ETo defined as the maximum ETo that is likely to occur in 3 years out of 4 (Ref: FAO 24, fig 10)

TABLE 23 CROP WATER REQUIREMENTS

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
OPTIMUM CROP WATER REQUIREMENT
(File Ref: IWRCHAN)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EVAPOTRANSPIRATION (based on data for Sibi)												
Mean Daily ETo (mm)	2.59	3.15	5.26	7.43	9.5	10.62	9.51	8.47	7.37	5.44	3.52	2.54
Mean Monthly ETo (mm)	80	105	163	223	295	319	295	263	221	169	106	79
Peak Daily ETo (mm)	2.85	4.13	5.79	8.17	10.45	11.68	10.46	9.32	8.11	5.98	3.87	2.79
RAINFALL (Sibi)												
Monthly 50% exceedance (mm)	5	6	5	2	0	0	22	11	0	0	0	0
Monthly 80% exceedance (mm)	0	0	0	0	0	0	3	0	0	0	0	0
SORGHUM INTER-CROPPED (SPRING PLANTED) (50% nominal plant population)												
Crop Coeff - plant crop			.09	.26	.43	.18						
first ratoon							.18	.26	.43	.50	.25	.18
Net Mean Daily IWR (mm)	.00	.00	.47	1.93	4.09	1.91	1.71	2.20	3.17	2.72	.88	.46
Net Mean Daily Volumetric IWR per Acre (cu ft)	0	0	68	276	584	273	245	315	453	389	126	65
MUNG INTER-CROPPED (SPRING PLANTED) (50% nominal plant population)												
Crop Coefficient			.18	.35	.53	.35						
Net Mean Daily IWR (mm)	.00	.00	.95	2.60	5.04	3.72	.00	.00	.00	.00	.00	.00
Net Mean Daily Volumetric IWR per Acre (cu ft)	0	0	135	372	720	531	0	0	0	0	0	0
SORGHUM AND MUNG (SPRING PLANTED)												
Crop Coefficient	0	0	.27	.61	.96	.53	.18	.26	.43	.5	.25	.18
Net Mean Daily IWR (mm)	.00	.00	1.42	4.53	9.12	5.63	1.71	2.20	3.17	2.72	.88	.46
Net Mean Daily Volumetric IWR per Acre (cu ft)	0	0	203	648	1303	804	245	315	453	389	126	65
SORGHUM INTER-CROPPED (SUMMER PLANTED) (50% nominal plant population)												
Crop Coeff - plant crop								.18	.35	.5	.5	.35
first ratoon	.09	.18	.35	.5								
Net Mean Daily IWR (mm)	.23	.68	1.84	3.72	.00	.00	.00	1.52	2.58	2.72	1.76	.89
Net Mean Daily Volumetric IWR per Acre (cu ft)	33	96	263	531	0	0	0	218	369	389	252	127
MUNG INTER-CROPPED (SUMMER PLANTED) (50% nominal plant population)												
Crop Coefficient								.18	.35	.53	.45	.35
Net Mean Daily IWR (mm)	.00	.00	.00	.00	.00	.00	.00	1.52	2.58	2.88	1.58	.89
Net Mean Daily Volumetric IWR per Acre (cu ft)	0	0	0	0	0	0	0	218	369	412	226	127
SORGHUM AND MUNG (SUMMER PLANTED)												
Crop Coefficient	.09	.18	.35	.5	0	0	0	.36	.7	1.03	.95	.7
Net Mean Daily IWR (mm)	.23	.68	1.84	3.72	.00	.00	.00	3.05	5.16	5.60	3.34	1.78
Net Peak Daily Volumetric IWR per Acre (cu ft)	33	96	263	531	0	0	0	436	737	801	478	254
SORGHUM (SUMMER PLANTED)												
Crop Coeff - plant crop								.35	.7	1	.9	.6
first ratoon	.18	.35	.7	1								
Net Mean Daily IWR (mm)	.47	1.31	3.68	7.43	.00	.00	.00	2.96	5.16	5.44	3.17	1.52
Net Mean Daily Volumetric IWR per Acre (cu ft)	67	188	526	1062	0	0	0	424	737	777	453	218
OILSEED (SUMMER PLANTED)												
Crop Coefficient								.35	.65	.9	.9	.8
Net Mean Daily IWR (mm)	.00	.00	.00	.00	.00	.00	.00	2.96	4.79	4.90	3.17	2.03
Net Mean Daily Volumetric IWR per Acre (cu ft)	0	0	0	0	0	0	0	424	685	700	453	290
WHEAT (SUMMER PLANTED)												
Crop Coefficient	1.05	.95	.5							.18	.55	.95
Net Mean Daily IWR (mm)	2.72	3.56	2.63	.00	.00	.00	.00	.00	.00	.98	1.94	2.41
Net Mean Daily Volumetric IWR per Acre (cu ft)	389	509	376	0	0	0	0	0	0	140	277	345

Notes:

1. ETo calculations based on mean monthly climatic data for Sibi
2. ETo determined using CROPWAT 5.2 program based on Penman method (Ref: FAO 24)
3. Peak daily ETo defined as the maximum ETo that is likely to occur in 3 years out of 4 (Ref: FAO 24, Fig 10)
5. 80% reliable rainfall defined as the monthly rainfall that is exceeded in 4 years out of 5
6. The contribution from rainfall has been ignored.
7. Crop coefficients based on FAO 24, but modified to reflect scheme specific farming operations
8. Sorghum and mung are inter-cropped, so plant population for both is half the optimum, ie crop coefficients are also reduced by 50%

TABLE 24 **MEAN SEASONAL CROP WATER REQUIREMENT PER ACRE**

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
MEAN SEASONAL CROP WATER REQUIREMENT PER ACRE
(File Ref: IWRCHAN)

Depth of water impounded per irrigation:	2 ft
Field irrigation efficiency:	70 %
Net depth of application per season:	1.4 ft

CROP	OPTIMUM IRRIGATION Volume (cu ft)	Depth (ft)	Proportion of Optimum Applied (%)
Sorghum/Mung Inter-Cropped: (Spring Planted)			
- plant crop	90260	2.07	68
- first ratoon	48776	1.12	125
Sorghum/Mung Inter-Cropped: (Summer Planted)			
- plant crop	82666	1.90	74
- first ratoon	27818	.64	219
Sorghum (Summer Planted)			
- plant crop	79688	1.83	77
- first ratoon	55485	1.27	110
Oilseed (Summer Planted)	77948	1.79	78
Wheat (Summer Planted)	61285	1.41	100

Notes:

1. Where sorghum and mung are inter-cropped, the plant population for both is half the optimum, ie the crop coefficients are 50% of the recommended.

The gross crop water requirement assumes a field irrigation efficiency of 0.7. This takes account of losses such as evaporation from the ponded irrigation water and the soil surface, deep percolation and the uptake of water by weeds. Assuming an initial irrigation depth of 2ft (600mm) and an efficiency of 0.7, the depth of water available for plant growth is 1.4ft. The moisture holding capacity, ie the difference between field capacity and permanent wilting point, of the soils at Chandia is about 19%. Hence the wetted soil profile would be over 7ft deep, which is greater than the rooting depth of all the crops, however, this would be compensated to some extent by the capillary rise of moisture into the root zone from below. The optimum depth of application and volume of water required per acre are given in Table 24, together, with the proportion of the crop water requirement which is actually applied for each crop. For intercropped sorghum and mung, the deficit for the plant crop is about 30%, but after harvesting the mung and cutting the sorghum fodder, if flood water is available for a second irrigation, then the nominal 2ft depth of application is more than sufficient to obtain a ratoon sorghum crop. There is a deficit of about 20% for the oilseed crop, which is likely to result in a yield reduction of about 15%. In a mean year, the optimum net depth of application for wheat is 1.4ft which is the same as the estimated depth applied after taking account of field losses.

9.7 Proposed Cropping Pattern

The existing crops formed the basis of the proposed cropping programme, it is thought unlikely that there will be any significant change in the type or proportional area of crops grown. The biggest impact the project will have is through reducing the uncertainty of production, by making more water available more often. A summary of the expected benefits, in terms of increased cropped area, is shown in Table 25. A twenty year model average crop programme has been drawn up based on the average volume of expected water (Table 26). For the economic analysis, a series of thirty 20 year crop programmes was drawn up using the hydrographic time series to assess different yield flow outcomes. The area of each crop will obviously vary from year to year and is related to water availability. In addition to this relationship, the crop programme truncates the volume of available water. This procedure has been adopted as the proposed irrigation improvements greatly increase the amount of water in the with project situation and it was thought unlikely that the farmers would have the capacity to immediately use all of this available water. Therefore, in view of the need to adopt a conservative approach on the area of irrigated land, the truncation on the upper level of total irrigated area was set at 1,200 acres. It is likely, particularly in view of the availability of the bulldozer, that the irrigated area will increase. However, the rate of expansion is difficult to estimate.

The importance of ratooned sorghum and the economic importance of the winter rains has been taken into account in drawing up the cropping programme through the use of some basic parameters. Four basic rules were used to take account of the uncertainty associated with the rabi rains:

i) Rabi season is completely independent of the kharif season

ii) Rabi sorghum is relatively insensitive to the arrival of the winter floods (ie get ratooned crop any way regardless of the time of arrival of the winter floods as monsoon summer rains are more important.)

iii) Seasons are independent and do not get a second ratoon from Rabi season (the economic value is low and probability of rains is low).

iv) Probability of area data stream is the same as the probability of volume data used.

Conservative yields have been taken with no significant early increases, the yields do increase through the life of the project as it is expected that wider use of better varieties will occur, as they become available and project intervention increases. Increases are also likely to occur through improved water availability and improved farm practises, such as through the application of fertilisers and the wider introduction of mechanisation. Initially, these improvements are thought more likely to occur at Chandia than the introduction of a second irrigation, as farmers have stated their preference to irrigate larger areas.

