Japan International Cooperation Agency (JICA)

Irrigation and Power Department
Government of Punjab
The Islamic Republic of Pakistan

BASIC DESIGN STUDY REPORT
ON
MITHAWAN HILL TORRENT PILOT PROJECT
IN PUNJAB
IN THE ISLAMIC REPUBLIC OF PAKISTAN

JANUARY 1994

NIPPON GIKEN INC.

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Mithawan Hill Torrent Pilot Project in Punjab and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team headed by Mr. Masayuki Watanabe, Development Specialist, Japan International Cooperation Agency and constituted by members of Nippon Giken Inc., from August 23 to September 25, 1993.

The team held discussions with the officials concerned of the Government of Pakistan and conducted a field study in the study area. After the team returned to Japan, further studies were made. Then, missions were sent to Pakistan in order to discuss draft reports, and as this result, the present report was finalized.

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

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

January 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

January 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

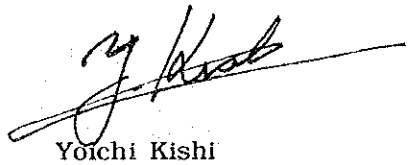
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Mithawan Hill Torrent Pilot Project in the Islamic Republic of Pakistan.

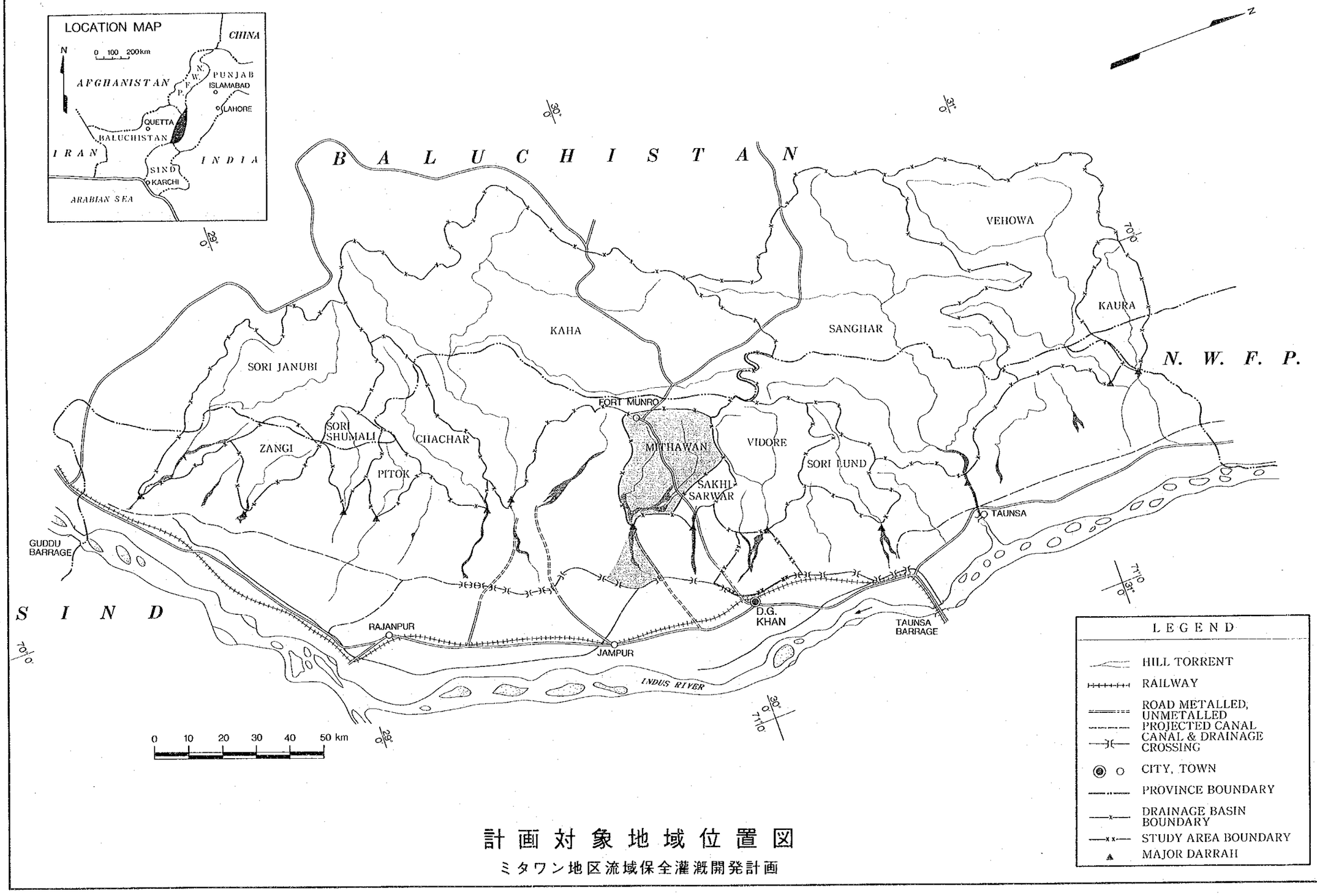
This study was conducted by Nippon Giken Inc., under a contract to JICA, during the period from August 26, 1993 to January 31, 1994. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Agriculture, Forestry and Fisheries. We would also like to express our gratitude to the officials concerned of the Ministry of Water and Power, the Federal Flood Commission , Irrigation and Power Department of the Punjab, JICA Pakistan Office and Embassy of Japan in Pakistan for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

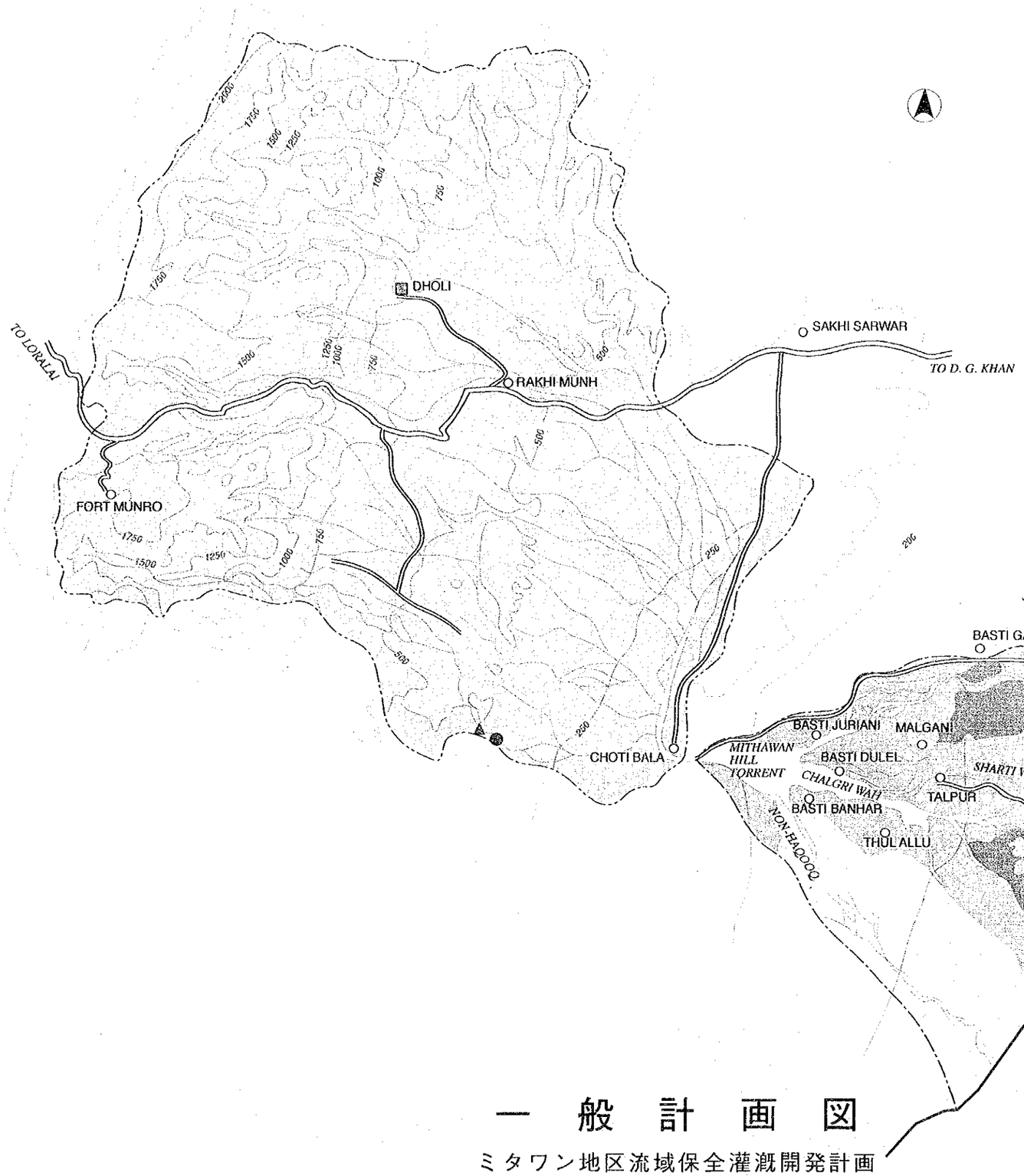


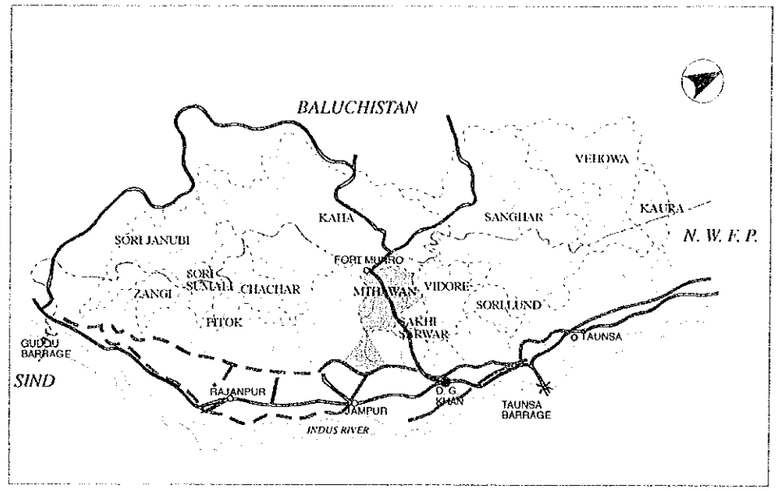
Yoichi Kishi
Project Manager
Basic design study team on the
Mithawan Hill Torrent Pilot Project
Nippon Giken Inc.



計画対象地域位置図

ミタワン地区流域保全灌漑開発計画





LEGEND

- BOUNDARY OF WATERSHED
- BOUNDARY OF PACHAD
- CHOTI NALLAH DISPERSION STRUCTURE
- CHOTI NALLAH SAND POCKET
- WATERSHED MANAGEMENT DEMONSTRATION AREA
- IMPROVEMENT ROAD
- HILL TORRENT
- D. G. KHAN CANAL
- CULTIVATED AREA
- UNCULTIVABLE AREA
- NON-HAQOOQ AREA

SCALE 1 : 200,000

0 2 4 6 8 10 km

一　般　計　画　図

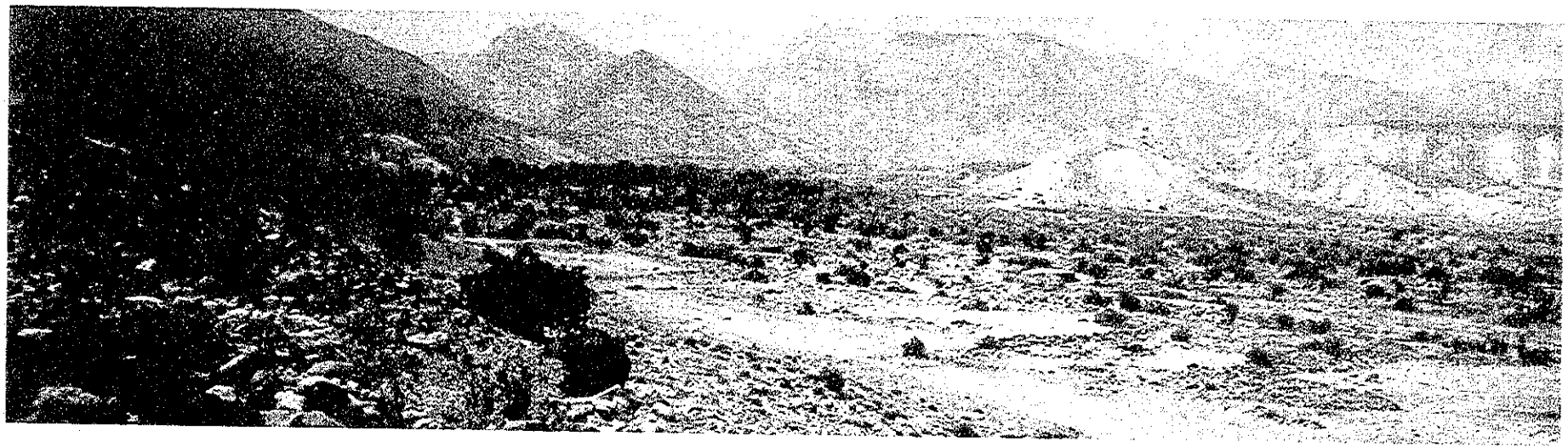
ミタワン地区流域保全灌漑開発計画

PHOTOGRAPHS

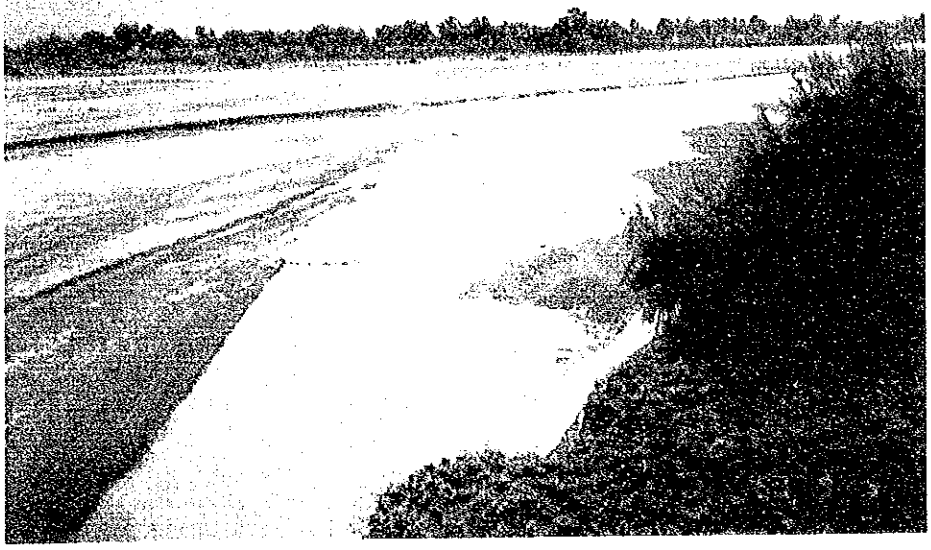
CHOTI NALLAH (A View of Down Stream from Darrah)

NANGAR NALLAH (A View of Down Stream from Darrah)

CULTIVATED AREA WITH FLOOD IRRIGATION

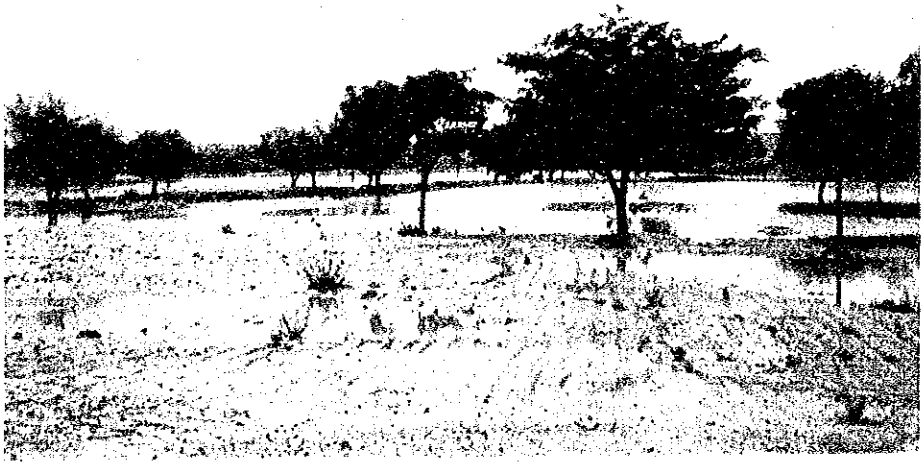


WATERSHED MANAGEMENT DEMONSTRATION AREA (A View of DHOLI)



MITHAWAN NALLAH
A View of Flood (no.1)

MITHAWAN NALLAH
A View of Flood (no.2)



A View of Flood irrigation

SUMMARY

The Islamic Republic of Pakistan is an agricultural country with population of over 100 million. The agricultural production, comprising mostly wheat, rice, cotton and sugar cane, accounted for about a quarter of the Gross Domestic Production (GDP). Most of production has yielded from Punjab and Sind provinces. Total area of Pakistan is around 79.6 million hectares, of which equivalent to 26 % about 20.7 million hectares, are cultivated. Seventy six percent of total cultivated area, 15.7 million hectares, is irrigated since agricultural production is unable to increase without irrigation under the severe climate conditions in Pakistan. However, irrigation remains still insufficient to attain the target of agricultural production. Therefore, the Government is making efforts to extend irrigation systems.