TABLE 25 EXPECTED VOLUMES AND AREAS FOR WITHOUT AND WITH PROJECT SITUATIONS

Annual Probability of Outcome being Exceeded (%)	Without Project		With Project Option 1		With Project Option 2	
	Annual Volume (acre ft)	Area (acres)	Volume (acre ft)	Area (acres)	Annual Volume (acre ft)	Area (acres)
90	8	2	8	2	8	2
50	855	205	1,521	365	3,683	883
10	3,864	927	3,864	927	8,168	1,960

TABLE 26 AVERAGE CROPPED AREA BUILD UP WITH PROJECT

BALOCHISTAN MINOR IRRIGATION AND AGRICULTURE DEVELOPMENT PROJECT
AVERAGE CROPPED AREA BUILD UP WITH PROJECT
CHANDIA FLOOD IRRIGATION SCHEME
OPTION-2

(Acres)

CROPS		YEAR AFTER DEVELOPMENT																			
	EXISTING	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
KHARIF																					
Sorghum	168	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334
Sorghum+Mung	84	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167
RABI																					
Wheat	45	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Oilseed	59	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118
Sorghum+Mung	40	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177

9.8 Social Amenities

There is an existing Public Health and Engineering Department potable water supply in Chandia village.

The main access to Chandia is from the south along a track which is frequently impassable for several weeks after rain. As part of the proposed development the intention is to up-grade this track into a semi-all weather road from Chandia to Mall, a distance of 44,600ft (13,600m). The discretionary fund of the Members of Provincial Assembly (MPA) financed the construction of a road to Chandia several years ago, however, the work was poorly designed and executed and the road failed during the first rains. The preliminary design for the new road follows the alignment of the MPA road, except for the first 10,400ft (3,170m), where it crosses the Talli Nullah and is prone to flooding. Here a new line is proposed which follows the present access track into the area. The way leave for the MPA road was finalised and settled by the government many years ago, so there will be no problems of resettlement or land purchase. The proposed alignment of the first section would have to be negotiated, but since the line coincides with the current main access track it may be possible to resolve the matter at a local level.

The preliminary alignment of the new road is shown on portions of the 1:50,000 scale maps 34 O/15 and 39 C/3 in Drawing Number CHA/FS/401. However, this will almost certainly be modified at the detailed design stage when the detailed strip survey is completed. The land on either side of the proposed road alignment is prone to flooding and in order to ensure that the base is free draining, the road would be constructed on a 3ft embankment formed from approved locally available fill. The provision of a gravel road base has not been included because the cost of importing suitable material cannot be justified economically at this stage of the development. However, it is recommended that consideration be given to providing a 1ft thick gravel base in the future. The nominal cross section of the road is shown in Drawing Number CHA/FS/402.

In order to simplify the construction, standard single, double and triple bore box culverts have been adopted. The nominal bore is 3ft high by 5ft wide and the design for a three bore version is given in Drawing Number CHA/FS/403. For the Talli Nullah crossing at RD 5,500ft a multi-span low level bridge is proposed with concrete approaches. During high floods it is accepted that water will pass over the structure making it impassable, for short periods. The preliminary design for the crossing is given in Drawing Number CHA/FS/404.

The road alignment has not been surveyed as part of the topographic survey, however, a preliminary walk-over survey of the proposed alignment identified the following features:

Chainage (ft)	Structure or Feature
0	Turning from metalled Mall/Sibi Road
5500	Double bore culvert
5630 - 6040	Talli Nullah causeway and low level bridge
7650	Triple bore culvert for flood channel
7750	ditto
9840	Single bore box culvert
10100	ditto
10400	Alignment joins existing MPA road line
10500	Single bore box culvert
12140	Double bore box culvert
17390	ditto
22640	Single bore box culvert
23300	ditto
23950	ditto
21500	ditto
25600	ditto
26250	ditto
31720 - 31920	Washin Dhori Nullah crossing, currently under construction
33460	Single bore box culvert
36090	ditto
40030	ditto
41340	ditto
44620	Road ends near veterinary hospital in Chandia

The provisional capital cost of the road is based on re-building all the existing embankment, to ensure satisfactory compaction of the sub-base. All the structures have been included, except the Washin Dhori Nullah crossing which is presently under construction with MPA funding.

9.9 Capital Cost

A semi-detailed bill of quantities for Option 2, the preferred development option for the Chandia Flood Irrigation Scheme, is presented in Table 27. For completeness the costs and other associated tables for Option 1 are included in Annex D.3. The construction costs are based on current (January 1993) contract rates for similar works being undertaken else where in the province. The rates used for works which will be undertaken by the farmers are based on contractor's rates less the estimated 40% mark up to cover overheads and profit.

The total capital cost used in the analysis includes provision for physical contingencies and engineering and administration. A figure of 10% of the basic construction cost has been adopted to cover the engineering and adminstration. The overall physical contingency has been derived by applying different percentages to the construction cost of the scheme components, reflecting the degree of uncertainty associated with the estimated cost. The resulting aggregated provision for physical contingencies is 19.92% of the construction cost. The residual value of the main civil works components at the end of the project life are based on the expected life values given in Jenson[16]. The derivation of the physical contingencies and residual values for Option 2 are given in Table 28 and are included in Annex D.3 for Option 1.

The economic cost of the civil works have been derived by breaking down the financial cost of the main components into the following constituent parts; steel, cement, unskilled and skilled labour, plant and others. Standard Conversion Factors have then been applied to these to build up the economic cost. The derivation of the economic costs for Option 2 is given in Table 29 and the corresponding table for Option 1 is included in Annex D.3.

The build-up of the financial and economic capital costs for the diversion Option 2 at Chandia are summarised in the Table 30.

[16] Design and Operation of Farm Irrigation Systems (1980)

TABLE 27 PRELIMINARY BILL OF QUANTITIES FOR OPTION 2

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
OPTION 2
PRELIMINARY BILL OF QUANTITIES FOR IRRIGATION INFRASTRUCTURE
(File Ref: CapCHAN2)

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
1.	BILL 1 - GENERAL & PRELIMINARY (Based on 10% of other bills)	Sum			1439270
2.	BILL 2 - RIGNT BANK ABUTMENT				
2.1	Excavation in river bed	cu ft	56806	2.00	113612
2.2	Concrete - Class B	cu ft	3104	45.00	139680
2.3	Class C	cu ft	388	40.00	15520
2.4	Masonry	cu ft	9190	40.00	367600
2.5	Tipped rock - Class A	cu ft	7670	15.00	115050
2.6	Class C	cu ft	2557	15.00	38355
2.7	Filter	cu ft	1278	15.00	19170
2.8	Backfill and compact	cu ft	35211	1.50	52817
	Sub-total				861804
3.	BILL 3 - WEIR				
3.1	Excavation in river bed	cu ft	98326	2.00	196652
3.2	Concrete - Class A	cu ft	5730	60.00	343800
3.3	Class B	cu ft	31327	45.00	1409715
3.4	Class C	cu ft	1515	40.00	60600
3.5	Reinforcement	Ton	9	25000.00	222750
3.6	Chute blocks	No	62	96.00	5952
3.7	Baffle blocks	No	60	156.00	9360
3.8	Joints - Expansion	sq ft	988	20.00	19760
3.9	Contraction	sq ft	1482	5.00	7410
3.10	Tipped rock - Class A	cu ft	13088	15.00	196320
3.11	Class C	cu ft	4363	15.00	65445
3.12	Filter	cu ft	2182	15.00	32730
3.13	Backfill and compact	cu ft	9140	1.50	13710
	Sub-total				2584204
4.	BILL 4 - SLUICE CHANNEL				
4.1	Excavation in river bed	cu ft	83674	2.00	167348
4.2	Concrete - Class A	cu ft	1003	60.00	60180
4.3	Class B	cu ft	13099	45.00	589455
4.4	Class C	cu ft	1112	40.00	44480
4.5	Reinforcement	Ton	1	25000.00	32000
4.6	Masonry	cu ft	28760	40.00	1150400
4.7	Chute blocks	No	2	630.00	1260
4.8	Joints - Expansion	sq ft	601	20.00	12020
4.9	Contraction	sq ft	240	5.00	1200
4.10	Tipped rock - Class A *	cu ft	3600	10.71	38556
4.11	Class B *	cu ft	3008	10.71	32216
4.12	Class C *	cu ft	2712	10.71	29046

Note: 1 (*) indicates work to be undertaken by farmers
2 minor discrepancies due to rounding errors

TABLE 27 (Continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	BILL 4 - Continued				
4.13	Filter *	cu ft	1504	10.71	16108
4.14	Backfill and compact	cu ft	11806	1.50	17709
4.15	Supply and install 9ft x 5ft steel gate	Sum			300000
4.16	Supply and install steel stoplog grooves	Sum			10000
	Sub-total				2501977
5.	BILL 5 -CANAL HEAD REGULATOR				
5.1	Excavation in river bed	cu ft	34677	2.00	69354
5.2	Concrete - Class A	cu ft	2475	60.00	148500
5.3	Class B	cu ft	12155	45.00	546975
5.4	Class C	cu ft	1166	40.00	46640
5.5	Reinforcement	Ton	0	25000.00	10500
5.6	Masonry	cu ft	16782	40.00	671280
5.7	Chute blocks	No	9	468.00	4212
5.8	Joints - Expansion	sq ft	484	20.00	9680
5.9	Contraction	sq ft	484	5.00	2420
5.10	Tipped rock - Class B *	cu ft	1640	10.71	17564
5.11	Class C *	cu ft	1094	10.71	11717
5.12	Filter *	cu ft	547	10.71	5858
5.13	Backfill and compact	cu ft	5712	1.50	8568
5.14	Supply and install steel stoplog grooves	Sum			30000
	Sub-total				1583269
6.	BILL 6 - EARTHWORKS				
6.1	Import, place and compact approved fill around headworks	cu ft	13683	3.00	41049
6.2	Remodel flood channel	cu ft	325000	2.00	650000
6.3	Raise height and strengthen right bank bunds	cu ft	526000	2.00	1052000
6.4	Raise height and strengthen left bank bunds	cu ft	160000	2.00	320000
6.5	Construct breachable bund across river *	cu ft	240000	.71	170400
6.6	Allow for spurs etc *	Sum			500000
	Sub-total				2733449
7.	BILL 7 - COMMAND AREA				
7.1	Farmers store	sq ft	1140	200.00	228000
7.2	Supply LGP D4 bulldozer	Sum			3900000
	Sub-total				4128000