In Punjab province, vast potentially cultivable area is available in D. G. Khan hill torrent area. However, the drainage basins of the hill torrents are prone to be eroded due to their denuded surface. Rainfall during Monsoon months, which is distributed mostly in July and August, causes flush floods with high concentration of a load of eroded material. The flush floods from the hill torrents damage the canal irrigated lands downstream-ward on the one hand, vast rain-fed area, so-called Pachad area, fails to receive valuable irrigation water on the other hand. Complicated hill torrent problems imposed mainly by uncertain flood flows have left D. G. Khan hill torrent area socio-economically behind.

In 1984, Ministry of Water and Power, the Federal Flood Commission and the Irrigation and Power Department of Punjab conducted a study for the flood management in accordance with agricultural development in the D. G. Khan hill torrent area, where the Mithawan hill torrent is located. In 1992, the Feasibility Study on Development of Irrigation based upon Flood Flows of D. G. Khan Hill Torrent covering whole the D. G. Khan hill torrent area was completed under Japanese International Cooperation Agency (JICA), in which Mithawan Hill Torrent Pilot Project was reviewed.

The Government of Pakistan requested the Government of Japan for the implementation of the "Mithawan Hill Torrent Pilot Project" as the Japan's Grant Aid program on the basis of these studies.

The Government of Japan dispatched the Preliminary Study team to Pakistan on the Mithawan Hill Torrent Pilot Project from May 17 to June 6, 1993 through JICA.

The Study team reached the conclusion below.

Most of the Pachad area looks like barren land in dry season and the productivity is undoubtedly lower in the Pachad area than in the canal irrigation area. Though flood irrigation is applied in the area, but scheduled stable farming might be impossible even during rainy season. Moreover flush floods from the hill torrent effect adversely to the canal irrigated area and villages depending on their magnitude. The team recommended the means to solve these problems. The recommendation includes construction of the Mithawan main dispersion structure and watershed management. The Mithawan main dispersion structure distributes flood flows to the Pachad area and prevents flood damage in the canal irrigated area. Watershed management aims to open the way toward construction of a dam in the future by means of recovery of vegetation which would decrease soil erosion and reduce runoff.

Watershed management in cooperation with FAO directs to not only growing vegetation but also community development with participation of the village population, such as establishment and management of community organizations, and introduction of rotational grazing.

The Mithawan main dispersion structure was recognized being important for the development of the area and most benefit of the project supposed to be produced from its flood controlling function. However, since uncertain flood occurrence in the Mithawan hill torrent would not necessarily effect adversely every year, the dispersion structure might not produce adequate benefit within a few years after its completion. And it is the difficulty to apply Japan's Grant Aid Program to the distribution structure.
Because of this, it was recommended to review the function of the distribution structure prior to the commencement of the Basic Design Study.

The Government of Japan reviewed the project based on the recommendation by the preliminary study team and decided to commence the Basic Design Study for the reviewed Mithawan Hill Torrent Pilot Project including irrigation development and watershed management. Regarding to the implementation of the watershed management, the Government of Japan settled that Japan's Grant Aid Program would cooperate with Food and Agricultural Organization of United Nations (FAO) because the watershed management would need people's participation in the works and also in its future maintenance with their understandings. JICA sent the Basic Design Study team headed by Mr. Masayuki Watanabe, Development Specialist of JICA in order to review

and justify the project as a grant aid program, for 34 days from August 23 to September 25, 1993.

The Study Team compiled the draft final report of the Basic Design study based on the field survey for a dispersion structure on Choti nallah, a distributor of Nangar nallah, proposed site for the watershed management, proposed route for road improvement and analyses of basic concept, cost estimate and operation and maintenance plan of the project several discussions with Pakistan side .
Basic Design study reached the conclusion mentioned below.

Choti nallah dispersion structure will utilize the whole quantity of the flood discharge for irrigation with reduced flood damage in the lower reaches in Mithawan main stream. Maintenance works are expected to be done without any difficulty because of its similarity to the existing structures built by the Irrigation and Power Department. The structure matches to the conditions of application of the Japan's Grant Aid Program by its urgency, scale of the structures, scheduled construction period.

Nangar nallah dispersion structure was planned for the irrigation purpose also. However, temporary structures will be available at the proposed site because of its physical condition, such as raised-bed of the stream and high seepage into the gravely river-bed. The proposed small scale structure could be constructed in the usual maintenance work. Nangar nallah dispersion structure excluded from the Grant Aid program for above reasons.

Road network will cater for transportation needs of village population in project area and also used for construction works. By this reason, road improvement will be also included in the project.

Watershed management program will be executed in cooperation with FAO. Japan's Grant Aid applied mainly for the short-term measures such as construction of structures and FAO will manage long-term measures, such as enlightenment on the grazing-yard management. The FAO's principle for project implementation is to develop the area through improvement of environmental circumstances by their understanding and self-help of the local people. Scope of cooperation of the Japan's Grant Aid Program includes construction works of major structures for demonstration in the proposed pilot area of Dholi, which contribute to the improvement of environmental

circumstances of the area, and construction of office buildings as a base for FAO's activity and several equipment supporting education and training. Construction of minor structures and vegetation raising works will be done by the community organization with technical assistance of FAO.

Construction period is divided into two stages considering to keep sufficient period for the cooperated activity with FAO. Scheduled construction period is three and half (3.5) months for detailed design and eight (8) months for the construction period in Phase 1-1, and three (3) months for detailed design and eleven (11) months construction period in Phase 1-2.

Regarding the benefit produced by the Project, crop yield will be expected to increase through more effective irrigation system by means of a new dispersion structure. Increase of yield due to the project is estimated at 6 to 17 % varied by crops at 5-year return period flood and 29 to 55 % at 25-year return period flood.
Cropping intensity will increase from 17.7 % of total available area at present to 32 % at 5-year return period flood and 70 % at 25-year return period flood with the project. Besides, reduction in flood damages will be brought as a by-product of the irrigation project.

As watershed conservation works will flatten out flood peak and minimize soil erosion, life-span of irrigation facilities will be extended with reduction of operation and maintenance cost. In Addition to this, it is expected that the change of attitude in local population by self-help and understandings will open the door for developing the environmental circumstances and raise the standard of living.

D. G. Khan hill torrent development will expand the agricultural activity in the Pachad area by converting flush hill torrent flows from harmful damaging floods to useful moisture for crop production. Development of hill torrent area under the severe climatic conditions with minimal rainfall will be attained not only by the improvement of facilities but also by a people's confidence in achieving the benefit through the project such as improvement of living conditions and increase of agricultural productivity. Implementation of the Mithawan Hill Torrent Pilot Project will demonstrate the functional and methodological effectiveness and to create a good effect to all of the D. G. Khan hill torrent area.

The Project is contemplated to contribute much as mentioned above. Besides, it will effectively promote the improvement of environmental conditions in the area and raise the living conditions of the local people. Implementation of the Project is expected to be quite significant in its practicality. There will be no difficulty in its operation and maintenance with proper numbers of personnel and budget.

TABLE OF CONTENTS

Chapter 1 Introduction

Agriculture is the largest of the sectors contributing to economic activity in Pakistan. The total area of Pakistan is around 796,000 square kilometers, or 79.6 million hectares, of which about 20.7 million hectares (26 per cent) are cultivated. A total of 15.7 million hectares (76 per cent) are irrigated. However, it is still necessary to extend irrigation systems because of the low agricultural productivity in spite of extensive irrigation systems. The Government of Pakistan lays emphasis on the establishment of sound national finance and economy and the alleviation of poverty in the Seventh Five-Year Plan (1988 - 1993). The Government focuses on the acceleration of rural area development across the country. Agricultural development is consequently placed to become one of the most important measures. In agricultural development strategy, its effective utilization of water resources is highly placed to become one of the indispensable measures to attain self-sufficiency of agricultural production and export promotion.

Agricultural productivity in the D. G. Khan hill torrent areas generally remains at considerably low level. It is attributed to shortage and uncertainty of rainfall and inadequate use of flood flows for irrigation contrary to its high potential irrigable lands in the hill torrent areas. Activation of agricultural productivity in the hill torrent areas has important meaning in order to rectify income disparities and achieve an poverty alleviation in line with the national targets of the Government of Pakistan.

The Federal Flood Commission, Ministry of Water and Power and the Irrigation and Power Department of the Government of Punjab conducted the study of Flood Management in 1984. The study aimed at attainment of the agricultural development by means of the flood control and its utilization for irrigation purpose in the D. G. Khan hill torrent areas. In response to the request of the Government of Pakistan (GOP), the Government of Japan (GOJ) has conducted the Feasibility Study on the Development of Irrigation Based upon Flood Flows of D. G. Khan Hill Torrents. The study has been conducted by the Japan International Cooperation Agency (JICA) in 1992.

Based on these study results, the GOP selected the Flood Management of Mithawan Hill Torrent as a "Pilot Project" from among the major hill torrents of D. G. Khan, and requested the GOJ to conduct the Basic Design Study (B/D) of the project. In response to the request, the GOJ sent the Preliminary Study Team through the JICA from May 17 to June 6, 1993, and the team reviewed the project by the field survey and study in Japan. The project components were composed of irrigation development and

watershed management. In regards to the watershed management, the GOP has requested the Food and Agricultural Organization of United Nations (FAO) for the technical assistance, and the GOJ also recognized the project as cooperative project with FAO. The GOJ decided to conduct the B/D Study on the Mithawan Hill Torrent Pilot Project. The JICA sent the B/D Study Team headed by Mr. Masayuki Watanabe, Development Specialist of JICA in order to review and justify the project as a grant aid program, for 34 days from August 23 to September 25, 1993. Minutes of Discussions regard to the project was exchanged during their stay in Pakistan (Member list and field survey schedule of the B/D Study Team, list of personnel concerned and the Minutes of Discussion are attached as the Appendices). The Study Team compiled the Draft Final Report of the B/D Study through several discussions and analyses in Japan.

JICA sent the mission headed by Mr. Hirohumi Taniguchi for explanation of the Draft Final Report from November 22 to December 1, 1993. As a result of discussion, the contents of the report except implementation schedule were acknowledged by the GOP.

From January 11 to 20, 1994, JICA sent the mission headed by Mr. Shinya Suzuki for explanation of the revised Draft Final Report. As a result of discussion, the revised implementation schedule was acknowledged by the GOP.

Chapter 2 Background of the Project

2.1 Profile of Pakistan

(1) Physical Geography

The Islamic Republic of Pakistan lies between 25°-30' and 36°-45' north latitudes and between 61°-00' and 75°-30' east longitudes. Pakistan is located at a very important place connecting Middle East and South Asia. The distance from north to south is about 1,600 km, and the one from east to west is about 885 km. Pakistan has an area of 796,000 km^2. The Himalayan, Hindukush and Karakoram mountains traverse the north and north-west, and the Tropic of Cancer runs through the south tip of the country.

The Indus River originating from Himalayan mountains runs through the plains in the middle of the country, and flows into the Sea of Arabia. The upper reaches of the Indus River has mountain districts, deep gorges and high plateaus, which form high-relief configuration. In contrast to this, the alluvial plain extends far and wide towards south-west downstream areas. The alluvial plain joins the Thar Desert that is located at the border of India.

(2) Climate

Pakistan is classified into subtropical climate, however, part of the country is located in the arid zone in Indo-Pak subcontinent. Accordingly, the rainfall in northern mountain districts is more than 900 mm in a year, but it hardly or never rains westward into Baluchistan and southward into Sind and the Thar desert (less than 130 mm in a year). Pakistan has two rainy seasons. One is Monsoon in summer from June to September (bringing about 70% of the annual rainfall), the other is in winter from December to March.

The high temperature season in plains is from May to June. The average and maximum temperatures recorded at Lahore are 31.5°C and 48.5°C, respectively. The cool season, December to January, has relatively low average temperatures. The average temperatures of 12.0°C and 18°C were recorded in January at Lahore and Karachi.

(3) Population

According to the 1981 Population Census, the population of Pakistan was 84.3 million, making it the ninth most populous country in the world. In

1987, it crossed the 100 million mark and 1991 was estimated at 113 million. As a result of declining mortality, the population growth rate has also risen from 2.8 % annum in the 1960s to 3.1 % at present, well above the South Asian annual average of 2.4 %.

Population density for the whole country was recorded at 106 persons/km^2 at the time of the 1981 census, and was estimated at 143 persons/km^2 in 1991. It is still not a very densely populated country. The majority of the population lives in the fertile Indus River plain in the Punjab and Sind and the other major areas of the country are geographically far less hospitable. There are therefore wide variations in population density between the provinces. In 1981 the figure for Baluchistan was just 12 persons per km^2, while it was 230 in the Punjab, 148 in the North-West Frontier Province, and 135 in Sind.

Pakistan has experienced rapid urbanization and the share of urban population has increased from 17.8 % in 1951 to 28.2 % in 1981. The average annual growth rate of urban population was 4 % in the 1960s and 4.3 % in the 1970s.

(4) People and Languages

There is considerable ethnic diversity within Pakistan. Main ethnic groups are the Punjabi (59.6 %), the Sindhi (11.1 %), the Pushtun (9.0%) and the Baluchi (2.7%).

Main languages are Punjabi (48.7%), Sindhi (11.8%), Pusht (13.1%) and Baluchi (3.0%). Some other minor regional languages are also spoken. The area where the ethnics are living, roughly correspond to current administrative divisions, provinces of Punjab, Sind, North-West Frontier and Baluchistan. However it is difficult to draw a distinct line between them due to complex composition and distribution. The same is the case with the area where the languages are spoken. The official languages are Urdu and English.

(5) Education

According to the 1981 Census, the literacy rate of Pakistan was at 26.2 %. The rate among women was much less at 16 %, among the rural population 15 %, and among rural women 5.5 %. The educational system is 5 years primary (including elementary school), 7 years secondary (including junior high school,

senior high school and intermediate college), and higher education (including degree college and university). The compulsory education is for 5 years up to primary level. In recent years, the mosque schools also provide the primary education. This is expected to rise the literacy in rural areas.

(6) Religion

97 % of population are Muslims. Of these majority are Sunni (75-85 %), the rest being Shia (15-20 %). There are also members of the heterodox Ahmadi sect, who consider themselves Muslims but have officially been declared non-Muslim by the government. There have been many clashes in the past over religious issues between the Sunnis and the others, and on occasion among the different groups in the Sunnis. There are also small communities of Hindus in Sindh, of Christians in the main cities and of Parsis in Karachi.

(7) Administrative Divisions

The territory of Pakistan comprises the four provinces of Punjab, Sind, North-West Frontier and Baluchistan, FATA: the Federally Administered Tribal Areas (the Gilgit Agency in the north and the tribal areas along the border with Afghanistan), and FCA: the Federal Capital Area of Islamabad. Pakistan also administers Azad Jammu and Kashmir. The provinces are autonomous units and each has a Provincial Assembly empowered to make laws for that province. For administrative purposes, each province is divided into a number of divisions, each of which is divided into districts, sub-divided into tehsils.