Note: 1 (*) indicates work to be undertaken by farmers
2 minor discrepancies due to rounding errors

TABLE 28 MAINTENANCE COSTS, LIFE EXPECTANCY, RESIDUAL VALUES AND CONTINGENCY FOR OPTION 2 IRRIGATION COMPONENTS

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
OPTION 2
MAINTENANCE COSTS, LIFE EXPECTANCY, RESIDUAL VALUE AND CONTINGENCY FOR IRRIGATION COMPONENTS
(File Ref: Cap2Cha)

ITEM	DESCRIPTION	Construction Cost (Rs)	Annual Maintenance % Construction Cost	Annual Maintenance (Rs)	Life Expectancy (yrs)	Residual Value	Physical Contingencies % Construction Cost	Physical Contingencies (Rs)
1.	BILL 1 - GENERAL & PRELIMINARY (Based on 10% of other bills)	1439270						286714
2.	BILL 2 - RIGNT BANK ABUTMENT							
2.1	Excavation in river bed	113612	.50	568	40	56806	20	22722
2.2	Concrete - Class B	139680	.50	698	40	69840	20	27936
2.3	Class C	15520	.50	78	40	7760	20	3104
2.4	Masonry	367600	.50	1838	40	183800	20	73520
2.5	Tipped rock - Class A	115050	.50 (2)	575	20	0	20	23010
2.6	Class C	38355	.50 (2)	192	20	0	20	7671
2.7	Filter	19170	.50 (2)	96	20	0	20	3834
2.8	Backfill and compact	52817	.50	264	40	26408	20	10563
	Sub-total	861804		4309		344614		172361
3.	BILL 3 - WEIR							
3.1	Excavation in river bed	196652	.50	983	40	98326	20	39330
3.2	Concrete - Class A	343800	.50	1719	40	171900	20	68760
3.3	Class B	1409715	.50	7049	40	704858	20	281943
3.4	Class C	60600	.50	303	40	30300	20	12120
3.5	Reinforcement	222750	.50	1114	40	111375	20	44550
3.6	Chute blocks	5952	.50	30	40	2976	20	1190
3.7	Baffle blocks	9360	.50	47	40	4680	20	1872
3.8	Joints - Expansion	19760	.50	99	40	9880	20	3952
3.9	Contraction	7410	.50	37	40	3705	20	1482
3.10	Tipped rock - Class A	196320	.50 (2)	982	20	0	20	39264
3.11	Class C	65445	.50 (2)	327	20	0	20	13089
3.12	Filter	32730	.50 (2)	164	20	0	20	6546
3.13	Backfill and compact	13710	.50	69	40	6855	20	2742
	Sub-total	2584204		12921		1144855		516841
4.	BILL 4 - SLUICE CHANNEL							
4.1	Excavation in river bed	167348	.50	837	40	83674	20	33470
4.2	Concrete - Class A	60180	.50	301	40	30090	20	12036
4.3	Class B	589455	.50	2947	40	294728	20	117891
4.4	Class C	44480	.50	222	40	22240	20	8896
4.5	Reinforcement	32000	.50	160	40	16000	20	6400
4.6	Masonry	1150400	.50	5752	40	575200	20	230080
4.7	Chute blocks	1260	.50	6	40	630	20	252
4.8	Joints - Expansion	12020	.50	60	40	6010	20	2404
4.9	Contraction	1200	.50	6	40	600	20	240
4.10	Tipped rock - Class A (1)	38556	.50 (2)	193	20	0	20	7711
4.11	Class B (1)	32216	.50 (2)	161	20	0	20	6443
4.12	Class C (1)	29046	.50 (2)	145	20	0	20	5809

Notes: (1) indicates construction work to be undertaken by farmers
(2) denotes maintenance work that could be undertaken by farmers at half the normal percentage

CHANDIA FLOOD IRRIGATION SCHEME
OPTION 2
MAINTENANCE COSTS, LIFE EXPECTANCY, RESIDUAL VALUE AND CONTINGENCY FOR IRRIGATION COMPONENTS CONTINUED
(File Ref: Cap2Cha)

TABLE 28 (Continued)

ITEM	DESCRIPTION	Construction Cost (Rs)	Annual Maintenance % Construction Cost	Annual Maintenance (Rs)	Life Expectancy (yrs)	Residual Value	Physical Contingencies % Construction Cost	Physical Contingencies (Rs)
	BILL 4 - Continued							
4.13	Filter (1)	16108	.50 (2)	81	20	0	20	3222
4.14	Backfill and compact	17709	.50	89	40	8855	20	3542
4.15	Supply and install 9ft x 5ft steel gate	300000	2.00	6000	20	0	20	60000
4.16	Supply and install steel stoplog grooves	10000	1.00	100	40	5000	20	2000
	Sub-total	2501977		17060		1043026		500395
5.	BILL 5 -CANAL HEAD REGULATOR							
5.1	Excavation in river bed	69354	.50	347	40	34677	20	13871
5.2	Concrete - Class A	148500	.50	743	40	74250	20	29700
5.3	Class B	546975	.50	2735	40	273488	20	109395
5.4	Class C	46640	.50	233	40	23320	20	9328
5.5	Reinforcement	10500	.50	53	40	5250	20	2100
5.6	Masonry	671280	.50	3356	40	335640	20	134256
5.7	Chute blocks	4212	.50	21	40	2106	20	842
5.8	Joints - Expansion	9680	.50	48	40	4840	20	1936
5.9	Contraction	2420	.50	12	40	1210	20	484
5.10	Tipped rock - Class B (1)	17564	.50 (2)	88	20	0	20	3513
5.11	Class C (1)	11717	.50 (2)	59	20	0	20	2343
5.12	Filter (1)	5858	.50 (2)	29	20	0	20	1172
5.13	Backfill and compact	8568	.50	43	40	4284	20	1714
5.14	Supply and install steel stoplog grooves	30000	1.00	300	40	15000	20	6000
	Sub-total	1583269		8066		774065		316654
6.	BILL 6 - EARTHWORKS							
6.1	Import, place and compact approved fill around headworks	41049	1.00 (2)	410	20	0	20	8210
6.2	Remodel flood channel	650000	1.00 (2)	6500	20	0	20	130000
6.3	Raise height and strengthen right bank bunds	1052000	1.00 (2)	10520	20	0	20	210400
6.4	Raise height and strengthen left bank bunds	320000	1.00 (2)	3200	20	0	20	64000
6.5	Construct breachable bund across river (1)	170400	1.00 (2)	1704	20	0	20	34080
6.6	Allow for spurs etc (1)	500000	1.00 (2)	5000	20	0	20	100000
	Sub-total	2733449		27334		0		546690
7.	BILL 7 - COMMAND AREA							
7.1	Farmers store	228000	2.50	5700	20	0	15	34200
7.2	Supply LGP D4 bulldozer	3900000	(3)		(3)		20	780000
	Sub-total	4128000		5700		0		814200

Notes: (1) indicates construction work to be undertaken by farmers
(2) denotes maintenance work that could be undertaken by farmers at half the normal percentage
(3) maintenance and residual value of bulldozer built into the hourly rate

Notes: (1) indicates construction work to be undertaken by ...
(2) denotes maintenance work that could be undertaken by farmers at half the normal percentage
(3) maintenance and residual value of bulldozer built into the hourly rate

TABLE 29 DERIVATION OF ECONOMIC COST FOR OPTION 2

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
OPTION 2
DERIVATION OF ECONOMIC COSTS
(File Ref: Cap2Cha)

ITEM	DESCRIPTION	CONSTRUCTION AND CONTINGENCY COSTS (Rs)	PROPORTIONS OF TOTAL COSTS						ECONOMIC CONSTRUCTION AND CONTINGENCY COSTS (Rs)
					Labour				
			Steel SCF .86	Cement SCF .62	Unskilled SCF .75	Skilled SCF 1	Transport & Plant SCF .48	Other SCF .9	
1.	BILL 1 - GENERAL & PRELIMINARY (Based on 10% of other bills)	1725984			.10	.20		.70	1562016
2.	BILL 2 - RIGNT BANK ABUTMENT								
2.1	Excavation in river bed	136334			.55	.05		.40	112135
2.2	Concrete - Class B	167616		.15	.20	.05	.10	.50	132584
2.3	Class C	18624		.15	.20	.05	.10	.50	14732
2.4	Masonry	441120		.05	.10	.20	.20	.45	355984
2.5	Tipped rock - Class A	138060			.40	.05	.15	.40	107963
2.6	Class C	46026			.40	.05	.15	.40	35992
2.7	Filter	23004			.40	.05	.15	.40	17989
2.8	Backfill and compact	63380			.45	.05	.10	.40	50419
	Sub-total	1034164							827798
3.	BILL 3 - WEIR								
3.1	Excavation in river bed	235982			.55	.05		.40	194096
3.2	Concrete - Class A	412560	.05	.15	.20	.05	.10	.45	325510
3.3	Class B	1691658		.15	.20	.05	.10	.50	1338101
3.4	Class C	72720		.15	.20	.05	.10	.50	57522
3.5	Reinforcement	267300	.35		.10	.05	.10	.40	222928
3.6	Chute blocks	7142	.05	.05	.15	.20	.10	.45	5996
3.7	Baffle blocks	11232	.05	.05	.15	.20	.10	.45	9429
3.8	Joints - Expansion	23712			.20	.20		.60	21104
3.9	Contraction	8892			.20	.20		.60	7914
3.10	Tipped rock - Class A	235584			.40	.05	.15	.40	184227
3.11	Class C	78534			.40	.05	.15	.40	61414
3.12	Filter	39276			.40	.05	.15	.40	30714
3.13	Backfill and compact	16452			.45	.05	.10	.40	13088
	Sub-total	3101045							2472041
4.	BILL 4 - SLUICE CHANNEL								
4.1	Excavation in river bed	200818			.55	.05		.40	165172
4.2	Concrete - Class A	72216	.05	.15	.20	.05	.10	.45	56978
4.3	Class B	707346		.15	.20	.05	.10	.50	559511
4.4	Class C	53376		.15	.20	.05	.10	.50	42220
4.5	Reinforcement	38400	.35		.10	.05	.10	.40	32026
4.6	Masonry	1380480		.10	.15	.15	.20	.40	1077465
4.7	Chute blocks	1512	.05	.05	.15	.20	.10	.45	1269
4.8	Joints - Expansion	14424			.20	.20		.60	12837
4.9	Contraction	1440			.20	.20		.60	1282
4.10	Tipped rock - Class A (1)	46267			.60	.10	.30		32109
4.11	Class B (1)	38659			.60	.10	.30		26829
4.12	Class C (1)	34855			.60	.10	.30		24189