(8) National Economy and Industry

The growth rate of Gross Domestic Product (GDP) during 1990/91 was recorded at 5.6 %, in 1991/92 it was estimated at 6.4 % and per capita income was also estimated at US$ 414 per annum. Agriculture made up 24.5 % of GDP, and the growth rate was put at 6.4 %, especially raw cotton, onion and potato production is increasing. The growth rate of manufacturing was estimated at 7.7 %. The industry of cotton cloth, soda ash, cotton yarn and sugar rose up well (18.0 %). Manufacturing in Pakistan is based on the textile industry such as cotton processing. Accordingly agriculture have still strong effect on Pakistani economy.

(9) National Finance

In 1990/91, the deficit financing reached 8.8 % of GDP. However in 1991/92, it decreased to 7.6 %, due to the abolition of the reduction and exemption of income tax, the introduction of new commodity tax, the reinforcement of ability to collect taxes in annual revenue, and the 10 % cut in annual expenditure of national defense, interest, and so on except social sector.

(10) International Balance of Payments

The rate of exports increase was 19.8 % in 1990/91, and was 16.6 % in 1991/92. The main commodities were raw cotton (35.5 %), textiles (34.0 %), clothes (33.3 %), rice (31.8 %). The rate of import increase in 1991/92 was 8.6 %. The commodities showing high rate were wheat (76 %) and capital goods (37.6 %). The reason for high rate of capital goods was a liberalization of imports policy for the promotion of private investment in the rural areas.

Remittance from Pakistanis working abroad have been an important source of revenue. But as a consequence of the economic slump and the stability of oil price of Gulf countries where the main working force was, the remittance decreased substantially (US$ 2,900 million in 1982/83, $1,800 million in 1990/91, $1,500 million in 1991/92). Accordingly, the ratio of deficit in current balance to GDP was increased from 4.8 % in 1990/91 to 5.2 % in 1991/92.

(11) Prices

In 1990/91, the consumer prices rose by 12.7 %. One of the reason was 42 % rise in the price of the oil products due to Gulf War. Pakistani Government adopted a control of all demand policy to increase the supply of main commodities. As a result, the consumer prices declined by 9.6 %. The main items whose prices rose, were fuel (11.8 %), clothes (11.2 %), rent (10.8 %), and so on.

(12) Employment

The total size of the labor force was estimated in 1990/91 to be 32.8 million, of which 23.9 million was officially estimated at 3.1 % in 1990/91 but as much as 10 % of the labor force is under employed (defined as working less than 35 hours a week). Only 25.5 % of the employed labor force are wage earners. In rural areas, the percentage of waged employees was 20.1 %, and in the urban areas 45.4 %.

Agriculture in 1990/91 accounted for an estimated 51.1 %, it represents the largest percentage of the whole industry, while in 1963/64 it accounted for 60.5 %. Comparing 1963/64 and 1990/91, employment in manufacturing and mining has decreased slightly from 13.6 % to 12.8 %. Trade, up from 7.6 % to 12.5 %, construction, up from 1.4 to 6.4 %, and transport, up from 2.0 to 4.9%.

(13) Foreign Economic Assistance

Pakistan has obtained loans from international organizations and foreign countries. At the end of 1991/92, long-term debt was estimated at US$ 16.4 billion, and it accounted for 33.9 % of GNP (33.2 %, 1990/91). Debt service ratio deteriorated slightly (23.6 %), because of increase of interest disbursements in 1991/92 (24.1 %), and attaching more importance on short-term loan.

2.2 Agriculture in Pakistan

Agriculture is the largest of the sectors contributing to economic activity in Pakistan, providing 25 % of GDP, employing 50 % of the labor force, and sustaining 75 % of the population. The sector directly accounts for 25 % of total exports and cotton textiles and other agro-based manufactured exports account for an additional 35 to 40 % of total exports. The provinces of Punjab and Sind are the granary of Pakistan, whereas the North-West Frontier Province and Baluchistan are food-deficit regions.

The cropping pattern in Pakistan has, of course, not remained static. Since the 1960s, the share of food grains, cash crops, vegetables, fruits and condiments has risen steadily while that of pulses, oilseeds and other crops (mainly fodder) has declined. Along with the change in cropping pattern, there has also been an increase in land utilization. Since 1951 cultivated area in Pakistan has augmented by over 5 million hectares, cropped area by about 8 million hectares, and cropping intensity by 15 %. Accordingly, agricultural growth is accounted for by the changing technological environment in agriculture and output and input pricing policies that led to the introduction of high-yield varieties in wheat, rice and more recently cotton, subsidies on fertilizer and pesticides, and greater availability of irrigation water.

Pakistan is situated in arid and semi-arid climatic zones and is heavily dependent on irrigation. Of the country's total area of 79.6 million hectares, 20.7 million hectares were cultivated in 1990 and a total area of 15.7 million hectares were irrigated, most of it in the Punjab and Sind. It is estimated that four-fifths of cropping depends on irrigation and that the increase in cultivated land by over a third since 1947

has largely been due to improvements in irrigation. However, there is still believed to be scope for extension of the irrigation system to potentially cultivable areas as well as improvement in the management of the existing system. Of equal importance to new irrigation works is reclaiming irrigated land that has become saline through water logging, especially in Sind. Surface water resources contribute approximately two-thirds of total water availability and ground water resources one-third.

Agricultural production in Pakistan is carried out under several types of tenancy and farm size arrangements. The 1980 Agricultural Census indicates there were a total of 4 million farms in that year, of which 20 % were less than 2.5 acres (1.0 ha) but accounted for 2.3 % of total farm area. At the other end of the scale, farms above 150 acres (60 ha) constituted 0.3 % of the total but covered 8.4 % of farm area. About 48 % of farm area was tenanted and 52 % owner-cultivated.

The six major food grains grown in Pakistan are wheat (66 %), rice (18 %), maize (7 %), bajra (4 %), jowar (3 %) and barley (2 %), which together are grown on 11.9 million hectares. After adding 1.5 million hectares of pulses, the total food crop area comes to 13.4 million hectares.

Wheat is the most important crop in area, value added, and its role in consumption. Production climbed rapidly from around 7 million tons in the early 1970s to reach 14.4 million tons in 1989 and was estimated at 14.3 million tons in 1990. Between 1961 and 1990, area increased from 4.6 to 7.8 million hectares. Over the same period wheat output more than tripled from 3.8 to 14.3 million tons. These increases were achieved through intensive use of fertilizer and high-yield varieties as well as tube well irrigation. The weather, however, continues to be a crucial factor, particularly in the un-irrigated areas.

Livestock rearing contributed about 30 % to the value of agricultural production in 1990 and the agricultural sector relies on animals for over 80 % of its motive power. During the past ten years, livestock rearing has sustained an annual growth rate of 6 %. Livestock rearing is, however, still relatively undeveloped and the Government has recently expanded the size of crossbreeding programs and taken other measures to increase productivity. In 1990, there were an estimated 17.6 million head of cattle, 14.7 million buffaloes, 35.4 million goats and 29.2 million sheep.

2.3 Relevant National Development Plan

(1) Eighth Five-Year Plan

In the Eighth Five-Year Plan (1993/94 - 1998/99), the Government has planned to attain substantial economic growth of 8.1 % per annum, which is comparatively higher than the target of 6.5 % in Seventh Five-Year Plan. Meanwhile, the Government launches new population program aimed at reducing the birth rate up to 2.6 % to control overpopulation by the year 2000. This program is based upon the aim to gradually double the annual per capita income over this 12 - 15 years period. In this connection, shifting to intensive and highly productive agricultural management is expected to rectify an income distribution disparity between several industrial sectors taking into consideration the importance of agricultural sector principally contributing to national economic development.

(2) New National Agricultural Policy

A synopsis of the New Agricultural Policy was unveiled in May 1991. The major weakness in the agricultural sector was identified to be the communication gap between researchers and growers and it was announced that the cooperative system would be re-organized to help growers adopt new technology and use quality inputs. The synopsis consists of five policy goals, six policy parameters, nine basic objectives and seven strategy points.

The five policy goals are :

(i) self-reliance,
(ii) social equity,
(iii) export orientation,
(iv) sustainable agriculture, and
(v) enhanced productivity.

The six policy parameters are:

(i) rapid population growth,
(ii) potential for higher agricultural productivity,
(iii) dependence on vertical (productivity) improvement rather than horizontal (aerial) expansion,
(iv) raising incomes, which propel demand for non-cereal agricultural products,
(v) concentrating on optimizing production in areas

of comparative advantage (larger irrigated farms), and

(vi) dependence of a rapidly growing number of non-farm households on agro-business development.

The nine basic objectives are:

(i) achieving self-sufficiency in cereal and other essential farm products,

(ii) developing high-value products for exports,

(iii) ensuring equitable and stable prices for farmers,

(iv) ensuring adequate and easy availability of farm inputs, including credit,

(v) improving marketing infrastructure,

(vi) conserving the agricultural resource base of land, forests and water,

(vii) concentrating on research gaps and ensuring rapid transmissions of new technologies through an effective extension program,

(viii) emphasizing agro-business and agro-industry, and

(ix) enhancing the role of the private sector in agriculture.

The seven strategic pillars are:

(i) a growth rate faster than the population growth rate,

(ii) higher productivity in all sub-sectors,

(iii) emphasis on high-value crops in exports,

(iv) conservation and development of natural resources,

(v) promotion of the private sector in production, processing and distribution,

(vi) greater attention to small farmers and barani area development, and

(vii) greater employment in rural areas through agro-business and agro-related industries.

A package of incentives for the agricultural sector was outlined, comprising:

(i) a productivity enhancement program,

(ii) fiscal incentives, and

(iii) non-fiscal incentives.

2.4 Background of the Project

2.4.1 Circumstances of the Request

Economic activity in Pakistan depends mostly on agricultural sector. The total area of Pakistan is around 79.6 million hectares, of which about 20.7 million hectares, equivalent to 26 %, are cultivated. A total of 15.7 million hectares, equivalent to 76 % are irrigated. However, the Government is still developing and improving the irrigation systems to eliminate their malfunction. Agricultural productivity remains still low level in comparison with world standards due to insufficient irrigation, lacking of new cultivation technology and inadequate farming management while vast cultivable areas are still available in the country. Development of irrigation systems is urgent matter of the Government to attain the goal of agricultural productivity to achieve sound national economic development.

Complexity of hill torrent problems mainly imposed by uncertain floods have kept D. G. Khan hill torrent belt socio-economically behind. The drainage areas of D. G. Khan hill torrent belt are subject to erosion due to scarce vegetation. The annual rainfall is about 300 mm. More than 50 % of annual rainfall is brought in two months of July and August. Because of high runoff characteristics of denuded land surface, floods with high peaks move down in a short time. Sediment volume ranges between 800 m^3/km^2/year to 1,800 m^3/km^2. In the rain-fed area, called as the Pachad area, water source for irrigation depends on the uncertain hill torrent flows. Meanwhile, the flush flows from the hill torrents cause flood damage in the canal-irrigated area, which is located in the western bank of the Indus river plain. Several measures have been proposed and undertaken against hill torrent flood-flows in the area. However, lack of comprehensive planning has failed in supplying any satisfactory solution to the flood problems.

In 1984, the Federal Flood Commission, the Ministry of Water and Power and the Irrigation and Power Department of the Government of Punjab conducted the study of Flood Management in line with their agricultural development scheme in the D. G. Khan and Rajanpur districts, where the Mithawan hill torrent is located. The study concluded the feasibility of the flood control and irrigation project in selected hill torrents. The Mithawan hill torrent pilot project was also one of these proposed project. These studies were carried out by a consultant in Pakistan. The Government of Pakistan (GOP) has requested the Government of Japan (GOJ) for the implementation of the "Mithawan Hill Torrent Pilot Project" as the Japan's Grant Aid Project on the basis of these studies.

Preceding to the request of the Mithawan Hill Torrent Pilot Project, the GOP requested the GOJ to conduct a Feasibility Study (F/S) on the Development of Irrigation based upon Flood Flows of D. G. Khan Hill Torrent covering the whole D. G. Khan hill torrent area. The F/S was conducted in 1991 and 1992, including review on validity and effectiveness of the Mithawan Hill Torrent Pilot Project.

The Project is composed of flood dispersion facilities and watershed management. The GOP has requested the Food and Agricultural Organization of United Nations (FAO) for the technical assistance for the watershed management in line with the recommendations by the Feasibility Study.

The GOP requested the GOJ to implement the Mithawan Hill Torrent Pilot Project as Japan's Grant Aid Program. The GOJ sent the Preliminary Study Team through the Japan International Cooperation Agency (JICA) from May 17 to June 6, 1993. The team reviewed the project and recommended to reduce components as mentioned section 2.4.2.2.

The JICA sent the B/D Study Team in order to review and justify the project as the Japan's Grant Aid Program, for 34 days from August 23 to September 25, 1993.

2.4.2 Outline of The Request

2.4.2.1 Outline of Request of the Pakistan Government

The Project envisages the Mithawan Hill Torrent area by using flood-flows from the hill torrent in D. G. Khan tehsil, Punjab province of Pakistan. The Project will be implemented by the Irrigation and Power Department of Punjab Government. The GOP requested the GOJ for assistance under Japan's Grant Aid Program for the implementation of the following works of the Project.

1	Main Dispersion Structure at Darrah of Mithawan Hill Torrent
2	Improvement of Bhattiwala Bund
3	Dispersion structure on Choti Nallah
4	Improvement of Distribution System on Nangar Nallah
5	Watershed Management
5-1	Contour Hedges by Vetiver Grass
5-2	Construction of Check Dams (45 nos.)
5-3	Experimental Farm
5-4	Appurtenant Structures
6	Road Construction
6-1	Improvement of Existing Road (40 km)

6-2 Temporary Road for Construction Works (12 km)

2.4.2.2 Review by the Preliminary Study

The JICA dispatched preliminary study team for Mithawan Hill Torrent Pilot Project from May 17 to June 6, 1993 with the request of the GOP. The GOP proposed that watershed management would be implemented by assistance of Japan's Grant Aid Program in cooperation with FAO, in which main structures would be constructed under Japan's Grant Aid Program and FAO would spread education for the villagers. The Preliminary Study Team counseled that the steps to push forward the project should be formulated through careful study because cooperated implementation with another agency is exceptional in Japan's Grant Aid Program. The study team reached the following conclusions.

Most of the Pachad area looks like barren land in dry season and productivity is undoubtedly lower in the Pachad area than in the canal irrigation area. Though flood irrigation is applied in the area, but scheduled farming might be impossible even during rainy season. Though flush floods from the hill torrent effect adversely the canal irrigated area and villages depending on their magnitude. The team recommended the means to solve these problems. It includes construction of the Mithawan main dispersion structure and watershed management. The main dispersion structure distributes flood flows to the Pachad area and prevents flood damage in the canal irrigated area. Watershed management aims to open the way toward construction of a dam in the future by means of recovery of vegetation which would decrease soil erosion and reduce runoff.

Watershed management in cooperation with FAO directs to not only growing vegetation but also rural development with participation of villagers, such as establishment of community organization for the future operation and introduction of rotational grazing.

It is described that the dispersion structure contributes to produce most benefit of the project by its flood control function and it is important facility for the development of the area. However, since uncertain flood occurrence in Mithawan hill torrent would not necessarily effect adversely every year, the dispersion structure might not produce adequate benefit within a few years after completion.

Because of this, it is recommended to review the function of the distribution

structure.

FAO's concept to the watershed management is quite different from that of Japan's Grant Aid Program in respect of participation of beneficiaries or promotion/support for their activities, such as organizing of grazier's association, restriction for grazing or introduction of rotational grazing. Therefore, concept to administering project including long term schedule for implementation should be established during the Basic Design Study regarding the cooperation with FAO. The detailed schedule for implementation of the project and provision of equipment should be prepared in closer consultation with the implementing agency of Pakistan.