Notes: (1) indicates construction works by farmers

TABLE 29 (Continued)

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
OPTION 2
DERIVATION OF ECONOMIC COSTS CONTINUED
(File Ref: Cap2Cha)

ITEM	DESCRIPTION	CONSTRUCTION AND CONTINGENCY COSTS (Rs)	Steel SCF .86	Cement SCF .62	Labour Unskilled SCF .75	Labour Skilled SCF 1	Transport & Plant SCF .48	Other SCF .9	ECONOMIC CONSTRUCTION AND CONTINGENCY COSTS (Rs)
	BILL 4 - Continued								
4.13	Filter (1)	19329			.60	.10	.30		13415
4.14	Backfill and compact	21251			.45	.05	.10	.40	16905
4.15	Supply and install 9ft x 5ft steel gate	360000	.30		.05	.20	.05	.40	316620
4.16	Supply and install steel stoplog grooves	12000	.20	.05	.10	.15	.05	.45	10284
	Sub-total	3002372							2389112
5.	BILL 5 -CANAL HEAD REGULATOR								
5.1	Excavation in river bed	83225			.55	.05		.40	68452
5.2	Concrete - Class A	178200	.05	.15	.20	.05	.10	.45	140600
5.3	Class B	656370		.15	.20	.05	.10	.50	519189
5.4	Class C	55968		.15	.20	.05	.10	.50	44271
5.5	Reinforcement	12600	.35		.10	.05	.10	.40	10508
5.6	Masonry	805536		.10	.15	.15	.20	.40	628721
5.7	Chute blocks	5054	.05	.05	.15	.20	.10	.45	4243
5.8	Joints - Expansion	11616			.20	.20		.60	10338
5.9	Contraction	2904			.20	.20		.60	2585
5.10	Tipped rock - Class B (1)	21077			.60	.10	.30		14628
5.11	Class C (1)	14060			.60	.10	.30		9758
5.12	Filter (1)	7030			.60	.10	.30		4879
5.13	Backfill and compact	10282			.45	.05	.10	.40	8179
5.14	Supply and install steel stoplog grooves	36000	.20	.05	.10	.15	.05	.45	30852
	Sub-total	1899922							1497202
6.	BILL 6 - EARTHWORKS								
6.1	Import, place and compact approved fill around headworks	49259			.05	.15	.40	.40	36427
6.2	Remodel flood channel	780000			.05	.15	.40	.40	576810
6.3	Raise height and strengthen right bank bunds	1262400			.05	.15	.40	.40	933545
6.4	Raise height and strengthen left bank bunds	384000			.05	.15	.40	.40	283968
6.5	Construct breachable bund across river (1)	204480			.10	.20	.60	.10	133525
6.6	Allow for spurs etc (1)	600000			.40	.10	.40	.10	409200
	Sub-total	3280139							2373475
7.	BILL 7 - COMMAND AREA								
7.1	Farmers store	262200	.10	.15	.10	.15	.10	.40	212906
7.2	Supply LGP D4 bulldozer	4680000						1.00 (2)	3088800
	Sub-total	4942200							3301706

Notes: (1) indicates construction works by farmers
(2) SCF for the supply of bulldozer .66

TABLE 30 SUMMARY OF FINANCIAL AND ECONOMIC CAPITAL COSTS OF IRRIGATION WORKS - OPTION 2

Bill	Description	Financial Construction & Contingency Costs (Rs)	Economic Construction & Contingency Costs (Rs)
1	Preliminary & General	1,725,984	1,562,016
2	Right Bank Abutment	1,034,164	827,798
3	Weir	3,101,045	2,472,041
4	Sluice Channel	3,002,372	2,389,112
5	Canal Head Regulator	1,899,922	1,497,202
6	Earthworks	3,280,139	2,373,475
7	Command Area	4,942,200	3,301,706
	Sub-Total	18,985,826	14,423,350
Engineering & Administration		1,583,197	1,424,878
	TOTAL	20,569,024	15,848,227

Note: SCF for Engineering & Administration is 0.9

The total financial and economic capital costs of the proposed irrigation development at Chandia are Rs20.57 million and Rs15.85 million respectively. This corresponds to a financial cost per beneficiary of Rs22,931.

The proposed development at Chandia also includes the up-grading of the road from Mall to Chandia to provide all weather access. The financial and economic analysis of this road has been considered separately from the irrigation works. The capital cost, calculation of annual maintenance, residual value and contingency and derivation of the economic cost are presented in Tables 31, 32 and 33 respectively. The financial and economic costs are summarized in Table 34.

TABLE 31

PRELIMINARY BILL OF QUANTITIES FOR MALL-CHANDIA ROAD

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
PRELIMINARY BILL OF QUANTITIES FOR MALL-CHANDIA ROAD
(File Ref: CapCHAN3)

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
1.	BILL 1 - GENERAL & PRELIMINARY (Based on 10% of other bills)	Sum			995326
2.	BILL 2 - ROAD EMBANKMENT				
2.1	Clear road alignment	sq ft	1840000	.50	920000
2.2	Import, place and compact embankment fill	cu ft	3700700	1.75	6476225
2.3	Import, place and compact road base material (rate only)	cu ft	0	10.00	0
	Sub-total				7396225
3.	BILL 3 - ROAD CULVERTS				
3.1	Single span road culvert	No	13	60790.00	790270
3.2	Double span road culvert	No	3	89098.00	267294
3.3	Triple span road culvert	No	2	115427.00	230854
	Sub-total				1288418
4.	BILL 4 - TALLI RIVER CROSSING				
4.1	Excavation in wet	cu ft	54038	2.00	108076
4.2	Concrete Class A	cu ft	1140	60.00	68400
4.3	Class B	cu ft	10653	45.00	479385
4.4	Class C	cu ft	945	40.00	37800
4.5	Reinforcement	Ton	3	25000.00	75500
4.6	Masonry	cu ft	4692	40.00	187680
4.7	Backfill and compaction	cu ft	18848	1.50	28272
4.8	Tipped rock Class B	cu ft	9450	15.00	141750
4.9	Class C	cu ft	6300	15.00	94500
4.10	Filter	cu ft	3150	15.00	47250
	Sub-total				1268613

Note: 1 (*) indicates work to be undertaken by farmers
2 minor discrepancies due to rounding errors

TABLE 32

MAINTENENCE COSTS, LIFE EXPECTANCY, RESIDUAL VALUE AND CONTINGENCY FOR MALL-CHANDIA ROAD

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
MAINTENANCE COSTS, LIFE EXPECTANCY, RESIDUAL VALUE AND CONTINGENCY FOR ROAD COMPONENTS
(File Ref: Cap3Cha)

ITEM	DESCRIPTION	Construction Cost (Rs)	Annual Maintenance % Construction Cost	Annual Maintenance (Rs)	Life Expectancy (yrs)	Residual Value	Physical Contingencies % Construction Cost	Physical Contingencies (Rs)
1.	BILL 1 - GENERAL & PRELIMINARY (Based on 10% of other bills)	995326						270015
2.	BILL 2 - ROAD EMBANKMENT							
2.1	Clear road alignment	920000	.50	4600	40	460000	15	138000
2.2	Import, place and compact embankment fill	6476225	.50	32381	40	3238113	15	971434
2.3	Import, place and compact road base material	0	.50	0	20	0	15	0
	Sub-total	7396225		36981		3698113		1109434
3.	BILL 3 - ROAD CULVERTS							
3.1	Single span road culvert	790270	1.00	7903	20	0	25	197568
3.2	Double span road culvert	267294	1.00	2673	20	0	25	66824
3.3	Triple span road culvert	230854	1.00	2309	20	0	25	57714
	Sub-total	1288418		12884		0		322105
4.	BILL 4 - TALLI RIVER CROSSING							
4.1	Excavation in wet	108076	1.00	1081	20	0	20	21615
4.2	Concrete Class A	68400	1.00	684	20	0	20	13680
4.3	Class B	479385	1.00	4794	20	0	20	95877
4.4	Class C	37800	1.00	378	20	0	20	7560
4.5	Reinforcement	75500	1.00	755	20	0	20	15100
4.6	Masonry	187680	1.00	1877	20	0	20	37536
4.7	Backfill and compaction	28272	1.00	283	20	0	20	5654
4.8	Tipped rock Class B	141750	.50 (2)	709	20	0	20	28350
4.9	Class C	94500	.50 (2)	473	20	0	20	18900
4.10	Filter	47250	.50 (2)	236	20	0	20	9450
	Sub-total	1268613		11269		0		253723

TABLE 33

DERIVATION OF ECONOMIC COST FOR MALL-CHANDIA ROAD

BMIADP - PHASE II PREPARATION STUDIES
CHANDIA FLOOD IRRIGATION SCHEME
DERIVATION OF ECONOMIC COSTS FOR THE ACCESS ROAD
(File Ref: Cap3Cha)