The team concluded that the components of the project should be reviewed because some structures might not generate adequate benefit every year. Since the project will be promoted under the new concept which consists of not only structural flood control but also villagers' participation in the watershed management, it is necessary to establish project managing organization and detailed implementation schedule including personnel and budget for smooth implementation of the project.

2.4.2.3 Concept for Basic Design Study

Based on the conclusion by the preliminary study, the Basic Design Study contained following components.

1	Dispersion structure on Choti Nallah
2	Improvement of Distribution System on Nangar Nallah
3	Watershed Management
3-1	Contour Hedges by Vetiver Grass
3-2	Construction of Check Dams (45 nos.)
3-3	Experimental Farm
3-4	Appurtenant Structures
4	Road Construction
4-1	Improvement of Existing Road (40 km)
4-2	Temporary Road for Construction Works (12 km)

Since the watershed management program will be conducted in cooperate project of Japan's Grant Aid Program and FAO's program, the implementation schedule will have to be arranged considering the schedule of each party. It is recognized that Pakistan agency should implement the project adjusting FAO's and Japan's.

Regarding to the Mithawan main dispersion structure and Bhattiwala bund, their function would be necessary to review because they might not produce benefit every year even they are important components for flood irrigation.

2.4.2.4 Request of Punjab Government after Basic Design

The objective and components of the project investigated in the Basic Design study, and design and cost estimate also carried out.

Considering the flood with high concentrate of a sediment load, the sediment pocket is planned to be placed for separation of cobbles and boulders from the flood flow. Nangar nallah dispersion structure excluded from the component because of constraint in the physical condition. Some structures in the watershed management program was changed their scale and design through the discussion with FAO staffs.

Regarding to the construction period, it assumed difficult to complete within twelve months of the Grant Aid project period because most of the structures are composed of stone masonry, which are mostly done by manual work and need many laborers.

FAO's implementing period for watershed management is scheduled for five years and it is recognized that Japan's Grant Aid Project need to keep sufficient period for close cooperation with FAO.

Considering these circumstances, the project period is recommended to divide into two stages.

During the basic design study toward the end of rainy season, agricultural activities were observed carefully in the area by study team members. The study has revealed that improvement of irrigation systems, especially dispersion structures, are essential to extend flood irrigation area and to raise agricultural production. Moreover, it will function for a flood control measure as a by-product from irrigation systems.

Basic design study concludes that construction of main dispersion structure at the darrah of Mithawan hill torrent and improvement of Bhattiwala bund, which included in the request of Pakistan, should be implemented in the project because of their effectiveness of flood dispersing function. Consequently, Pakistan government requests Basic Design study for the Mithawan dispersion structure and Bhattiwala bund.

Table 2.4.2.4 -1 Content of Request of Pakistan Government

PC1	Result of P/S	Result of B/D (Phase 1)
Dispersion structure on Mithawan hill torrent		
Dispersion bund on Bhattiwala		
Dispersion structure on Choti Nallah	Dispersion structure on Choti Nallah	Dispersion structure on Choti Nallah
Dispersion bund on Nangar Nallah	Dispersion bund on Nangar Nallah	
		Sediment pocket on Choti Nallah
Watershed management structure/equipment	Watershed management structure/equipment	Watershed management
Vegetation bunds	Vegetation bunds	Small impounding pond
Check dams	Check dams	Check dams
Nursery farm	Nursery farm	Contour bunds
Other relevant facilities	Other relevant facilities	Weir
Road improvement	Road improvement	Nursery
Road improvement (40 km)	Road improvement (40 km)	Horizontal drilling work
Temporary road for construction (12 km)	Temporary road for construction (12 km)	Other relevant facilities
		Road improvement
		Road improvement
		(Choti Zerin - Choti Bala - Sakhi Sarwar)
		Temporary road for construction (12 km)

Chapter 3 Project Area

3.1 Project Site and General Conditions

D. G. Khan hill torrent belt where the Project area of Mithawan hill torrent is located lies between the Indus River and the Sulaiman Range in the south-west of Punjab Province and is bordered by the Province of Sind in the south, Baluchistan in the west, and the N.W.F.P. in the north. Mithawan hill torrent area is located in the center of D. G. Khan hill torrent districts, and is bordered by Vidor hill torrent area in the north, Kaha hill torrent in the south and west. The D. G. Khan irrigation canal lies at the east of it. Mithawan hill torrent area lies within the Punjab and approximately between north latitudes of 29°47' to 30°25' and east longitudes of 69°58' to 70°17'.

Mithawan hill torrent area measures around 1,000 km^2. It is divided into the area of upstream reach of Mithawan hill torrent (Mithawan darrah) and downstream area ranging from Mithawan darrah to D. G. Khan irrigation canal. The downstream area is called "pachad" comprising the sediment from the upstream reach, and shows developing fan configuration. The drainage and pachad areas are 729 km^2, 264 km^2, respectively. There are five (5) minor hill torrents in the area joining to the Mithawan hill torrent. Mithawan water course lies in the center of pachad area.

The major village in the Project area is Choti Bala at about 46 km east-south-east of D. G. Khan City. There are two routes to Choti Bala, one is from Choti Zerin located in the east connected by 24 km asphalt paved road, the other one is from Sakhi Sarwar located in the north connected by 20 km poorly maintained feeder road. The national road connecting the Provinces of Punjab and Baluchistan divides the Project area in two. Fort Munro, which is well known as a summer resort, is located along the national road at the elevation of 1,800 m above sea level. Fort Munro is located near the west rim of the Mithawan drainage area.

3.2 Physical Conditions

3.2.1 Topography

Mithawan Watershed up to darrah covers an area of 729 sq.km and is characterized by north and south extending steep mountain ridges and valleys.

This area is categorized into the following five zones:

I. Sulaiman Range
II. Northern area between Sulaiman Range and darrah of antecedent river
III. Southern area between Sulaiman Range and darrah of antecedent river
IV. Area between darrah of antecedent river and Mithawan darrah
V. Area downstream of Mithawan darrah

The area I (Sulaiman Range) extending north and south rises up to 2,000 m above sea level with usual altitude more than 1,000 m above sea level. It consists of hard sedimentary rocks of Pre-Tertiary age with central anticline axis called Fort Munro Anticline. The Ranges are asymmetric feature having relatively gentle western slope, actively eroded hilly central area and eastern steep slopes comprising single layer plane inclined 30 to 40 degrees. Antecedent river flowing eastward dissected deeply the Ranges. The slope of the river bed is over 1/20.

The area II consists of actively weathered and eroded soft sedimentary rocks of Tertiary to Pleistocene age with altitude ranging from 500 to 1,000 m above sea level. Partly very deep gully with depth 50 to 100 m dissected the land and some gravel layers remains on the top of non-eroded flat land. Scarps of 100 to 300 m high bound the area to its eastern and southern end. River bed of this area have gradient of from 1/40 to 1/70 and flow into three nallahs (Mithawan, Siri, Rakhi) at the eastern end of the darrah.

The area III with altitudes between 340 and 1,000 m above sea level is more eroded than area II so that the basement rocks of Tertiary to Pliocene age are covered with diluvial and alluvial gravel deposits so that the flat basin may be formed. The northern end of this area is higher gravel terrace with relative height being 40 to 80 m from recent river bed. The east and south end is bounded by scarps of 100 to 300 meters high. The slope of river bed in this area ranges from 1/30 to 1/50. All channels of this area flow into Nangar and Choti nallahs at the eastern end of darrah.

The area IV with altitude between 220 and 700 m above sea level is overlaid by sub-recent to recent river deposits. Five antecedent rivers and several minor channels starting from gravel plains converge into the Mithawan nallah at the upstream side of Mithawan darrah. The deposits are composed mainly of cobbles and boulders in the higher part and of sand in Mithawan nallah. The inclination of land is less than 2 degrees in the northern area and less than 4 degrees in the southern area.

The area V (Alluvial fans) is composed of sands, silts and clays derived from high land of the watershed. The altitude ranges from 100 to 200 meters above sea level. The composing grain size decreases gradually with the increase in distance from the darrah. The bunds are embanked well for effective utilization of runoff water, in the lower reaches from about 5 kilometers to about 15 kilometers downstream of the darrah.

The salient features of main hill torrents are as following.

Table 3.2.1-1 Feature of Main Hill Torrents

Name of nallah	Catchment Area (Sq. km)	Division	Altitude ASL (m)	Total Length (km)	Gradient of bed
Mithawan	145	upstream	600 to 2,100	14.7	1/6 to 1/18
		midstream	360 to 600	15.3	1/59 to 1/70
		downstream	360 to 255	10.1	1/96
Siri	94	upstream	700 to 1,900	13.8	1/8 to 1/16
		midstream	360 to 700	14.1	1/43 to 1/46
		downstream	360 to 255	10.1	1/96
Rakhi	105	upstream	640 to 1,830	15.4	1/9 to 1/22
		midstream	390 to 640	11.1	1/43 to 1/46
		downstream	390 to 240	10.0	1/67
Nangar	86	upstream	780 to 1,940	12.7	1/10 to 1/15
		midstream	310 to 780	16.6	1/24 to 1/75
		downstream	310 to 220	5.5	1/61
Choti	76	upstream	800 to 1,940	12.8	1/10 to 1/16
		midstream	280 to 800	15.2	1/16 to 1/73
		downstream	280 to 220	7.0	1/117

The division of area by altitude exhibits that 16 % of the area is higher than 1,500 meters, 24 % between 900 and 1,500 meters above sea level, 46 % between 300 and 900 meters, and 14 % lower than 300 meters. Details are as follows.

Table 3.2.1-2 Share of area by altitude

Altitude A.S.L. (m)	Portion of Area (%)
less than 300	14
300 to 600	31
600 to 900	15
900 to 1,200	8
1,200 to 1,500	16
more than 1,500	16

3.2.2 Geology

Mithawan watershed lies on Sulaiman fold belt trending its axis north and south. Geological distortion of this area is formed mainly in the period of Plio-Pleistocene age which Himalayan tectonic movement still continued from Cretaceous and even it may go on so far. Fort Munro Anticline runs in the center of Sulaiman Range and Baghal Chur Syncline on the boundary area of northern Mithawan watershed and Sakhi Sarwar watershed. The watershed is mainly composed of sedimentary rocks of Cretaceous to Tertiary age and deposits of Quaternary age.

The main compositions of respective ages are:

- the Cretaceous ; hard limestone, sandstone, and shale forming Sulaiman Range, the Paleocene; hard sandstone and limestone lying east- and westward of the Cretaceous,
- the Eocene ; relatively hard shale and limestone (Gazij formation) or limestone and soft shale (Kirthar formation),
- the Miocene to Pliocene ; limestone, sandstone, shale and hard clays lying between Sulaiman Range and antecedent river darrah, and
- the Plio-Pleistocene ; clays, shale, sandstone and conglomerates form the cliff of antecedent river darrah and decreasing its altitude of land surface to eastward.

Table 3.2.2-1 Stratigraphy of the Mithawan Watershed

Geological age	Strata
Quaternary	
Holocene	Cultivable layer (Qcs)
	Alluvial deposits (Qal)
	Dune deposits (Qd)
	Piedmont gravel deposits(Qp)
	Terrace gravel deposits(Qtg)
	Flood plain deposits(Qs)
----------Unconformity----------	
Pleistocene	Dada gravel layer (Qdc)
Tertiary	
Pliocene	Chaudwan formation (Nscd)
	Siwalik group
	Litra formation (Nsl)
	Vihowa formation (Nsv)
----------Unconformity----------	
Miocene	
to	Chitarwata formation (Nc)
Oligocene	
----------Unconformity----------	
Eocene	Kirthar formation (Pk)
	Gazij formation (Pg)
Paleocene	Dungan formation (PD)
	Khadro formation (PK)
----------Unconformity----------	
Upper Cretaceous	Moro formation (KM)
	Pab Sandstone (Kpb)
	Fort Munro formation(KFm)

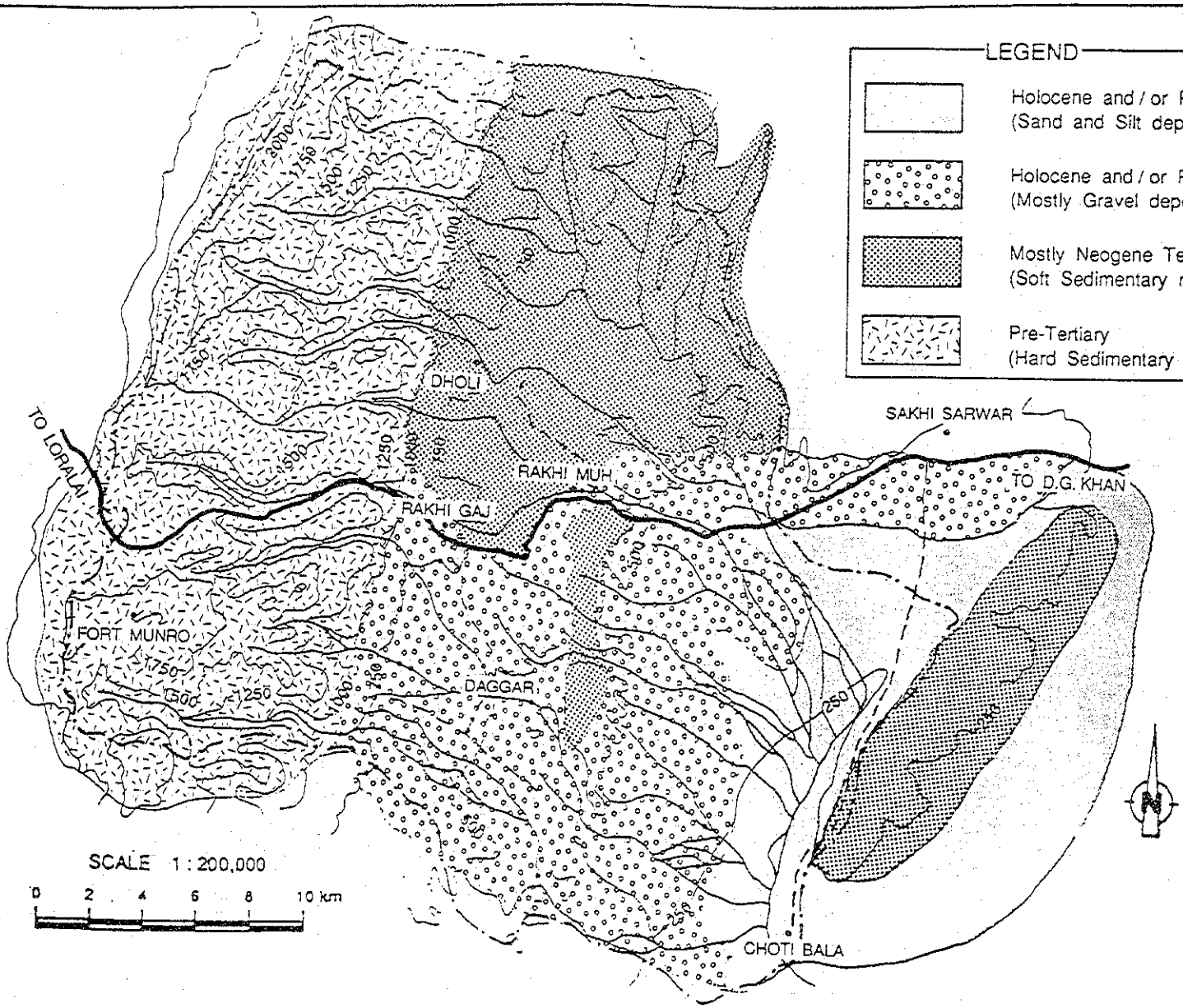


Fig3.2.2—1 GEOLOGICAL MAP OF MITHAWAN WATERSHED

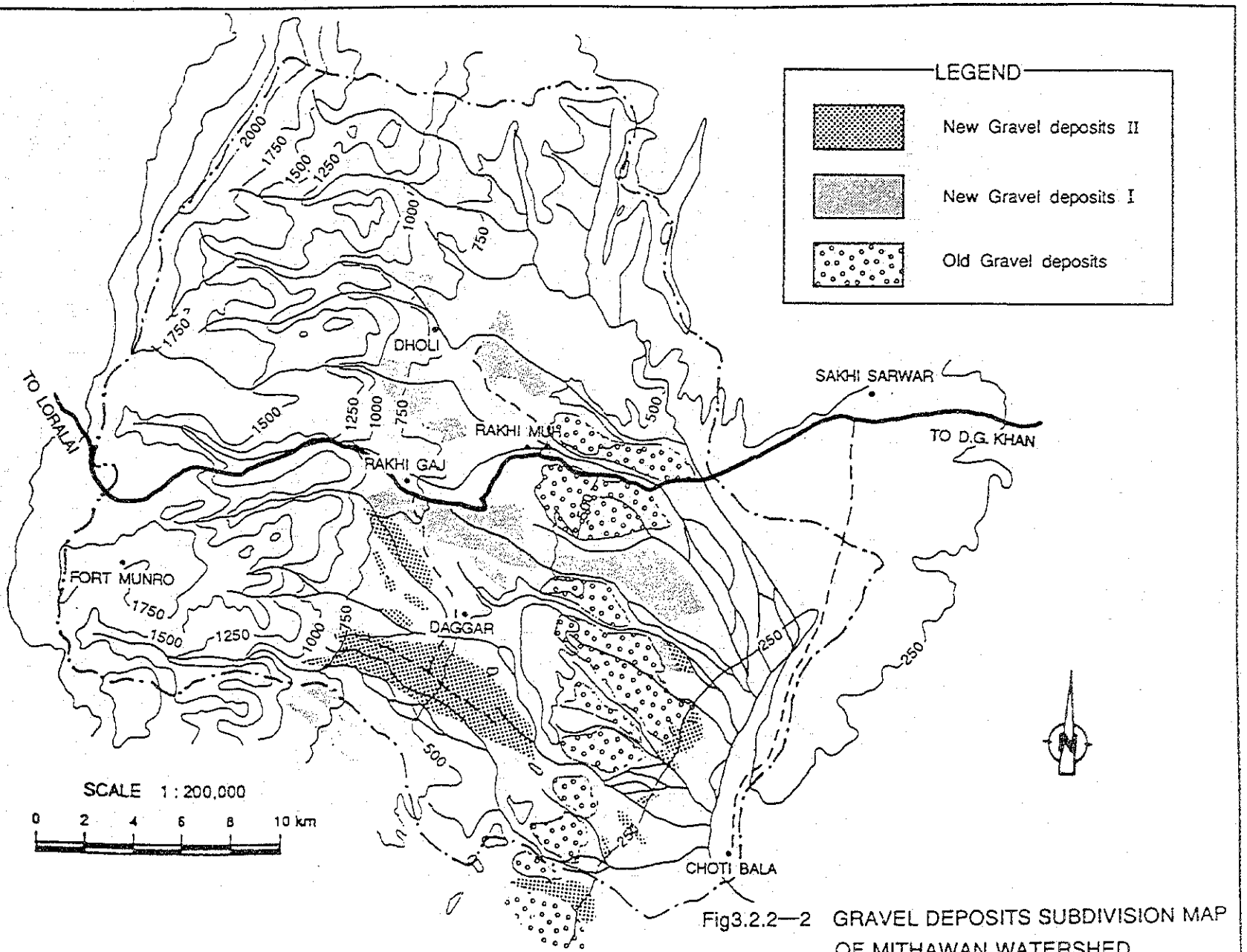


Fig3.2.2—2 GRAVEL DEPOSITS SUBDIVISION MAP OF MITHAWAN WATERSHED

Older gravel layers with thickness 0.5 to 20 meters extend widely on higher plateau in downstream of antecedent river darrah and some of terrace gravel deposits and recent river deposits in between Sulaiman Range and antecedent river darrah and on lower plain in downstream side of antecedent river darrah.

Geology of Mithawan hill torrent is shown in Fig. 3.2.2-1.

Surface geology of the area is characterized by the wide spread gravel deposits, therefore, the planning and designing with regard to erosion control and dispersion structure need to consider the geologic history and mechanical properties. Fig. 3.2.2-2 shows their distribution.

Gravely deposits consist of almost same gravel type and radius, but their sedimentation processes seem to be different. The forming mechanism of these deposits is considered as described below.

The soft base rocks of Post-Paleocene age such as sandstone, shale and clay were actively eroded, associated with up heaving by tectonic movement and then covered with thick sediments. The upheaval movement continued and the channels were dissected downward. The erosion dissected land up to the base rocks through gravel deposits. The flood flow also scraped out the base of gravel deposits, then cut-banks were overhanging and falling out as a mass of gravel aggregate. Because the gradient of river bed was less than 1/20, boulders remained at the same places. On the other hand, eroded base rocks were broken into fine material and suspended in the runoff water. As a result, they were washed out and deposited in around the downstream reaches. This phenomenon is still going on in Recent time. In case of Choti nallah, which seems to be the newest antecedent river, the flood water is scraping the base of cut-bank and falling the mass into river bed. Thus, its flow channel is enlarging year by year.

Gravel deposits categorized as following.

- Older Gravel Layers

  They seem to have originated from Molasse in early diluvial epoch composed mainly of coarse grains associated with Himalayan orogeny. The thickness is 5 to 20 meters and various size of grains compose it ranging from boulder of sandstone or volcanic to silt and clay. The fines are washed out from surface layer. Boulders outcropped to surface are weathered and faded to chocolate color. These sediments cover Chaudhwan formation of Pliocene age and are distributed in Mithawan darrah extending 20 km north and south. Furthermore they are found on the high land rising to 220 m above sea level

among the darrahs of Choti nallah, Nangar nallah, Rakhi nallah, Siri nallah and main Mithawan nallah. Gradient of the surface is less than 4 degrees. These sediments seem to have overlaid Rakhi Gaj formation, but to be eroded and almost washed out accompanied with gradual up heaving of the area.

- Terrace Gravel Deposits 1

These deposits form mainly the out-washes of Rakhi nallah and Nangar nallah, spreading from the top of cone with elevation at around 900 m to 360 m. The other small scales of terrace with its elevation at around 900 m is also composed of these deposits. Their surface inclination are less than 3 degrees. The top point of this deposits is higher than terrace deposits 2 described bellow. The types and radius of the gravel are almost same as Older gravel layers.

- Terrace Gravel Deposits 2

These are extending widely around the southward area forming the mountain foot of Sulaiman Range and in lowland of downstream side of antecedent river darrah. These deposits originated eroded Terrace deposits 1 and are eroded by recent river flow. The slope of the extending area is less than 2.5 degrees. The types and radius of the gravel are almost same as Older gravel layers.

- Recent River Deposits

Eroded materials from Terrace deposits 2 form those, and dissecting downward. Many boulders compose this deposits near the top of alluvial fans, but in the downstream sand is the main component.

3.2.3 Meteorology

(1) Precipitation

There are 48 rainfall gauge stations in the D. G. Khan hill torrent districts. However, their data are statistically not reliable due to their short observation period except three (3) long period observation data and 20 observation data for seven years. There are four (4) meteorological observation stations in Mithawan hill torrent area, ie Fort Munro, Rakhi Munh, Mihal and Moli Bun. However, no rainfall record is available in those stations.

D. G. Khan hill torrent districts are classified into three (3) zones by means of the average annual rainfall distribution. Mithawan hill torrent area belongs to zone II, and it amounts to approximately 250 mm to 300 mm and average of 268 mm (1969 - 1988). More than 60 % of annual rainfall is concentrated in three monsoon months of July to September. The following gives monthly average rainfall in Mithawan hill torrent area.

Table 3.2.3-1 Monthly Average Rainfall (unit: mm)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall	7.5	14.6	19.6	19.8	11.9	20.7	69.4	60.9	32.7	4.0	3.2	3.6

Rainfall in zone II is characterized by medium rainfall intensity and short duration of rainfall. The following shows probable rainfall in each return-period of rainfall in this area.

Table 3.2.3-2 Probable Rainfall in each Return-Period

		Rainfall (mm)		
Return-period:		1 day	7 days	15 days
2.33	:	48.3	88.9	101.6
5	:	69.9	114.3	142.2
10	:	87.6	135.1	165.1
25	:	109.2	162.6	218.4

(2) Temperature/Evaporation

Annual mean temperature is 21.8°C in the upland and monthly mean temperature ranges from 31.2°C in June to 11.0°C in January. Annual mean temperature in the lowland is 24.9°C. Mean annual evaporation is 2,429 mm with maximum 349 mm in June and minimum 80 mm in January.

3.2.4 Hydrology

The following are the results of flood analysis applying latest precipitation and run-off data.

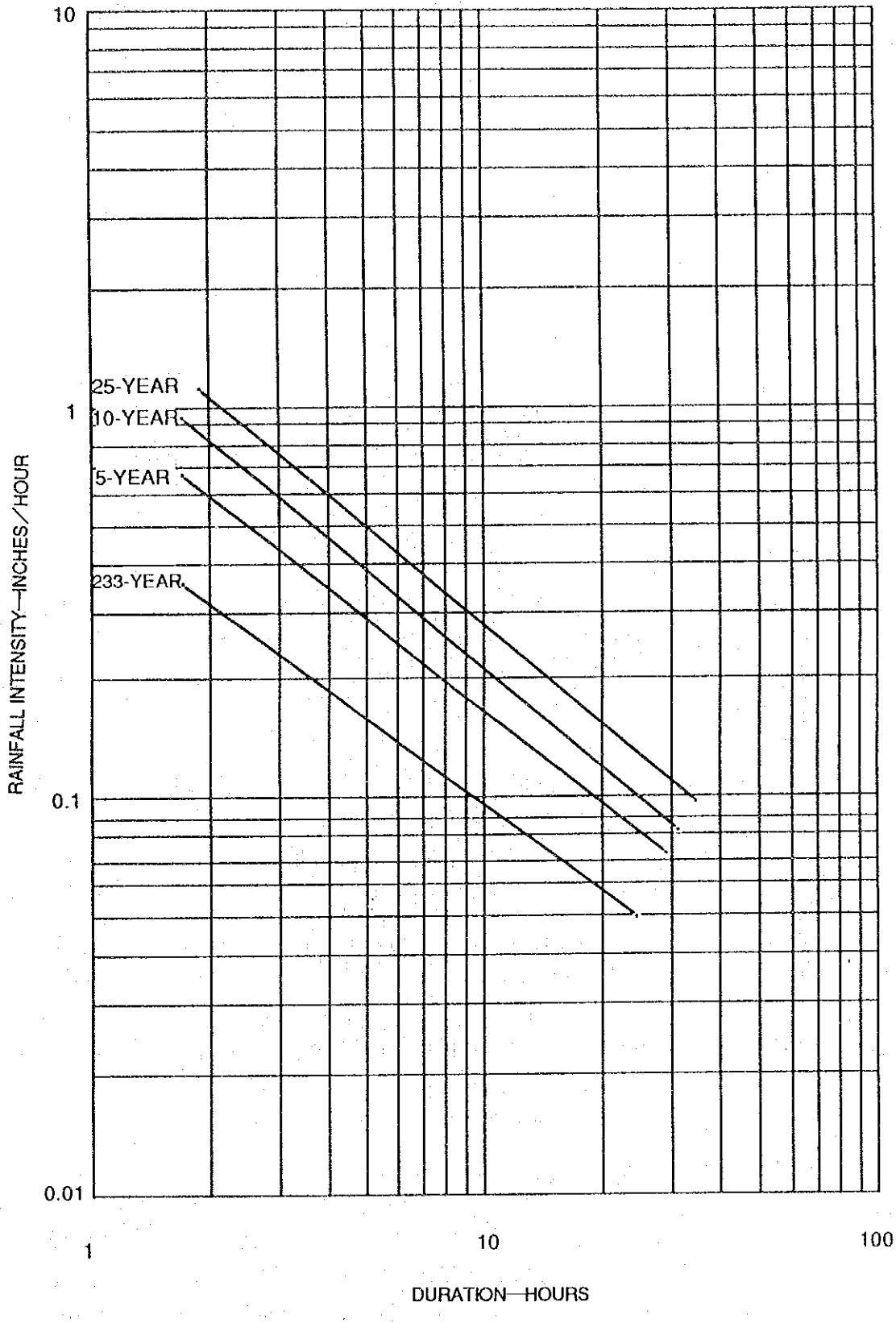


Fig3.2.4—1 INTENSITY DURATION FREQUENCY CURVES

Table 3.2.4-1 Run-off Data in 1958-1964, 1975-1987, and 1989

Year	Peak discharge (cu.m/sec)		Year	Peak discharge (cu.m/sec)
1958	2,193	:	1979	729
1959	502	:	1980	2,251
1960	1,631	:	1981	110
1961	1,270	:	1982	518
1962	1,674	:	1983	299
1963	968	:	1984	232
1964	611	:	1985	730
1975	1,695	:	1986	1,446
1976	1,637	:	1987	65
1977	518	:	1989	1,392
1978	2,264	:		

As shown above, the distribution of the flood peak discharge is considerably fluctuating year to year. The maximum peak flood discharge observed is 2,264 cu.m/sec in 1978 and the minimum is 65 cu.m/sec in 1987. Statistical calculation results are enumerated below:

Table 3.2.4-2 Probable Peak Flood Discharge

Return period (Year)	2	5	10	20	25	30	50	100
Peak flood discharge (cu.m/sec)	973	1,713	2,203	2,674	2,809	2,944	3,282	4,738

Meanwhile, lag time of flood is estimated in different river reaches as follows:

Table 3.2.4-3 Lag Time of Flood

	Difference of height (m)	Distance (km)	Lag time (hours)
Upstream	1,305	14.7	0.87
Mid-stream	240	15.3	1.21
Downstream	160	24.2	2.24
Total			4.32

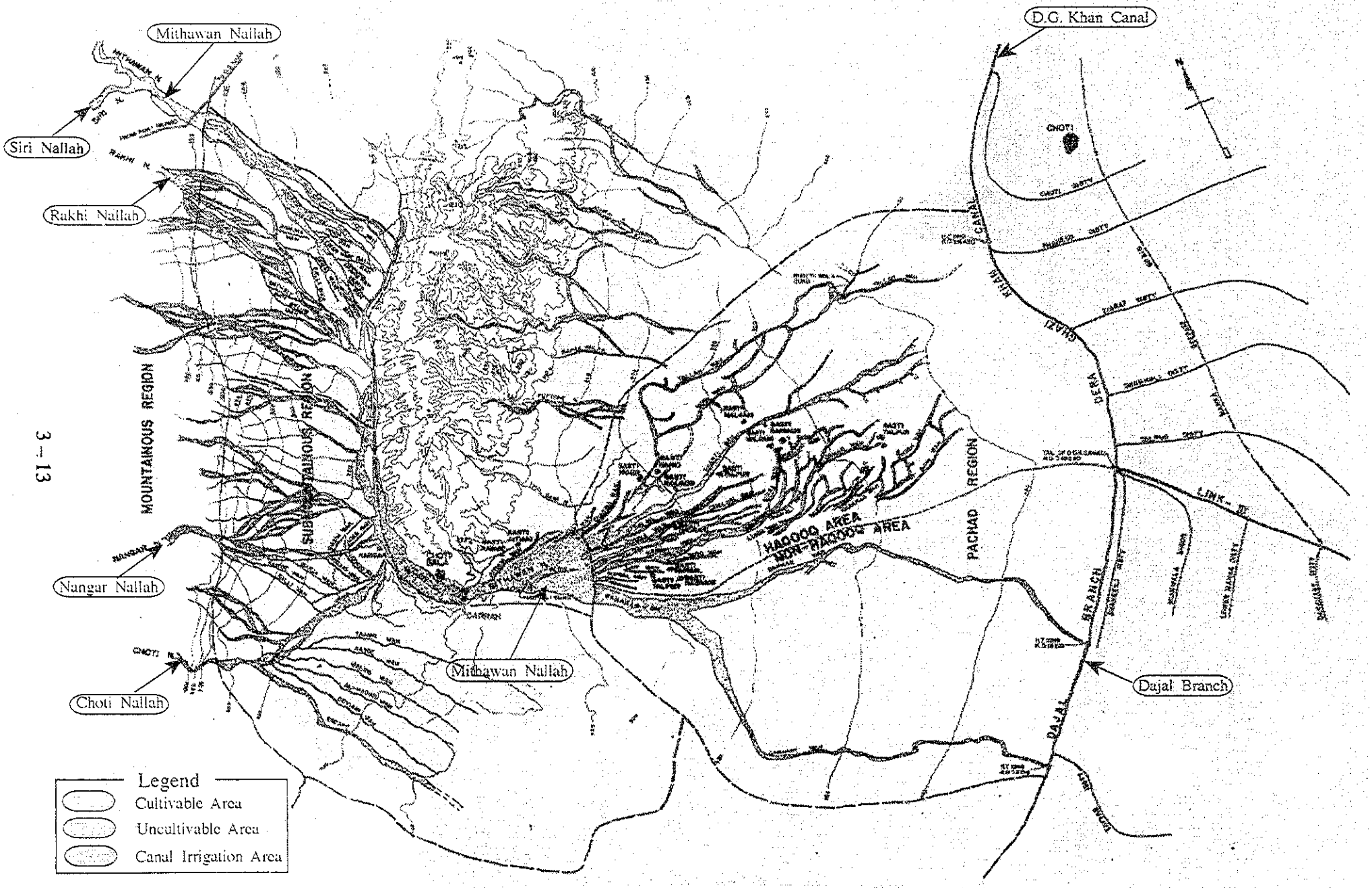


Fig. 3.2.6–1 LAND USE MAP

Intensity of rainfall of 13 mm/hr within the flood lag time is given from intensity curve in Fig. 3.2.4-1. Peak flood discharge is estimated at 2,106 cu.m/sec by rational formula (Catchment area : 729 km^2).