ITEM	DESCRIPTION	CONSTRUCTION AND CONTINGENCY COSTS (Rs)	PROPORTIONS OF TOTAL COSTS Steel SCF .86	Cement SCF .62	Labour Unskilled SCF .75	Labour Skilled SCF 1	Transport & Plant SCF .48	Other SCF .9	ECONOMIC CONSTRUCTION AND CONTINGENCY COSTS (Rs)
1.	BILL 1 - GENERAL & PRELIMINARY (Based on 10% of other bills)	1265341			.10	.20		.70	1145133
2.	BILL 2 - ROAD EMBANKMENT								
2.1	Clear road alignment	1058000			.05	.15	.40	.40	782391
2.2	Import, place and compact embankment fill	7447659			.05	.15	.40	.40	5507544
2.3	Import, place and compact road base material	0			.05	.15	.40	.40	0
	Sub-total	8505659							6289935
3.	BILL 3 - ROAD CULVERTS								
3.1	Single span road culvert	987838	.03	.15	.20	.10	.12	.40	776835
3.2	Double span road culvert	334118	.03	.15	.20	.10	.12	.40	262750
3.3	Triple span road culvert	288568	.03	.15	.20	.10	.12	.40	226929
	Sub-total	1610523							1266515
4.	BILL 4 - TALLI RIVER CROSSING								
4.1	Excavation in wet	129691			.55	.05		.40	106671
4.2	Concrete Class A	82080	.05	.15	.20	.05	.10	.45	64761
4.3	Class B	575262		.15	.20	.05	.10	.50	455032
4.4	Class C	45360		.15	.20	.05	.10	.50	35880
4.5	Reinforcement	90600	.35		.10	.05	.10	.40	75560
4.6	Masonry	225216		.10	.15	.15	.20	.40	175781
4.7	Backfill and compaction	33926			.45	.05	.10	.40	26988
4.8	Tipped rock Class B	170100			.40	.05	.15	.40	133018
4.9	Class C	113400			.40	.05	.15	.40	88679
4.10	Filter	56700			.40	.05	.15	.40	44339
	Sub-total	1522336							1206710

TABLE 34 SUMMARY OF FINANCIAL AND ECONOMIC CAPITAL COSTS OF MALL TO CHANDIA ROAD

Bill	Description	Financial Construction & Contingency Costs (Rs)	Economic Construction & Contingency Costs (Rs)
1	Preliminary & General	1,265,341	1,145,133
2	Road Embankment	8,505,659	6,289,935
3	Road Culverts	1,610,523	1,266,515
4	Talli Road Crossing	1,522,335	1,206,710
	Sub-Total	12,903,858	9,908,293
Engineering & Administration		1,094,858	985,372
TOTAL		13,998,716	10,893,666

Note: SCF for Engineering & Administration is 0.9

The total financial and economic costs of the Mall/Chandia road are Rs13.99 million and Rs10.89 million respectively. The total population that is likely to benefit from the road is 3,497, which gives a cost per head of Rs4,003.

9.10 Recurrent Costs

The main operational cost will be the running cost of the bulldozer. This includes fuel and lubricants, drivers wages, maintenance and depreciation. Assuming straight line depreciation over 12,000[17] hours and 1,200 operating hours per year, which is about half the number that could be expected from a commercially operated machine, the financial operating cost is Rs852 per hour. A breakdown of the hourly operating cost is given in Annex F.1.

The provision of a bulldozer is essential for the reinstatement of the breachable bund, though it does represent the weak link in the proposed development. The bund is expected to fail on average once every two years and assuming it is completely washed away, it will take an estimated 240 hours for the bulldozer to rebuild. The average annual machine input is therefore estimated to be 120 hours or 10% of the assumed annual operating hours. It is also anticipated that the bulldozer will be used for repairs and improvements to the flood channel and for costing purposes an annual input of 120 machine hours has been adopted for this work. Consequently an estimated 20% of the annual

[17] Caterpillar Performance Handbook.

machine hours will be attributed to scheme maintenance and the annual cost based on the financial operating cost, is Rs204,480. The balance of the annual machine hours would be accumulated from hiring the bulldozer to farmers, either individually or in groups. It is essential that the hire charge applied covers the financial operating cost of the machine and it is recommended that an hourly rate of Rs1,000 be used as the basic hire charge, this allows for a limited number of non-revenue hours per year.

The procedure for operating the bulldozer still has to be finalized with the Chandia WUA, but at this stage it is recommended that they open a separate account for the operation of the bulldozer. Given an economic machine life of 12,000 hours and an estimated annual operation of 1,200 hours, the bulldozer is expected to need replacement in year 11. Consequently it is essential that sufficient funds be put aside to cover the replacement cost. If, however, the annual operation hours are less than the assumed hours, the replacement of the machine would be delayed. In the event of the farmers choosing to use the machine exclusively for scheme maintenance then it is unlikely that the bulldozer would require replacement during the life of the project. An indication of the build up of the replacement fund for the bulldozer is given in the Annex F.4.

The annual maintenance cost of the irrigation infrastructure has been estimated as a percentage of the construction costs of the main components. The percentage factors are based on values quoted in Jenson[18] and the derivation is shown in Table 28. The estimated annual financial operation and maintenance cost for the scheme is derived in Table 35.

[18]Jenson M E: Design and Operation of Farm Irrigation Systems.

TABLE 35 ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST FOR CHANDIA

Item	Annual Maintenance (Rs)
Diversion Works	75,391
Rebuilding Breachable Bund	102,240
Repairs to Flood Channel	102,240
Total	279,871

The estimated annual maintenance cost for the development is Rs279,871 which represents a cost per beneficiary of Rs312.

The intention is to hand over the proposed Mall/Chandia Road to the relevant Government Department on completion so that maintenance will not be the responsibility of the community. The estimated annual maintenance of the road is Rs61,134.

9.11 Command Area Development

An integrated approach to the development of the command area would be adopted, in an attempt to draw together the different activities and changing priorities required for successful implementation. The design and construction work would have to be socially accepted, and additional inputs would need to be targeted at alleviating any constraints the farmers face. The development would be based on the existing system and would not involve a major change in the production.

The initial contact for extension work would be organised at the village level through the WUA, which would act as the catalyst for further farmer oriented development. A critical aspect in the implementation of the project would be the ability of the WUA to digest and respond to the project inputs. Consequently the early establishment and formalisation of a representative WUA is essential.

The proposed improvements in irrigation infrastructure and the envisaged agricultural development require a strengthened and formalized farmers' organization. The institutional and field element of the development of the command area would be integrated with inputs from the Field Services, the Field Services Support and the Agriculture and Social Development Component. Concurrent development processes will occur initially through the lead of the WUA and, as farmer participation increases, the extension element is expected to increase in importance.

The initial starting point would be:

- farmer awareness programme: presentation with video and then feedback and follow-up; and

- WUA follow-up: registration, bank account and initial organisation.

9.11.1 Role of the Water Users Association

The water users of Chandia have established, with the aid of the project, a WUA committee in December 1992. The eight committee members represent the different clans in the village, the current status of the WUA is included in Annex C.2. They include the persons who have taken the lead in maintaining the scheme. The Chairman is the Malik Shah Mohammed. The WUA is currently being registered under the Balochistan Water Users' Association Ordinance 1981, Annex C.3, giving it a legal status and a bank account has been opened with an initial deposit of Rs10,000.

The main WUA activities required for the successful implementation of the scheme would include:

- the establishment or improvement of a body responsible for the operation and maintenance of the upgraded irrigation facilities;

- training in maintenance, financial, organisation and management;

- training in the management, appropriate use and maintenance of the bulldozer;

- dispute settlement assistance;

- grievance hearing, assistance in communal decision making eg. siting of new main channels and scheme design; and

- the organisation of maintenance contributions.

9.11.2 Role of the Farmer Support Unit

The main agricultural extension activities would be implemented through the Farmer Support Unit with the Village Development Agent being the primary link between the scheme and various inputs required from the project. The role of the FSU would be supportive in the planning and implementation of the scheme extension programme.

The extension input at Chandia will particularly have to involve women in the implementation of the project, given the importance of their contribution to agricultural production. The FSU's role will encompass the following:

- identification of scheme priorities and constraints;
- liaison between contractor and WUA for field design to maintain continuity;
- channel services to the scheme eg extension, research, commercial out-lets, pest and disease problems;
- establish crop demonstration plots;
- recommend crop practises, varieties, crop patterns and inputs etc;
- post harvest technology;
- identify progressive farmers;
- encourage the formation of farmer groups for crop husbandry improvement, improvement of irrigation scheduling, inputs; and
- a women's programme would, in addition to involvement in many of the above, necessarily included items on family life improvement, transfer of technology and labour saving, time allocation and gender division of labour.

9.12 Farmer Participation and Contributions

The sustainability of the projects is very much dependent on the farmers being involved in the development process and recognizing that it is their scheme and that they have a major interest in the development and maintenance of the scheme. In most cases, the schemes that are considered for inclusion in the project have been developed by the farmers with little or no help from the Provincial Government. This independence from limited government resources has often led to a strong market led agricultural base which has encouraged an entrepreneurial approach to farming. It is unlikely in the foreseeable future that the GoBAL will have the resources, or wish, to become involved in providing a much increased level of service to the agricultural sector. Indeed, it is questionable whether the government should be encouraged to become more involved in the existing dynamic farming system.

Consequently, farmer participation and maintenance are seen as highly desirable elements in the overall project strategy. However, these two aspects should not be seen as the panacea for the successful development of all schemes. There are a number of issues that will affect the outcome of the schemes.

The extension service is extremely under-resourced and many schemes will require a significant input to raise the agricultural output above subsistence level. It is envisaged that the required extension advice would be forthcoming from the project and will emphasize farmer self help. The performance of contractors has, in the past, been less than desired and increased supervision, particularly through the involvement of the scheme recipients, needs to be improved. Cost recovery is not feasible due to the remoteness of some areas, the weakness of government infrastructure and the local customs of the people; this adds to the externalities effecting the sector. It is expected that the major form of cost recovery for the scheme will be through indirect means.

9.12.1 Overall Strategy

It is anticipated that there will be a major element of farmer participation and contribution attached to the development of the scheme and in particular in the maintenance and replacement of the bulldozer. The participation is expected to be in the form of involvement in the design of the scheme, contributions of cash to capital and recurrent costs, and labour to construction. The contributions will be related to the ability of the farmers to pay. The rational for farmer involvement and passing part of these costs on is to:

- encourage farmer allegiance to their scheme;
- encourage long term commitment to the scheme;
- improve project accountability to the farmers;
- improve contractor accountability to the farmers;
- improve scheme sustainability by imparting construction knowledge to farmers and through the establishment of a maintenance fund;
- remove recurrent costs from the Government;
- increase farmer awareness of the economic cost of water; and
- in a limited fashion, reduce externalities.