3.2.5 Soils

Almost all of upland and plain between Sulaiman Range and Mithawan darrah, consists of outcrops of base rock or gravel deposit. Agricultural land extends as confined areas along the rivers, which are also composed of gravely soil. In the areas of the upstream reach and downstream of Mithawan darrah, the soil of the piedmont plains derived mainly from sedimentary rocks of the Sulaiman Range, ranges in texture from gravely soil to clay. The soils spread between upstream reach and Mithawan darrah range in texture from gravely soil to clay, but clay and loam are the dominant soil textures on the downstream of Mithawan darrah. The desert soils are rich in montmorillonitic clays but their organic matter content is generally low. The soils of alluvial fan are generally non-saline and non-alkaline. The soils of the alluvial fan are always in dry condition.

3.2.6 Land Use

Natural vegetation has been damaged for cultivation, grazing, firewood collection, or has been replaced by introduced species, as well. The upland is generally denuded except the scarce natural vegetation that survives along the small water ways. While, area at the foot of upland has scarce grass and shrubs, and the river plain has several species of grass and shrubs due to better soil moisture conditions.

The soils of the Mithawan hill torrent area are put to multifarious uses according to the water supply, although socio-economic factors, land forms, and the nature of the soil materials also affect land use. In the area, land use is largely restricted to food and fodder crops for domestic consumption. Torrent-watered cultivation is the dominant cropping system in the piedmont plain. It is practiced near the hills and along the larger torrents, where a relatively assured supply of torrent water is available during most years. However, more than half part of the piedmont plains remains unused during most years because of the scare rainfall. Areas far from the cultivation are generally covered with sparse natural vegetation.

3.3 Socio-Economy

3.3.1 Administrative Divisions

D. G. Khan Division is made up of the districts of D. G. Khan , Layyah, Muzaffargarh and Rajanpur, each of which is divided into tehsils. In the case of D. G. Khan District there are two tehsils, namely D. G. Khan and Taunsa. In the case of Rajanpur District there are three tehsils, namely Janpur, Rajanpur and Rojhan. Mithawan hill torrent area lies in the D. G. Khan tehsil. Both districts include tracts of tribal land, which lie parallel to the tehsil administered areas and extend from the piedmont of the Sulaiman range across to Baluchistan. Tribal land occupies the hilly region of the whole part of Mithawan hill torrent area.

3.3.2 Population

(1) D. G. Khan District

The population of D. G. Khan District, according to the 1981 Population Census, was 861,412 (this figures exclude tribal area population). The total area of D. G. Khan District is 6,583 km^2, which gave a population density of 130 persons per square kilometer. The average size of a family was seven persons.

In 1981 the urban population of D. G. Khan District was 121,941, i.e. 14.2 %, and grew at an average annual rate of 4.5 % between 1972 and 1981, higher than the district average annual growth rate of 3.9 %. There was only one municipal committee in D. G. Khan District, namely D. G. Khan Municipal Committee, with a total population of 102,007, and one town committee, namely Taunsa, with a population of 19,934 persons.

Table 3.3.2-1 Population Statistics of the D. G. Khan; 1981

	D. G. Khan Tehsil	% share of total population	Taunsa Tehsil	% share of total population
Total population	635,612	100.00	225,800	100.00
Total urban population	102,007	16.05	19,934	8.83
Total rural population	533,605	83.95	205,866	91.17
Population engaged in torrent-watered cultivation	142,956	22.49	167,752	74.29

Source: Adapted from 1981 District Census Report of D. G. Khan.

The literacy ratio for the district was 16.3 %, much lower than the national average of 26.2 %, and much higher in the urban areas (42.3 %) as compared to the rural areas (12.8 %). The population is overwhelmingly Muslim (99 per cent), with small communities of Christians.

(2) Pachad Area

The population engaged in the hill torrent agriculture in the pachad area of Mithawan hill torrent was estimated at around 33,085 in 1981 and 47,874 in 1991. Accordingly, annual growth rate was at 3.77 %.

3.3.3 Socio-Economy

Agriculture, including livestock rearing, dominates the economy of the Mithawan hill torrent area. However, scarce and fluctuating rainfall severely hampered agricultural production in the area. Household incomes always need to be supplemented by income from livestock rearing and services using water only from torrent flood spreading and tube wells, where available. Accordingly, agricultural development or economic development is tied to expanding irrigation and using hill torrents for cropping through better water control and improved distribution of water resources.

Social infrastructure, such as roads, schools, power supply system, telecommunication system, are well facilitated in the vicinity of canal irrigated areas. On the contrary, these have been sparsely facilitated in the pachad and tribal areas. Poorly facilitated social infrastructure has also restricted the agricultural development in addition to the climatic conditions unsuitable for cultivation. Decrease of employment opportunities due to reliance to torrent flood cultivation will induce the outflow of population.

3.4 Outline of the Agricultural Sector

3.4.1 Agriculture

(1) Hill Torrent Agriculture

In the plains of the Mithawan hill torrent area, mean annual rainfall is less than 300 mm mostly concentrated during the Kharif season (April - September). Consequently, the acreage under cultivation varies every year, and in much of the cropped land water from torrent is used for irrigation. Jowar, bajra and pulses are the main Kharif crops. Wheat, gram, fodder and oilseeds are the main Rabi crops (October - March). Grazing is an important activity in the

pachad area. The soils comprise rich alluvial soils of a high fertility and good moisture holding ability. However, shortage of water and its storage facilities for crops and fodder production are major constraints to the development of irrigation system and effective use of water from hill torrents in the Pachad area.

(2) Hill Torrent Agriculture (Flood Irrigation)

Flood irrigation is mainly practiced in the areas of piedmont plain, downstream of Mithawan darrah (pachad), and alluvial fan along the antecedent four streams, (Choti, Nangar, Rakhi and Siri nallahs) which are developing adjoining to Mithawan nallah. Water from torrent-spreading is available for irrigation in these hill torrent areas, except the small areas along the D. G, Khan irrigation canal or other areas where tube wells are available.

Irrigated area are illustrated in Fig. 3.4.1-1. Table 3.4.1-1 shows agricultural land area of respective hill torrents.

Table 3.4.1-1 Agricultural Land Area

Hill torrent		Agricultural land area
Mithawan darrah (pachad)	:	15,334 ha
Mithawan/Rakhi nallah	:	736 ha
Choti/Nangar nallah	:	8,481 ha
Total	:	24,551 ha

Total households are around 8,000. Average farm size is estimated at around 3.1 ha. It is expected that 75 % of the farmers own their land title, remaining 25 % of farmers are tenants.

(3) Marketing

The towns of D. G. Khan , Sakhi Sarwar and Choti are the largest markets for both of outputs and inputs in the vicinity of Mithawan hill torrent area. Agricultural activity is largely restricted to food and fodder crop production for domestic consumption. In hill torrent and pachad areas, few of surplus production, such as wheat and other grain are sold in small markets near their residence. Poor condition of farm to market roads and transportation problems depress the marketing activities.

(4) Farm Mechanization

The Agricultural Engineering Organization was established to provide custom-hire services of agricultural machinery for land development and the drilling of tube wells, implement subsidy schemes for diesel tube well installation, training farmers in agricultural machinery operation, repair and overhaul, and provide technical guidance for the purchase, maintenance and upkeep of such machinery. The Organization has only 80 bulldozers against its real needs of 250 working bulldozers for D. G. Khan Division.

(5) Agricultural Credit

The amount of institutional credit is provided through the Agricultural Development Bank of Pakistan (ADBP) and commercial banks, these operate only on a land collateral and personal surety basis, and although expanding rapidly, still provide only 10 to 15 % of the local requirements for short-term production loans and medium to long-term credit.

In the Mithawan hill torrent area, the ADBP advances loans through its branch offices in D. G. Khan . Farmers in the pachad utilize between 10 and 15 % of loans as a result of the nature of agricultural activities in the area, which are undertaken without the use of productivity-enhancing inputs such as fertilizers, high-yield varieties or pesticides, and have smaller fixed-capital requirements. According to the ADBP, the average size of loans secured by these farmers is smaller than those obtained by the farmers in the irrigated areas.

(6) Agricultural Research and Extension

An Agricultural Research Division has been created in the Ministry of Food, Agriculture and Cooperatives to supervise and coordinate the research activities of various agricultural institutes in the country both at the federal and provincial level. The Pakistan Agricultural Research Council (PARC) is the principal organization which has carried agricultural research in different fields. In the vicinity of Mithawan hill torrent area, there is a Fodder Research Station and a Livestock Experimental Station.

Until recently, virtually no research was aimed specifically at increasing productivity of pachad (barani) areas. The Barani Agricultural Research and Development project, funded by Canada, spanned ten years from October 1982 to June 1991. Its objectives were to improve the quality of life

among farmers engaged in barani agriculture, mainly through the introduction of high-quality, high-yield cultivators suitable for use on barani lands and development of appropriate machinery.

(7) Framers Organization

In 1990, there were 1,063 cooperatives in D. G. Khan district. Membership totaled 31,000 members, and a cooperative consists of about 20 to 30 farmers on the average. The main function of cooperative societies is to provide loans to its members for the purchase of fertilizers, pesticides, seeds and diesel oil. Loans are made with a grace period of one season (Kharif or Rabi) and carry an interest rate of 12.5 % equal to that charged by the ADBP.

3.4.2 Livestock

Livestock rearing is a traditional activity for most farmers in the pachad. However, it is difficult to maintain high productivity in hilly areas because the insufficient torrent-water and rainfall reduce the grazing productivity.

Sheep and goats are equally common in the hills as well as in the adjoining plains of the district of D. G. Khan . However, there are about five times more sheep than goats in the piedmont plains. Fertility of both sheep and goats is lower than in other regions but estimates suggest growing populations for each species. The land-less own a moderate fraction of both small and large herds. Sheep herd sizes are moderate at small farms but rise rapidly with farm size, indicating that sheep are integrated with cropping to an extent not evident in other pachad areas. They are still held unusually many by small farm owners. In contrast, the size of goat herds is relatively insensitive to farm size. The normal size of a sheep and goat flock varies from 50 to 150 head.

Large ruminants form a smaller proportion of the animal herd. The cattle herd is not always represented with respect to total area and cultivated area and has a strong draft component. Cattle fertility is average and the bullock component is increasing while the cow component is static. Thus, the cattle herd is becoming more of a draught herd (see Table 3.4.2-1).

According to the Farm Economic Survey, the average numbers of livestock kept per household is 8 head of cattle, 17 sheep and 9 goats. Camels and donkeys are found in limited numbers throughout the pachad.

Table 3.4.2-1 Livestock in Mithawan Hill Torrent Area (head)

Species	1988	1989	1990	1991	1992
Cattle	15,100	15,500	16,300	16,830	17,225
Buffalo	5,758	5,870	5,960	6,015	6,137
Sheep	35,600	36,115	37,810	38,615	39,561
Goats	36,365	36,970	37,810	38,615	39,561
Horses	590	640	698	731	815
Donkey	3,400	3,495	3,579	3,612	3,698
Camel	827	879	932	998	1,002
Poultry	51,539	53,570	56,136	58,696	61,376

3.4.3 Flood Irrigation

(1) Flood Irrigation

The indigenous system of irrigation practiced in the hill torrent areas is such that the cultivators, under an organized method of co-operation, construct a number of earthen embankments in the river every year for raising the water to the surface. Cultivators living for many miles along the banks of the river are called in with their bullocks to construct the embankments. There are many of these embankments and in July and August, when the floods come, the upper embankments are broken as soon as sufficient water for the irrigation area has been received.

At suitable intervals earthen embankments are erected extending about halfway across the torrent bed to head up the flood water and lead it down the distributary channels which open immediately above the embankments. "Bund" is the name of an embankment as well as a containing field levee, and a distributary is called a "wah".

The site of each embankment and the rule as to its permanency or its liability to be broken are recorded in the registers of water rights. In the wah or main distributor similar embankments, in this case called wakra, and extending right across the channel are inserted at intervals to entirely dam up the water and force it into the channel (wahi) by which the water is conducted to the fields. Each of these is cut as soon as the field irrigated by it has received sufficient water.

The enforcement of rules related to cutting of bunds and wakras is a constant source of disputes. The system of irrigation practiced by the locals was institutionalized by the British in the form of registers of irrigation rights. Normally people owning lands on both sides of a torrent, its shakhs, wahs, and wahis have rights of irrigation based on saropa-paina principle. But there are certain areas of lands which have no rights or secondary tracts rights. The first regular settlement of the area was commenced in April 1869 and finished in July 1874 by Sir Fredrick Fryer.

Irrigation right or "haqooq" were revised in the settlement of 1917, under the supervision of Mr. W R Wilson, Collector. Consolidation of then D.G. Khan district, and the revised registers of rights were produced in 1919 after approval from cultivators of all the torrents. There is one register for every torrent having irrigation rights. These hand written registers are still in use as legal document in both D.G. Khan district to regulate the irrigation and to solve water disputes.

Saropa-paina is the cardinal principle of the irrigation rights, other rules governing the irrigation are more or less common for all the hill torrents. When conducted into the field the water is allowed to flow until it stands as high as the embankment (Lath) surrounding the field can stand. Often a height is of one meter or more. The head of a torrent or distributary is called Mundh and the tail Pand.

(2) Flood Irrigation in Mithawan Hill Torrent Area

Fig. 3.4.3-1 and 3.4.3-2 illustrate the existing flood irrigation system in Mithawan hill torrent area. Principal water resources for irrigation are the run-off flow of Choti, Nangar, Rakhi, Siri and Mithawan nallah. The first four streams (nallahs) join Mithawan nallah at right upstream of Mithawan darrah. The inhabitants in the hilly area avail hill torrent flow for their living and small-scale irrigation. Farmers construct embankments with heights of 1.0 - 1.5 m, dividing agricultural land into 2 - 8 ha, and lead the flood water down to the land. Water distributions are governed by the water right and the embankment works are made by farmers' organization, called "Kamara system". Embankments are easily subject to collapsing by floods due to the low stability of sandy materials used in the embankments on the river. In case, that the embankment can not control the flood without doing any basin irrigation,

flood flow reaches to D.G. Khan canal and Dajal branch canal, and causes heavy damages to these canals, crops and other infrastructures.

(3) Flood Damages in the Project Area

Scarce vegetation and excess amount of rainfall cause the occurrence of flood flows in hill torrent areas. In floods, accelerated river flow due to steep river slope in mountainous and hilly portion where the base rock is exposed, erodes banks heavily and carries much sediment to the downstream. The torrent splits into three main branches at piedmont plain, below Mithawan darrah. It reaches to D.G. Khan canal and Dajal branch canal, and causes heavy damages to these canals, agricultural lands, houses, roads and other infrastructure as well. Cross drainage were provided across these canals to drain flood water to the downstream. However, the said damages have been occurring continually due to insufficiency of the total flow capacity (260 cu.m/sec) of the cross drainage. Principal flood damages are listed below:

Table 3.4.3-1 Flood Damages in the Project Area

Year	Damaged facility		Inundated area (ha)	Flood discharge (m^3/sec)	Damage amount (million Rs.)
1967	D. G. Khan canal	: 3	---	---	15.0
	Dajar canal	: ---			
	Branch canals	: ---			
1973	D. G. Khan canal	: ---	---	---	1.4
	Dajar canal	: ---			
	Branch canals	: 3			
1975	D. G. Khan canal	: 5	16,200	196	24.0
	Dajar canal	: ---			
	Branch canals	: ---			
1976	D. G. Khan canal	: 7	---	---	17.0
	Dajar canal	: 3			
	Branch canals	: 3			
1978	D. G. Khan canal	: 4	---	---	42.2
	Dajar canal	: 4			
	Branch canals	: ---			

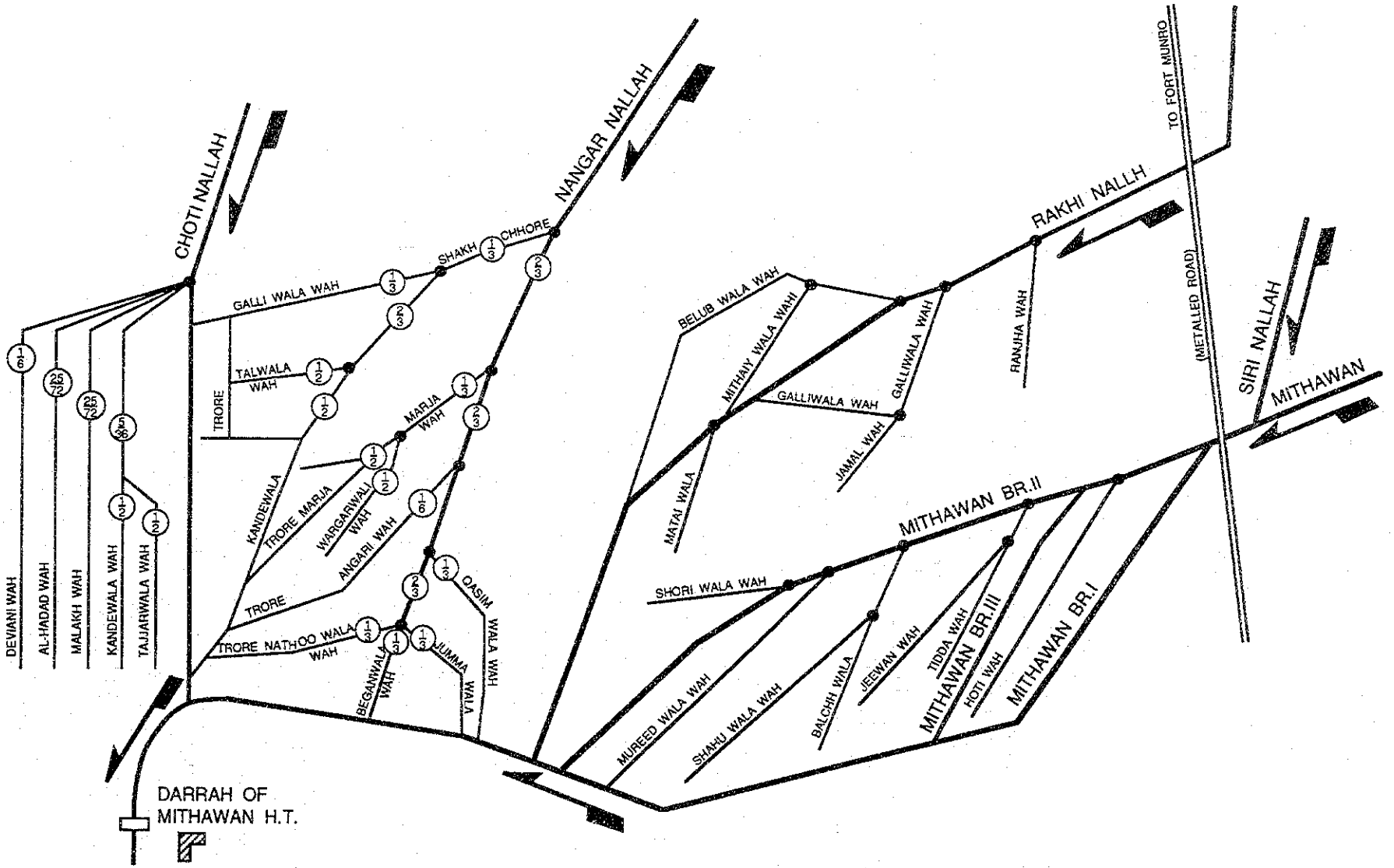


Fig. 3.4.3 –1 MITHAWAN HILL TORRENT LINE DIAGRAM
IRRIGATION SYSTEM – ABOVE DARRHA OF MITHAWAN H.T

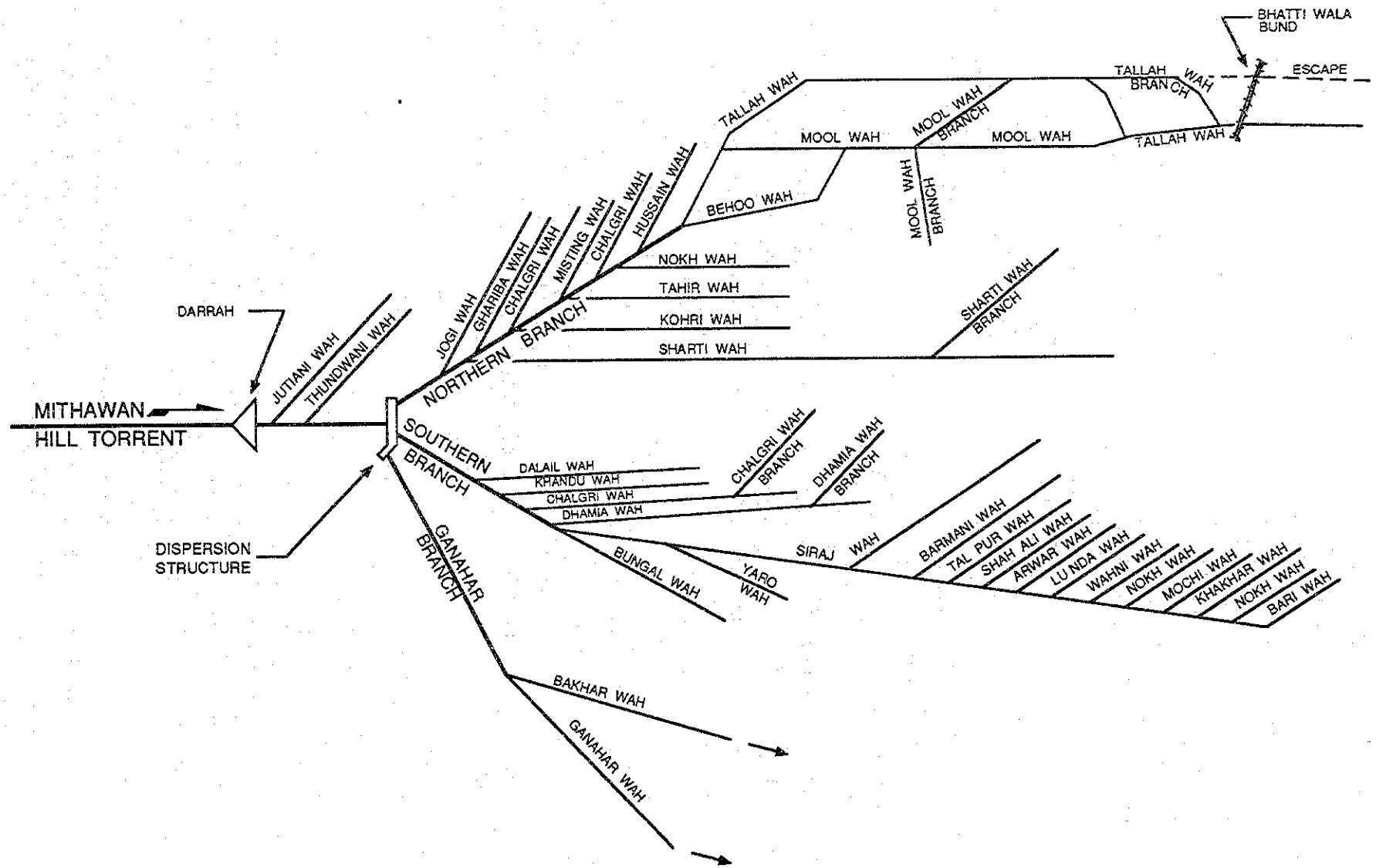


Figure 3.4–2 MITHAWAN HILL TORRENT LINE DIAGRAM
IRRIGATION SYSTEM - PACHAD AREA

3.5 Infrastructure

(1) Transport Facilities

Fig. 3.5-1 shows existing road networks in Mithawan hill torrent area. National road located in the center of Mithawan hill torrent area from east to west is a link between D.G. Khan and Quetta (Baluchistan Province). The national road is one lane road with asphalt pavement within the area of Mithawan hill torrent. Another one lane asphalt paved road is connecting Choti Zerin and Choti Zerin over a distance of 20 km. However, the road has been already damaged at causeway portions due to floods. The damages could be a major obstacle for the traffic. Other roads are not paved and heavily damaged especially at steep portion caused by road surface erosion. Furthermore, insufficient bearing capacity of road sub-base against heavy loads could be a obstacle to traffic. The road connecting Sakhi Sarwar to Choti Bala is also in poor condition in many portions in its total length of 20 km, and the road is required to be improved immediately. For watershed management, road improvement of 8 km length is indispensable to secure smooth transportation of project equipment and machinery. The road is located in steep hilly region, and routed across the major hill torrent in a length of 400 m, where the road was continually damaged by floods.

(2) Industry

Industrial infrastructure in Mithawan hill torrent is primarily agro-based and located in the canal-irrigated areas, particularly in D.G. Khan Tehsil. There several units of flour mills, cotton ginning, and one tractor assembly plant.

(3) Social Services

Public health services in the Punjab include Government-run hospitals, dispensaries, rural health centers, basic health units and maternity child centers. In 1990, the districts of D.G. Khan and Rajanpur had 5 small hospitals each (total 437 beds), 37 dispensaries in all (total 28 beds), 15 rural health centers (total 260 beds), 72 basic health units, and 8 maternity child centers. These figures are among the lowest in the Punjab.

Educational facilities in the areas include colleges and middle and high schools, most of which are operated by the Government and are located in the canal-irrigated areas. The shortage or absence of teachers in the larger

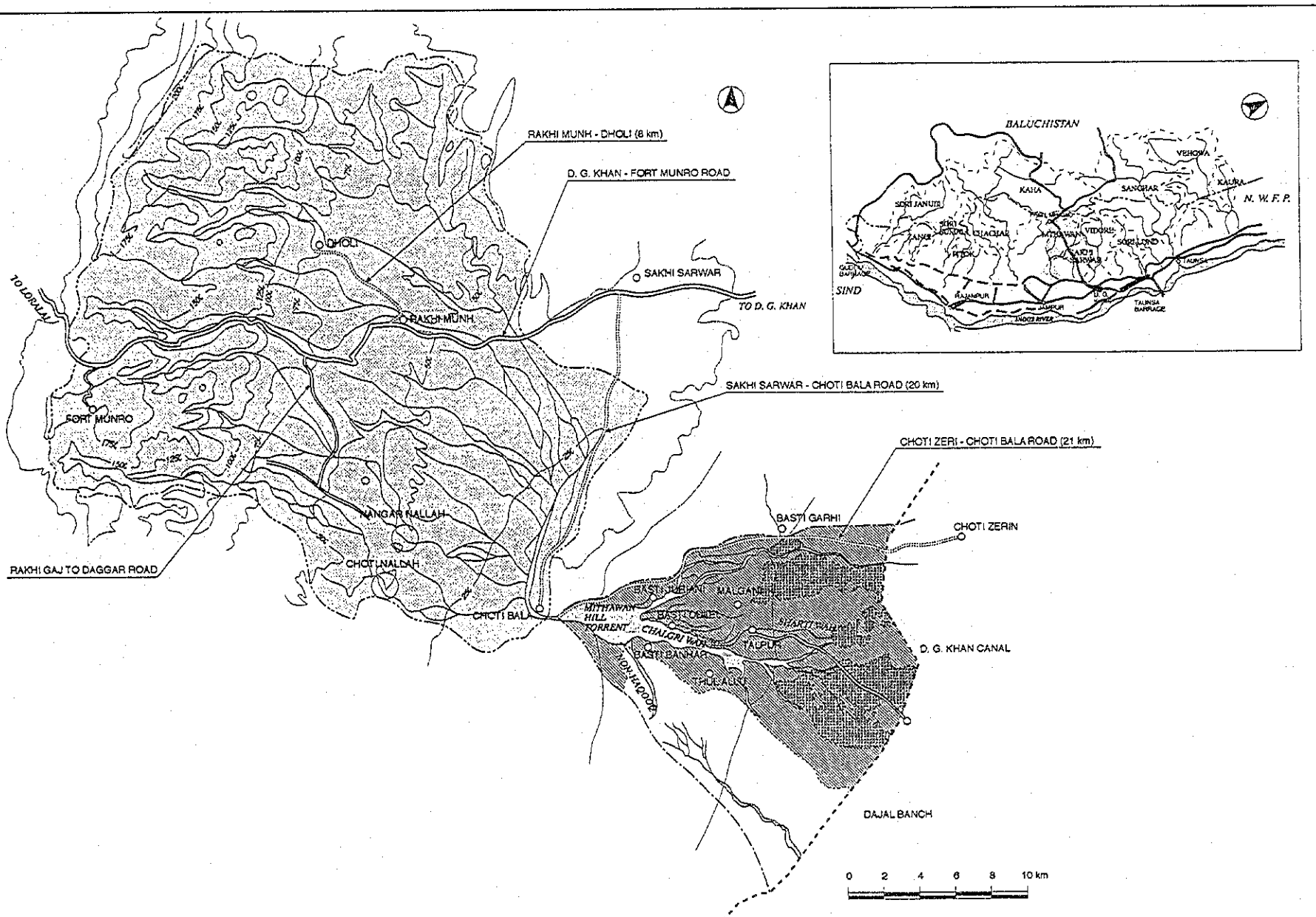


Fig. 3.5-1 MITHAWAN HILL TORRENT AREA MAIN ROAD MAP

communities of the pachad is directly responsible for the low literacy rate in the rural areas. The following are the social services facilitated in Mithawan hill torrent area:

(1) School	:	10 places
(2) Hospital	:	1 place (Basic Health Unit)
(3) Water system	:	1 system
(4) Electrification	:	none
(5) Tele-communication	:	none

Chapter 4 General Description of Scheme

4.1 Purpose of the Project

The Government of Pakistan has planned to maintain the self sufficiency of food supply and increase of export of agricultural products in his policy in the Seventh Five-year development plan. In order to achieve that policy, the development scheme at D. G. Khan hill torrent area was proposed as an enhancement in increasing the agricultural productivity by full utilization of water resources.

Mithawan Hill Torrent Pilot Project aims to increase agricultural production and to mitigate flood damages caused by hill torrent through suitable flood control. This scheme was formulated as a pilot project for the development model of water utilization and mitigation of hill torrent flood damages in D. G. Khan District.

This project consist of an irrigation development scheme by using floods flowing out through Mithawan hill torrent and an watershed management scheme in collaboration with FAO.

The area of Mithawan hill torrent basin is 729 sq.km. Most parts are covered by erosible weathered rock. Moreover, no vegetation exist due to cutting trees and un-restricted grazing in most of the area. Consequently, surface soil were carried away and land productivity has deteriorated, and flood damages and silting are prominent in the downstream area. The available land for farming extends over about 24,500 ha and cultivated area varies year by year depending upon the availability of flood water.