It is generally acknowledged that areas where a flood irrigation scheme is considered, are likely to be relatively poorer than areas of perennial cropping. The socioeconomic indicators of Chandia suggest that the residents are comparatively wealthy and with their involvement in the construction of the project the people are expected to be able to meet the desired level of financial commitment and in particular the funds required for the project to begin. It is thought likely that the inhabitants will be able to respond to the expected contributions in a similar manner to the Phase II perennial schemes. However, this is very unlikely to the case at any other flood irrigation scheme. It is therefore anticipated that the expected contributions should initially be based on the perennial contributions with a substantial amount of leeway applied to the exact contributions expected from the individual flood irrigation scheme. The rational for this is that the individual flood schemes are likely to vary considerably in the technical design and amount and type of maintenance.

The farmers access to cash, during construction will be enhanced by the project paying for the works undertaken by the farmers themselves. In addition, by adopting this approach it will assist in the distribution of scheme benefits particularly to the poorer section of the community, it is also hoped that if the floods fail during the construction period, work will be provided for those who would normally expect to seek employment away from Chandia.

The minimum contribution expected from the farmers is 5% and it is anticipated that this will be adequate to form the basis of the maintenance of the scheme. The farmers contribution towards the development costs would involve the construction of the breachable bund.

9.12.2 Maintenance Strategy

It is envisaged that the current farmer orientated maintenance will be adequate to undertake minor repairs to the scheme and will be financed through a locally based Maintenance Fund. This will initially be established with a 2% (of the capital cost) contribution from the farmers. Contributions to this fund are expected to be made every year.

More extensive repairs, in particular, to the headworks or damage resulting from large floods is likely to be beyond the scope of the farmers both technically and physically. It is thought very unlikely that the Government of Balochistan will have funds or the ability to intervene effectively if major damage occurred.

To address this shortcoming, it is proposed that a Development Fund is established. The fund will provide finance to cover maintenance problems otherwise outside the technical competence of the local farmers. Initially, the fund will be jointly administered by the WUA and the main project. It is envisaged, however, that the WUA will eventually become solely responsible. The initial source of funds will be the capital cost contributions which are expected to be 3% of the scheme cost. It is anticipated that the fund will grow substantially over time and provided this occurs, funds in excess to the expected scheme maintenance requirements could be released to initiate small development projects. Table 36 summarizes the administration of the funds.

Releases from the Development Fund, in the first three years, will only be possible with the approval of a project representative, who will be a cosignatory to the account. It is anticipated that the releases would be made for two purposes:

- emergency repairs, surpassing the resources available in the Maintenance Fund; or

- development activities, the scope of these will depend on the WUA, but may include village credit, commercial extension advice or development of village infrastructure.

After three years - when the after care programme is completed - the project will withdraw its control from the Development Fund bank account, provided the WUA has provided adequate maintenance and have kept the level of maintenance contributions to the 2% level.

A critical area in the development and maintenance of the project is the farmers use of the bulldozer. Initial discussions with the farmers indicate that they would be willing to undertake the responsibility of maintaining the bulldozer and controlling its use. Although the precise nature of the management of the bulldozer has yet to fully worked out with the WUA it is thought likely that the machine will be hired out to other farmer groups and that this should be seen as a revenue earning exercise to fund the replacement of the bulldozer. Accordingly it is expected that a separate account be set up within the Local Development Fund. The excess in money collected for the Local Development Fund could be used to make up any short falls in the fund for the replacement of the bulldozer.

TABLE 36 ADMINISTRATION OF PROPOSED MAINTENANCE FUNDS

Title	Location	Administration	Purpose	Source of Funds
Maintenance Fund	Local	WUA	Routine Maintenance	Maintenance Contribution
Local Development Fund	Local	WUA/Project Contributions collected during construction will form the basis of the fund.	Damage where repair requires external technical or physical assistance. Other development activities where approved by the project	Capital cost contribution

9.12.3 Capital Cost Contributions

The expected schedule of contributions to the capital cost are detailed below, Table 37, and are tied to specific phases in the development of the scheme. A direct relationship between fees paid and the service provided is apparent and the funds collected will be directed to the Development Fund. This should encourage accountability of both the farmers and the project and this close liaison should highlight any problems in the development process. The target contribution is 3% of the capital cost.

Part of the labour contribution involves the initial construction of the breachable bund, this is intended mainly as a training exercise to familiarize the farmers with the operation of the bulldozer and the method of construction.

TABLE 37 PROPOSED FARMER CONTRIBUTIONS TO CAPITAL COST

Scheme Stage	% for each stage	Contributions to Local Development Fund (Rs)
Scheme identification		10,000
Prior to commencing detailed design *	0.5	92,845
Prior to advertisement of tender	0.5	102,845
Balance during construction in the form of labour	2.0	411,380
Total Farmer Contribution	3.0	617,070

* Less identification payment

9.12.4 Maintenance Contributions

The single most important and problematic area for maintenance of the scheme is the maintenance of the bulldozer. Contributions will be required to maintain and operate the machinery. The main contributions to the maintenance of the scheme (Table 38) are expected to follow the existing system and will be in the form of farmer labour contributions organised by the WUA and the water bailiff.

It is expected that the WUA will also collect monies from farmers. The cash collections will be based on the water share and will be placed in the local Maintenance Fund. This will be administered by the WUA with technical assistance from the Farmer Support Unit of the main project. Contributions will be initiated by work payments during the first project year to fully establish the fund for the second year. Collections should then continue on an annual basis.

TABLE 38 PROPOSED FARMER CONTRIBUTIONS TO MAINTENANCE FUND

Type of Contribution and Stage of Development	% for each stage	Contributions to the Maintenance Fund (Rs)
Cash	1.0	205,690
Work Payment	1.0	205,690
Total Farmer Contribution	2.0	411,380

9.12.5 Summary of Contributions

The initial construction of the breachable bund by the farmers will assist them to generate the finances to establish the Maintenance and Development Funds. The contributions are summarised in Table 39. The collection of the funds will be timed to coincide with construction work. Cosignatory accounts will be established for the Development Fund. The estimated capital cost of the project is Rs20,569,024 and adopting farmer cash and labour contributions of 2% and 3% respectively, the corresponding amounts are Rs411,380 and Rs617,071 The total value of the construction work identified as being suitable for the farmers to undertake is Rs821,465, which exceeds the project requirement and the balance would be available to the farmers to dispose of how they saw fit, though it is hoped that it would be invested in agricultural development.

Part of the labour contribution involves the initial construction of the breachable bund, this is intended mainly as a training exercise to familiarize the farmers with the operation of the bulldozer and the method of construction.

TABLE 39 SUMMARY OF ENVISAGED FARMER CONTRIBUTIONS CHANDIA FLOOD IRRIGATION SCHEME

Development Stage of the Scheme	% of Capital Cost	Development Fund (Rs)		Maintenance Fund (Rs)	
		Capital Cost Contribution		Maintenance Contribution	
		Cash	Work Payment	Cash	Work Payment
Scheme Identification		10,000			
Prior to Commencing Detailed Design *	0.5	92,845			
Prior to Advertisement of Tender	0.5	102,845			
Payment for Labour During Construction	3.0		411,380		205,690
Cash Contribution During Construction	1.0			205,690	
Sub Total Cash Contribution	2.0	205,690		205,690	
Sub Total Work Contribution	3.0		411,380		205,690
Total Contributions to Funds (cash plus work payments)	5.0	617,070		411,380	

* Less any payment made at scheme identification

9.13 Gender Issues

Chandia is located on the edge of the Mid-level Uplands of Balochistan (its inhabitants say they are Baloch, but their language is Sindhi) and women's socio-economic situations reflect this particular ecological and cultural mix. Except for the very wealthiest families, women are involved in agriculture and even women from the elite group carry food for their menfolk in the fields.

Women participate to some extent in most agricultural activities. However, men are primarily involved in areas where property ownership may be an issue, for example in maintaining field boundaries.

Unlike the Pathan areas of Balochistan, women participate in sowing, manuring, fertilising and watering field crops. Their contribution is pronounced in weeding and harvesting. The marked degree of their involvement emphasises that efforts to improve agricultural efficiency must make every effort not to exclude women and, ideally, should be targeted at them directly.

This observation would also apply to livestock, where animal husbandry is predominantly women's work, again, in contrast to the Pathan areas. In practice this means going out to the fields to cut fodder and carrying it home, milking the goats and cows, making a variety of dairy products and drying animal dung for fuel, which is greatly prized for cooking, as it burns without smoke and at a moderate and constant heat. Bullocks milk is used to make yoghurt and butter.

Taking care of the bullocks is a particularly noteworthy area of female responsibility, as ploughing is largely done by animal traction. Women groom the bullocks and are expected to be able to nurse them with home remedies when they are sick or tired.

Families request their female relatives to come and help at key labour intensive periods in the crop cycle. They work without payment, as assistance is expected to be reciprocated. However, women from landless families are also employed on daily wages; five women from a sample of 15 households randomly selected for detailed socio-economic investigations, worked as casual agricultural labourers. Their economic contribution is conceptualised as help as it is shameful for women to be forced to work through economic circumstances.

One result is that they are paid in kind, by the women or men of the employing household, as convenient. Payment is made according to customary rewards for the nature of the work; sometimes simply a hot meal or some unwanted clothing, at other times cleaned or uncleaned grain.

These indigenous relationships could be advantageously utilised by project, in that these womens informal support networks could be enhanced. These could be used for channelling agricultural extension and other development-related activities to women specifically. A number of women expressed the wish that income-generating activities might be introduced.

Mostly, drinking water is carried home in pitchers, on donkey back, but some women fetch water in buckets balanced on their heads. Only the very wealthiest women can avoid fetching water. Used water is run to waste in the compounds; it is not used for kitchen gardens, though it could be. The standing pools of water are a breeding ground for mosquitoes, otherwise women's health status is not unusually problematic.

9.14 Environmental Considerations

The environmental impact of the proposed scheme is likely to be minimal as the area has been cultivated for many years and the project does not include the development of new areas; see Environmental Considerations - Annex E.

9.15 Health Issues

The state of health of communities living and working in irrigated agriculture is a complex issue which needs to take account of specific disease situations which may be introduced and promoted by irrigation as a result of increased availability of water.

Amongst the farmers at Chandia, malaria was identified as their most important health problem and is likely to act as an impediment to their ability to harvest. The main malaria transmission season is late August or early September and a further period of transmission occurs in late April and May, with a high incidence of P. falciparum. The endemicity and seasonality of the malaria occurring in flood schemes is not well documented, but it is possible that the spring transmission period may be important, being sudden and more severe than the main season.

During the time of data collection (May) the villagers reported an epidemic of malaria with two to four patients per household. The issue was discussed with the malaria control programme (MCP) who are now to incorporate the village into their survey treatment campaign.

To assist in the development of appropriate malaria control strategies in the poorer sectors of the agricultural community, the scheme is proposed for a pilot trial in the use of impregnated bed nets to identify the optimum strategy for use in flood schemes.

Cutaneous Leishmaniasis does occur at Chandia and may be a potential problem during construction if workers from non endemic areas, and therefore with no immunity, predominate.

10 ECONOMIC ANALYSIS

10.1 Overview

An economic analysis has been provided for the two with project options. Due to the variable nature of flood irrigation and the range of possible outcomes associated with the hydrology, a range of possible project outcomes have been assessed. A sensitivity analysis has been provided to asses the impact of poor and favourable years throughout the projected life of the scheme, together with an assessment of the viability of the scheme if the projects starts in a series of poor years, in terms of water availability, or a series of good years. In addition, a sensitivity analysis has been provided to assess robustness of the proposed scheme to delays and changes in prices.

10.2 General Assumptions

Farmgate prices for the scheme were based on information gathered in Sibi market. The existing market for fodder is large and will continue due to the comparatively large holding of livestock in the area and nomads who pass through the Kachhi plains around Sibi. The price of internationally traded goods are based on World Bank commodity price forecasts. Import parity prices were calculated for wheat, oilseed, and fertilisers. Family labour costs were included for crop production as was the average cost of maintaining the in-field irrigation structures.

Standard Conversion Factors (SCF) were used to calculate the impact of the project in economic terms and were calculated for important inputs and details can be found in the Annex F.1. In calculating the SCFs, government guidelines for foreign exchange percentage, inflation rate and pricing of labour were used.

The areas used for the farm budgets were based on published data of the Sibi area and by farmer interview. Land holdings are comparatively large both for the landowners and tenant farmers.

Project life is taken as twenty years after construction; a discount rate of 12% was used.

Conservative assumptions have been made for yield increases over the project life.

10.3 Results

10.3.1 Financial Analysis

The financial rate of return for the project, using the preferred option 2, was estimated to be 11.8%. Details of a sample of the financial analysis for the average area can be found in Annex F.4. The model budgets indicated that good rates of returns would be available to both tenants and landowners, the budgets can be found in Annex F.5.

10.3.2 Economic Analysis

In obtaining a result for the economic analysis the average irrigated area over the life of the project was used to establish a benchmark, if this indicated that the option being considered was feasible. To make an assessment of the impact of the variable nature of flood irrigation and to take account of the hydrographic time series the economic analysis is given as probabilistic outcome. A more detailed analysis and sensitivity analysis was undertaken to take account of the complexities of various hydrological outcomes of the project.

Irrigation Scheme

The median economic rate of return for Option 1 was 1.6%. The economic rate of return for Option 2, taking the median result was 11.55%. Details of a sample of the economic analysis for the average area can be found in Annex F.6.

Road

The road has been treated separately in the economic analysis. The economic analysis of the road was based on the impact of the change in prices for carrying produce out and the frequency of the bus serving the villages on the route to Chandia and reduction in the bus fare. The benefits from the road include an assumption in the increase in the number of buses from two to eight, with the projected population expansion in the area. In addition, the benefits from the savings in transport cost have been estimated.

Although there are constraints on access to Chandia, the cost of building an all weather road, due to the lack of suitable raw material in the area, is high. The analysis is based on an improved dirt road which could be up-graded later. Even with the reduced specification the economic return from the road is estimated at only 7.7%.

The economic benefits from serving a small community offer comparatively small savings, particularly as the prices of transport are already very low. There is little prospect of expansion into a new agricultural area as the limiting constraint is the availability of water. Consequently the road is only marginally economically viable.

Obviously, an improved road link to Chandia and the villages on the route to Chandia will have social benefits, however, the social benefits to be derived from a road serving a small community of total population of around 3,497 people are likely to be small. Details of the economic analysis for the road can be found in Annex F.7.

10.3.3 Sensitivity Analysis

As only the second option produced a viable return, this option was considered for the sensitivity analysis.

The sensitivity analysis undertaken is in two forms. Due to the variable nature of the floods, the first sensitivity analysis seeks to determine the influence of relatively favourable and poor floods. In addition, and more importantly, the impact of the proposed project starting point needs to be taken into account in the hydrological time series. The second part of sensitivity analysis establishes the impact of changes in prices and benefits.

As there is considerable variation in the flows in the Chakar River, it is impossible to establish with any degree of certainty what the expected yield flow outcome is for a start point within the hydrographic time series. The viability of the project would obviously be adversely affected if the project implementation start date falls within a series of years with poor yield flows. Similarly, if project year one falls within a good series of years, this will inflate the returns to the project. To incorporate this into the sensitivity analysis and assess the impact of a good, median or a poor series of yield flow outcomes, thirty EIRR outcomes with different start points within the hydrologic time series were calculated. This established the sensitivity of the proposed scheme to low yield flows, and unfavourable commencement dates. In addition a general assessment of favourable, poor and median outcomes was also possible. From the thirty outcomes, the expected EIRRs were ranked to calculate the exceedence probability of good, poor and median returns to the investment.

The ranked probabilistic outcomes for Option 2 are shown in Table 40 and as the outcomes are not discrete, a graph of exceedence probability and EIRR is shown in Figure 18.

A favourable outcome for expected EIRR was taken as 14% and has an exceedence probability of 0.16. The median EIRR outcome was taken as 11.55% and a poor EIRR outcome was taken as 10% which is approximately equal to the opportunity cost of capital. This outcome has an exceedence probability of .82 and would indicate that there is a 82% chance of the project EIRR outcome being equal or better than 10%. Given the variable nature of flood irrigation, this is a comparatively good level of exceedence probability.

Favourable outcome ------------------- Exceedence Pr = 0.16	Expected $EIRR_1$ = 14%
Average outcome ------------------- Exceedence Pr = 0.5	Expected $EIRR_2$ = 11.55%
Poor outcome -------------------- Exceedence Pr = 0.82	Expected $EIRR_3$ = 10%

The sensitivity of the recommended Option 2, taking the median value[19] of 11.55% as the standard case, to changes in costs and delays gave the following results for EIRR:

- Benefits reduced by 10% — 10.0%
- Capital and recurrent costs increased by 10% — 10.2%
- Benefits reduced by 10% Costs increased by 10% — 8.6%
- Benefits lagged by 3 years[20] — 10.5%
- Project life reduced to 15 years — 10.1%

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[19] This would not normally be given to two decimals, but is done in this case to differentiate the outcome from the ERR outcomes with exceedence probabilities of 0.48 and 0.52.

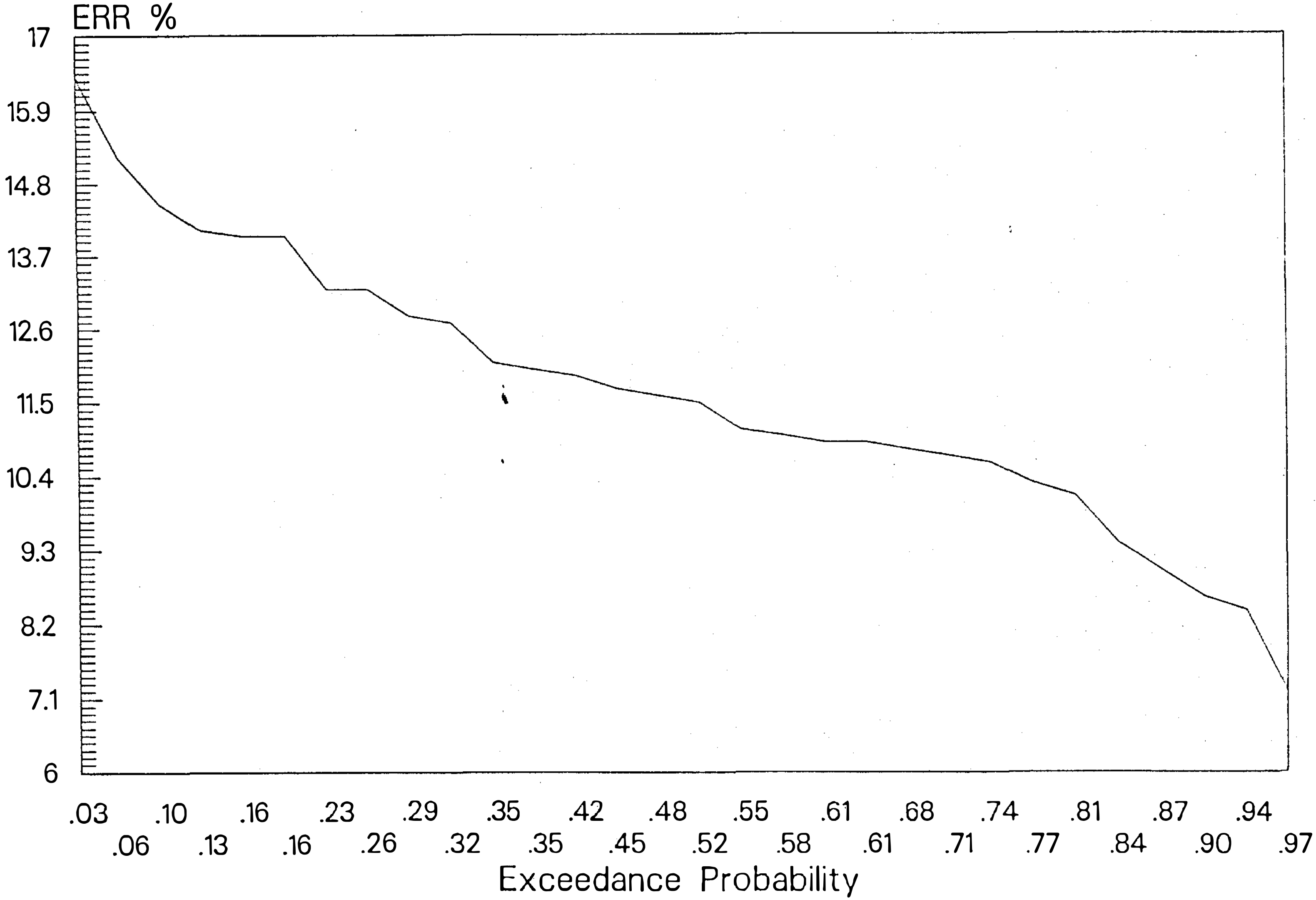
[20] This is indicative only, for if the implementation date or benefits are lagged for some reason the expected outcome would alter as the hydrographic outcomes alters. Similarly, the rate of return for a reduction in the project life would alter with outcomes from the hydrographic time series. This could adversely or conversely, have a positive effect on the rate of return.