Each farm plot with the area of 2 to 8 ha is surrounded with high bunds in order to store flood water in the farm land and this makes a traditional basin irrigation. Water drown by a dispersion structure is stored in the plot with about 1 meter depth.

Farmers restore such structures from time to time when they are damaged due to scour by flood water or silted by sand deposited by the flood. Without such restoration, flood water flows away without utilization. Hill torrent water courses are changed every flood by scouring and/or silting. This means the useful life of irrigation facilities in Pachad area is rather short and operation and maintenance expenditure bore by the farmer is considerably high. Furthermore, heavy floods tend to flush out farm land, irrigation facilities and various other social infrastructures in the downstream area.

Depending on the dispersion of flood water of Mithawan hill torrent to farm land evenly, the water could be utilized for irrigation in Pachad area and flood damages alleviated accordingly. Purposes of the project are restoration of the vegetation in the

watershed to diminish the soil erosion and flatten the flood peak flow on the one hand, and providing flood dispersion structures for taking water to farm land in downstream area on the other hand, and also enhance agricultural development in the project area.

4.2 Project Component

4.2.1 Components Requested by the Government of Pakistan

The Government of Pakistan requested following components in the project to utilize irrigation water, mitigate flood damage and conserve watershed area in Mithawan basin.

- Main Dispersion Structure at darrah of Mithawan Hill Torrent near Choti Bala
- Improvement of Bhattiwala Bund
- Dispersion structure on Choti nallah
- Improvement of Distribution System of Nangar nallah
- Watershed Management
  - Contour Hedging by Vetiver Grass
  - Construction of Check Dams (45 nos.)
  - Experimental Farm
  - Appurtenant Structures
- Road Construction
  - Improvement of Existing Road (40 km)
  - Temporary Road for Construction Works (12 km)

The Concept Paper of FAO has set forth following items to be provided for the watershed management.

- Project Site Office
- Site Office Equipment including Vehicles for Field Works
- Experimental Farm
- Small Dams, Check Dams, Silting Traps, Horizontal Wells
- Vegetation Works
- Heavy Equipment procurement for Water Resource Development and Watershed Management Works

The field study by the Basic Design team was carried out on following components in accordance with conclusion of Preliminary Study Mission stipulated in

2.4.2, except "Main Dispersion Structure at darrah of Mithawan Hill Torrent" and "Improvement of Bhattiwala Bund".

- Dispersion Structure on Choti nallah
- Improvement of Distribution System of Nangar nallah
- Watershed Management
- Road Construction
  Improvement of Existing Road (40 km) and
  Temporary Road for Construction Works (12 km)

Details of the field study are described for each item as under.

(1) Irrigation

(a) Dispersion Structure on Choti nallah

Choti nallah is a tributary of Mithawan hill torrent and located at upstream of darrah of Mithawan Hill Torrent. The beneficial area is about 6,000 ha located on the right bank of Choti nallah. The irrigation system consists of five irrigation canals drawing the flood water from Choti nallah as shown in Fig. 4.2.1-2.

The irrigation water is distributed at the proposed site for dispersion structure on Choti nallah in accordance with due shares and the water-rights. A primitive sand and stone diversion facility exists at the site constructed by traditional farmer's organization through the so-called Kamara System. These structures used to be washed out by heavy flood and no longer functioning as a distributor. Moreover, most of the flood concentrated into some definite water courses whose beds were scoured and lowered by flood flows. As a result, water would concentrate to the scoured channel and other water courses could no more be distributed water.

The Amount of flood is estimated at 280 m^3/s at a 25-year return period. Out of that 202 m^3/s discharge is utilized in this irrigation project because of limitation of the canal capacity. Excess discharge of 78 m^3/s is released to no water right areas by the escape. After completion of the project, no more flood flows down to the Mithawan nallah from this point at a 25-year return period flood.

(b) Distribution System of Nangar Nallah

Nangar nallah is located at the upstream of darrah of Mithawan nallah, north of Choti nallah. The irrigation system is planed that the flood water is diverted into several irrigation canals as shown in Fig. 4.2.1-1

The irrigable farm land is located in the lower part of an alluvial fan extended downstream of both banks of Nangar nallah. The water distribution has been made in accordance with the shares of water-right by the cobble stone dispersion structure.

The design flood discharge is 386 m^3/s at a 25-year return period. Out of that 157 m^3/s is utilized for the irrigation, and the excess of 229 m^3/s is diverted into Mithawan nallah. A dispersion structure is to be constructed at a bifurcation to Marja Wah in order to control the water allotment.

(2) Watershed Management

The watershed management program aims at betterment of the hill torrent basin and land conservation in the watershed. The watershed area of Mithawan hill torrent is denuded and rocky land without vegetation extending over 729 sq.km. These ground conditions cause heavy flood damages in the downstream area arising from rapid and high rate of run-off, and severe soil erosion. This program involves construction of structures to obtain quick returns on agricultural development and farming stabilization, and mitigation of flood damages in the downstream area. It is expected that vegetation works undertaken on the bare land will have long term effect on structures.

According to the planning and design report for the Mithawan Hill Torrent Pilot project, the watershed management is operated in combination of water and soil conservation, range management, terracing, gully plugs and afforestation. These operations are summarized as following.

- Sowing and planting along interrupted contour trenches dug on gradients not above 30 degrees to catch rain water to help the plant growth and establish themselves.

- Contour bunding on gentle slopes to hold runoff to increase infiltration of water and provide moisture to plant raised along earthen bunds.

- Contour furrowing suitable patches on gentle slopes and re-seeding with palatable grasses.

- Closure against grazing till re-vegetation including grass establishes itself and thereafter proving rotational grazing to a permissible grazing capacity.

- Gully plugging with loose stones and check damming in dry stone rubble masonry work at suitable intervals to retard the velocity of water in the nallahs and raising trees in appropriately protected soil pockets behind the check dams.

In the request from the Government of Pakistan, following components are shown on the watershed management.

1 Contour hedges of Vetiver grass
2 Construction of check dams
3 Demonstration farm for Vetiver grass
4 Nursery for Vetiver grass
5 Appurtenant structures

Watershed management will be implemented under Japan's Grant Aid Program in cooperation with FAO's Trust Fund program. Although the watershed management program shall be extended in entire watershed, it will initially restricted to Dholi with technical assistance by FAO as a pilot model project. FAO has insisted that this project shall be promoted by local people themselves who fully understand the purpose of project and the effect of restoration of vegetation on their living conditions. This program is expected to extend over the whole area directing towards land conservation together with upgrading of people's living standards. But it will take considerable time and the project efforts have to be continued into farther future.

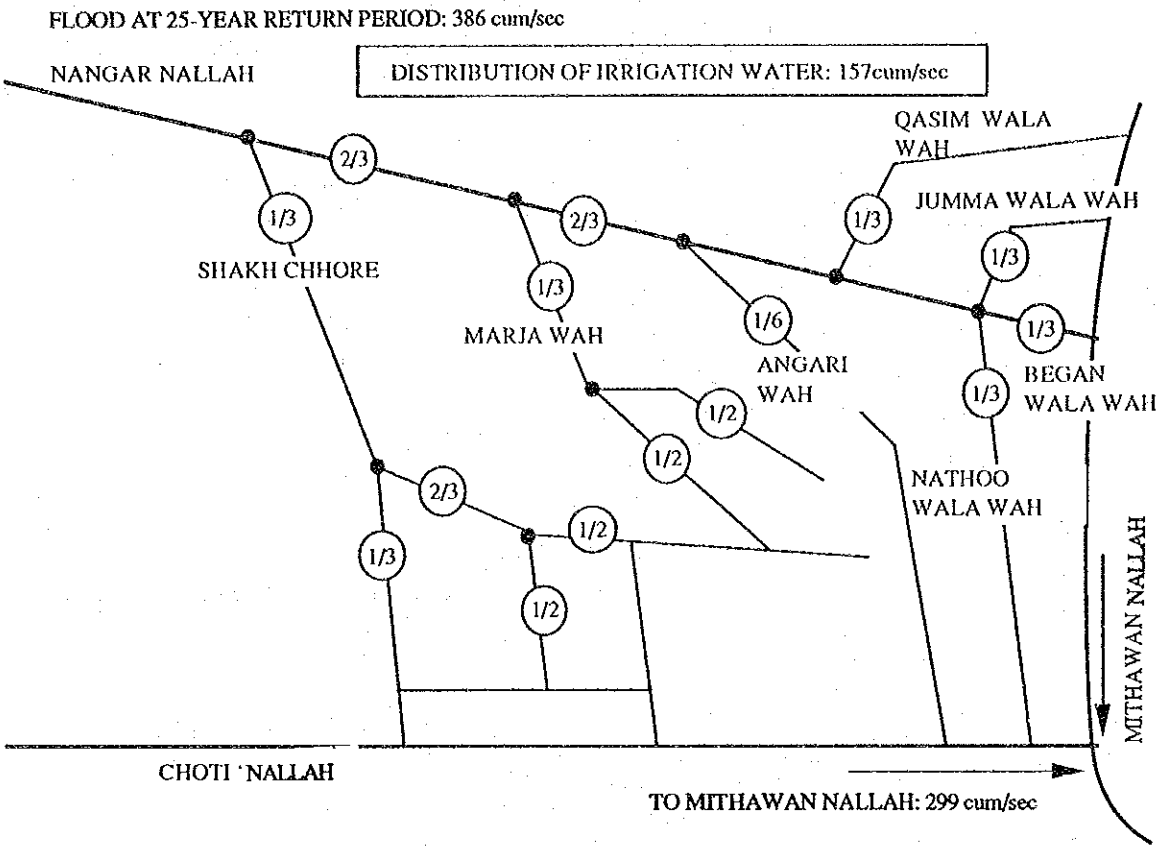


Fig. 4.2.1-1 NANGAR NALLAH HILL TORRENT LINE DIAGRAM

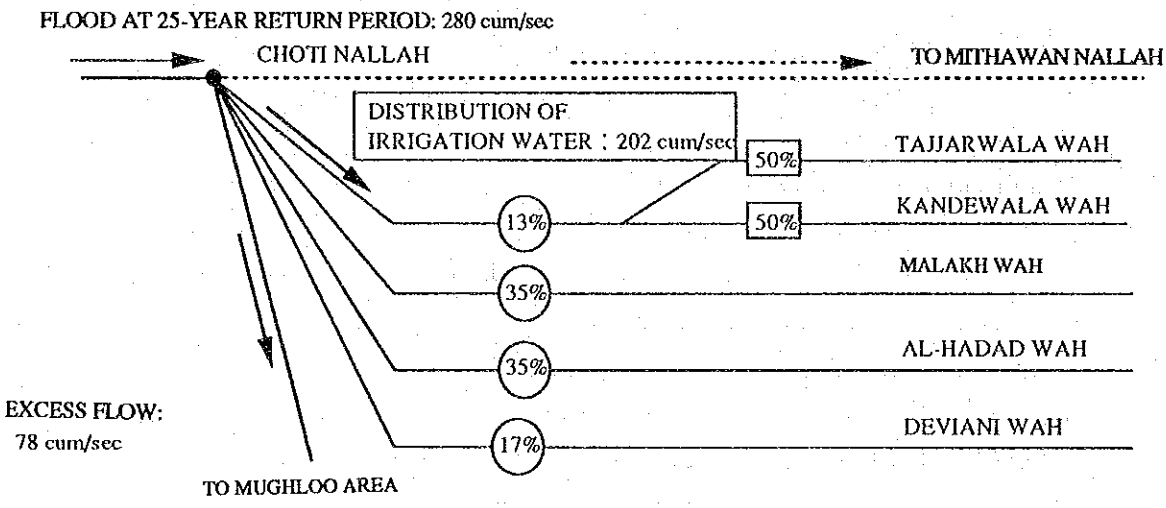


Fig. 4.2.1-2 CHOTI NALLAH HILL TORRENT LINE DIAGRAM

(3) Road

(a) Improvement of Existing Road

For purposes of transporting agricultural products and operation and maintenance of constructed facilities, existing roads shall be improved. These roads have an the important role as access road to dispersion structures for construction. Improvement of existing road will be prioritized. Following two routes which link the residential area to farm lands are selected for the road improvement.

Table 4.2.1-1 Road Improvement Plan

Route			Distance
From		To	
1. Choti Zerin	--	Choti Bala	21 km
2 . Choti Bala	--	Sakhi Sarwar	20 km

(b) Access Road

Access roads will be built from Choti Bala to construction sites. Some parts of the access road have to be used as temporary roads for the construction works. These routes are partially located on the river bed of Choti nallah. Width of the roads is 5 m with compacted gravel surfacing taking into account of passage of 11 tons trucks, and turnout/lay-by will be provided every 200 m intervals.

4.2.2 FAO'S Watershed Management

FAO has decided to assist the watershed management of the Mithawan hill torrent pilot project technically by the request of the Government of Pakistan.

Watershed of Mithawan Hill Torrent is designated for a tribal area. A part of the area belongs to private as farming lands and most of that belongs to the village communities as a grazing field. Since they have received limited education and little incentive from outside, they rely on the traditional un-restricted grazing. Un-restricted grazing coupled with rare rainfall has contributed to the decrease of the vegetation and low productivity of the livestock. The watershed management project directs to change attitude of the local population to the grazing through organizing grazier and

education/training program to the organization, and to extend conservation measures in the area.

FAO's concept of the watershed management is people's participation to the project for promoting it by them-selves with their self-reliance and understandings. The program of watershed management includes educating and organizing of the local population.

Watershed management program by FAO is expected to be continued 15 years. Six months at the beginning is mobilization period. Following five years are the major implementation period for technical transferring. After this period, management will transfer to the community organization gradually. FAO's watershed management program includes following activities.

Phase 1. Mobilization

The primary objective of the mobilization phase is to obtain an understanding of the social structure and the economics of the project area for the involvement of the local people in the implementation of the project and eventual organization of a viable Community Organization, and to get the project set up and operable. The conservation and range planning and developments would only preparatory activities with most actual work being during the second phase.

Phase 2. Project Development

Establish a viable resource development program to begin the rehabilitation of the vegetation, soil and water resources.

Establish viable grazing association in at least half of the villages of the project area for the organized, managed grazing of half of the area within the watershed.

Establish a Community Organization (CO) within the Mithawan Watershed that will be trained to maintain systems and structures developed by the project.

Activities will be training and education to the local population, introduction of rotation grazing, people's participation in the works such as mini-dam/check dam construction and afforestation, and training for operation and maintenance of the structures constructed by the project.

Phase 3.

Based on the evaluation of the project, local community organization will phase in to operate and to maintain project works.

Phase 4.

Donor funding will phase out and independent funding by CO will increase.

The Project includes education program that will teach the local population watershed management, improving their environment and bringing benefit through their future extension works. They will be taught that recovery of vegetation benefits them by increasing productivity and what methods are applicable to the area for the purpose.

Though recovery of vegetation make it possible to raise livestock in the area, growing grain crops in the area is recommended instead of increase of livestock and unrestricted grazing for preserving vegetation. For growing crops, multi-purpose mini-dams and water harvesting measures will be introduced and methods for construction, maintenance and operation of the facilities will be taught through training programs.

The structures in the watershed management program are mini-dams for silt trap, and multi-purpose reservoir for irrigation, silt trap, fish culture and water supply for inhabitant and livestock addition to popular check dams and gully plugs. Vegetation hedges of Saccharum munja and Vetiver spp. grass also proposed so as to restore the vegetation and conserve farm and/or sloped land, to introduce a rotational grazing for recovering of the natural vegetation, planting of fodder trees and minimum scale of artificial afforestation.

In addition to that providing of model grazing field, organizing of grazier's association, training and education to members of association for the range lands management, field trips to the developed area, improvement of management and guidance through extension services for grazier and farmers, securing of drinking water including for livestock by horizontal well, and others of cottage industry, fish culture, bee keeping, orchard production and preservation of wildlife are scheduled to be undertaken.

In the project, Dholi village is selected for a demonstration area owing to people's continuing effort toward development of their village. The Japan's Grant Aid