TABLE 40 EXPECTED ERR WITH EXCEEDENCE PROBABILITY FOR THE WITH PROJECT OPTION 2

Rank	Expected EIRR Outcome	Exceedence Probability
1	16.4	0.03
2	15.2	0.06
3	14.5	0.10
4	14.1	0.13
5	14.0	0.16
	14.0	0.16
7	13.2	0.23
	13.2	0.23
9	12.8	0.29
10	12.7	0.32
11	12.1	0.35
12	12.0	0.39
13	11.9	0.42
14	11.7	0.45
15	11.6	0.48
16	11.5	0.52
17	11.1	0.55
18	11.0	0.58
19	10.9	0.61
	10.9	0.61
21	10.8	0.68
22	10.7	0.71
23	10.6	0.74
24	10.3	0.77
25	10.1	0.81
26	9.4	0.84
27	9.0	0.87
28	8.6	0.90
29	8.4	0.94
30	7.2	0.97

FIGURE 18

Exceedance Probability and
Economic Rate of Return



10.4 Risks

Farming using the sailaba method in the Kachhi area of Balochistan will always be associated with a degree of uncertainty and risk as a consequence of the variation in rainfall and consequential flood water. The proposed scheme attempts to improve the reliability of water and thus reduce the uncertainties in the farming system.

The uncertainties, in particular the natural hazards associated with flood irrigation are reduced following the recommended Option 2. The risks associated with the outcome, risks being subjective, are not measured and are not accounted for in the hydrographic and economic model other than by using conservative yields and conservative yield increases and prices over the life of the project.

As the project does not envisage the introduction of new crops, the risks associated with the implementation of the project relate to the construction of the headworks and the maintenance of the breachable and flood protection bunds. The risks associated with the construction of the headworks, are that the headworks will be washed away before they are completed. The risks associated with the maintenance of the breachable and flood protection bunds are related to the use and maintenance of the bulldozer. The project will reduce this risk by encouraging the WUA to act in a responsible manner in the use and management of the machine and in the provision of adequate maintenance funds.

11 CONCLUSIONS AND RECOMMENDATIONS

11.1 Scheme Synopsis

The proposed design adopts the traditional gandha approach retaining the breachable bund, but with improved headworks and weir which will allow a more controlled use of the available flood water.

By improving the control of the flood waters through an improved offtake, yet retaining the traditional breachable bund of the gandha system, the scheme aims to reduce the uncertainties associated with the availability and periodicity of sailaba irrigated agriculture, and retain the flexibility of the old system at an appropriate level of technology. The improved supply of water will lead to improved risk management strategies being adopted by the farmers in what is a relatively harsh environment.

11.2 Approach to Development

The objectives of the proposed rehabilitation of the Chandia Flood Irrigation Scheme are to enable the farmers to utilize the small and medium floods in the Chakar River more efficiently, whilst the high floods are allowed to pass virtually unchecked. In addition, it is envisaged that the improved head works will regulate flows into the flood channel, reducing flood damage in the command area. Moveover it is important to ensure existing downstream users continue to receive their share of the flood waters.

11.3 Irrigation Improvements

The improvements to the existing irrigation system take the form of a concrete headworks structure incorporating intake regulator and flow limiter, sediment exclusion skimming weir and sluice and short weir with a breachable earth bund, which is essentially a development and improvement of the existing situation. In the with project situation the following outcomes, expressed as annual total volume of water, would range from 8 acre ft, for a very poor outcome, which is expected to be bettered 90% of the time to 8,168 acre ft in a favourable year, expected to be exceeded only 10% of the time. The median being 3,683 acre ft. The improvements in volume and area are summarised in Table 41.

TABLE 41 **SUMMARY OF IRRIGATION IMPROVEMENTS IN TERMS OF ANNUAL VOLUME AND AREA IN WITHOUT AND WITH PROJECT SITUATIONS**

Annual Probability of Outcome being Exceeded (%)	Without Project		With Project Option 2	
	Annual Volume (acre ft)	Area (acres)	Annual Volume (acre ft)	Area (acres)
90	8	2	8	2
50	855	205	3683	883
10	3864	927	8168	1960

11.4 Ancillary Works

The ancillary works involve the proposed construction and up grading of the road linking Sibi and Chandia. The road passes though Mall, Goramzai, Tora Golla and Gishkoori feeding a total population 3,497.

11.5 Benefits

The primary benefit from the scheme will be the more reliable supply of available water which will reduce in a major part the uncertainty in the crop production in Chandia. The introduction of a WUA is expected to assist in the economic and social development of the village. In addition, the social benefits from increased and more consistent supply of water and increased cropped area will be significant to farmers in their ability to grow food more consistently and gain a more reliable source of income.

11.6 Distribution of Benefits

The egalitarian nature of the distribution of water at Chandia is expected to encourage an equal distribution of benefits. In addition, the present distribution of land holdings is comparatively equal with most people holding land in the upper and lower parts of the command area. The scheme is likely to reduce the level of uncertainty which will be beneficial to the poor of the community and will add to the livelihood security of the village. The introduction and encouragement of a WUA is expected to be beneficial and will be encouraged to particularly assist the poor. The reduction of uncertainty associated with the water supplies will also encourage the men to remain in the village which would have a positive impact on the gender division of labour.

11.7 Social Amenities

It is difficult to justify the inclusion of the road due to the high cost of construction and the limited social benefits. It is unlikely to lead to any increase in the agricultural development of the area as this is constrained by the availability of water.

11.8 Participation

It is envisaged that the farmers will be encouraged to fully participate in the implementation of the scheme. Part of the construction work will be undertaken by the farmers and it is expected that they will be totally responsible for the maintenance of the scheme. Farmer participation is seen as a necessity to encourage a fully sustainable scheme, the total number of beneficiaries at Chandia is 897.

11.9 Involvement of Women

As the project lies within the Baloch speaking part of the province, women participate quite widely in the agricultural production cycle. The proposed project will take this into account during the implementation phase of the project. It is expected that the Women and Development programme of the main project will focus on providing appropriate training and advice as these needs are identified.

11.10 Costs and Rates of Return

The cost of the scheme following the preferred Option 2 is Rs20,569,024 which is a cost per beneficiary of Rs22,931. The cost of the road is Rs13,998,716 and is estimated to result in a cost per beneficiary of Rs4,003.

As the economic rates of return are based on the cropped area and therefore on the hydrological model and the starting point in terms of that data is unknown, a range of possible outcomes for the project have been calculated based on the exceedence probability of a certain outcome occurring. These are summarised in Table 42. From the expected outcomes it can be seen that a poor outcome with an EIRR of 10% is likely to have an exceedence probability of 82%, similarly a median outcome could be expected to have an EIRR of 11.55%. These rates of return are generally thought to be favourable for a flood irrigation scheme, and are indicative of the high prices that are available from fodder sorghum. It is unlikely that such a high rate of return would be repeated in other flood irrigation schemes which do not have a ready fodder market in the near vicinity.

TABLE 42 SUMMARY OF ECONOMIC RATES OF RETURN FOR DIFFERENT PROJECT OUTCOMES

Type of Outcome for the Scheme	Exceedence Probability for the given outcome (%)	Expected Economic Rate of Return (%)
Poor Outcome	82	10
Median Outcome	50	11.55
Favourable Outcome	16	14

The financial rate of return for Option 2 was found to be 11.8%.

The road improvement works are only marginally economically viable with an economic rate of return of 7.7%.

11.11 Environment

It is not expected that the scheme would have any appreciable impact on the local environment as there is already an existing scheme and no new area is to be developed. There is a potential for an increase in the incidence of malaria, however, the project will be introducing bed nets and the scheme has been brought into the malaria control programme.

11.12 Recommendations

Investment in traditional sailaba irrigation systems, which are a predominant form of subsistence agriculture in many parts of Balochistan has, in the past, been inappropriate. This is despite the importance of this type of farming for the production of cereals, oilseed and fodder. The uncertainties involved in flood irrigation and the difficulties in collecting data on the hydrology and predicting the flood volumes and benefits from the schemes have all proved to be problematic in the past when designing flood irrigation schemes.

However, as can be seen, where appropriate sites are found and with the aid of computer based modelling of the hydrology, favourable rates of return from flood irrigation are achievable. The proposed project, following the recommended Option 2, offers the possibility of significant improvements to the existing gandha system, whilst retaining the desirable safety aspects of the system which have been evolved by the farmers over hundreds of years.

It is thought, however, that the Chandia flood irrigation scheme will be exceptional with respect to the return on investment when compared to other flood schemes. This is a result of the benefits from a reduction in the uncertainties associated with water availability, but more importantly, the favourable returns from ratooned fodder sorghum.

It is therefore recommended that the proposed Option 2 proceed to detailed design and subsequent implementation.

The low rate of return on investment and the limited social benefits that can be expected from the proposed road improvement works suggest that it is unadvisable for the improvement to the road to proceed.