A geographical analysis of the rural economy in the margins of the Dasht-E-Kawir, central Iran: a case study of the Abuzaid-Abad area

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A GEOGRAPHICAL ANALYSIS OF THE RURAL ECONOMY IN THE MARGINS OF THE DASHT-E-KAWIR, CENTRAL IRAN : A CASE STUDY OF THE ABUZAID-ABAD AREA

by

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TO THE MEMORY OF MY FATHER

ABSTRACT

In this research a geographical analysis has been made of the rural economy in the margin of Dasht-e-Kawir Central Iran. In this region, as in all rural areas, two groups of factors affect the rural economy; physical and socio-economic.

Severe physical conditions, e.g. arid zone climate, shortage of water, saline soils and limitation of cultivable land, have restricted the agricultural development in the region. The main objective in the study of the physical conditions, is to recognize the area's capability for agricultural development and the influence of environmental conditions on the socio-economic factors. The severity of physical factors has encouraged the development of the craft industry in the area in general, and in the Abuzaid-Abad in particular. Thus over 50% of the rural income is derived from the carpet making industry, in which women provide the labour.

However, the rural economy in the area can not be assessed without examining the impact of the physical upon the socio-economic factors. In this study the two groups of factors have been investigated separately. In attempting to help the agricultural development, to increase the villagers' income and to improve rural welfare in the region, the complete set of factors must be analysed to identify the strongest correlation between them which is relevant to the above purposes.

In chapters one to four the physical factors have been discussed. Chapters five to ten are concerned with socio-economic and technical factors. In chapter eleven the rural income has been described. The conclusions summarise the most significant general findings of this study besides suggesting some further research for the future.

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Finally, I give my sincere thanks to my wife Azam for her help and encouragement. I would like to express my gratitude to my little daughter Mahsa for her patience which never failed during my study.

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Transliteration

The system of transliteration of the Persian names, titles and words in this study has been chosen according to the transliteration of the International Journal of Middle East Studies.

Words which have become naturalized in English, such as Islam, Iran, Kerman are spelt in accordance with the correct English usage. The long vowels of Persian are represented by â, û, î and short vowels by a̲, u̲, i̲ and diphthong by au and ai.

The norminal and adjective suffix is transliterated as eh because this is the usual Iranian practice,(1) but it is transliterated e when it is followed by a suffix (e.g. Dasht-e-Kawir).

		ف	f
ب	b	ق	q
پ	p	ك	k
ت	t	گ	g
ث	s̲	ل	l
ج	j	م	m
چ	ch	ن	n
ح	h	و	v or u
خ	kh	ه	h
د	d	ی	y
ذ	z		
ر	r	long vowels	
ز	z	ا	â
ژ	zh	و	û
س	s	ی	î
ش	sh	short vowels	
ص	s	َ	a̲
ض	z	ُ	u̲
ط	t	ِ	i̲
ظ	z	Diphthongs	
ع	e	وَ	au
غ	gh	یَ	ai

(1) Navabpour, 1981.

INTRODUCTION

I.1 Aims of the Study

The main aim of this research was to undertake a geographical analysis of the rural economy in the margin of Dasht-e-Kawir in central Iran.

The topic of this thesis has been chosen for four main reasons -

(a) My personal interest in recognizing the pressures and problems of the villagers in the margin of Dasht-e-Kawir.

(b) My own familiarity with village life or in other words, familiarity with the geographical, economic and social aspects of the villages in Iran in general, and the margin of Dasht-e-Kawir in particular.

(c) My wish to make an analysis of the elements and pressures involved in the villagers' lives, and their boundaries and interactions.

(d) My wish to affect rural development projects with proposals, and to provide primary data for future research in the region.

The selection of the margin of the Dasht-e-Kawir, in general, and the Abuzaid-Abad area (south west of Dasht-e-Kawir) as a case study for this investigation, resulted from my familiarity with the Abuzaid-Abad area, since I was an undergraduate in the university of Tehran. Subsequently, I made many field trips as a lecturer during my work in Tehran university. I had the opportunity of visiting at least 500 villages in different parts of Iran and to pursue investigations in many of them.

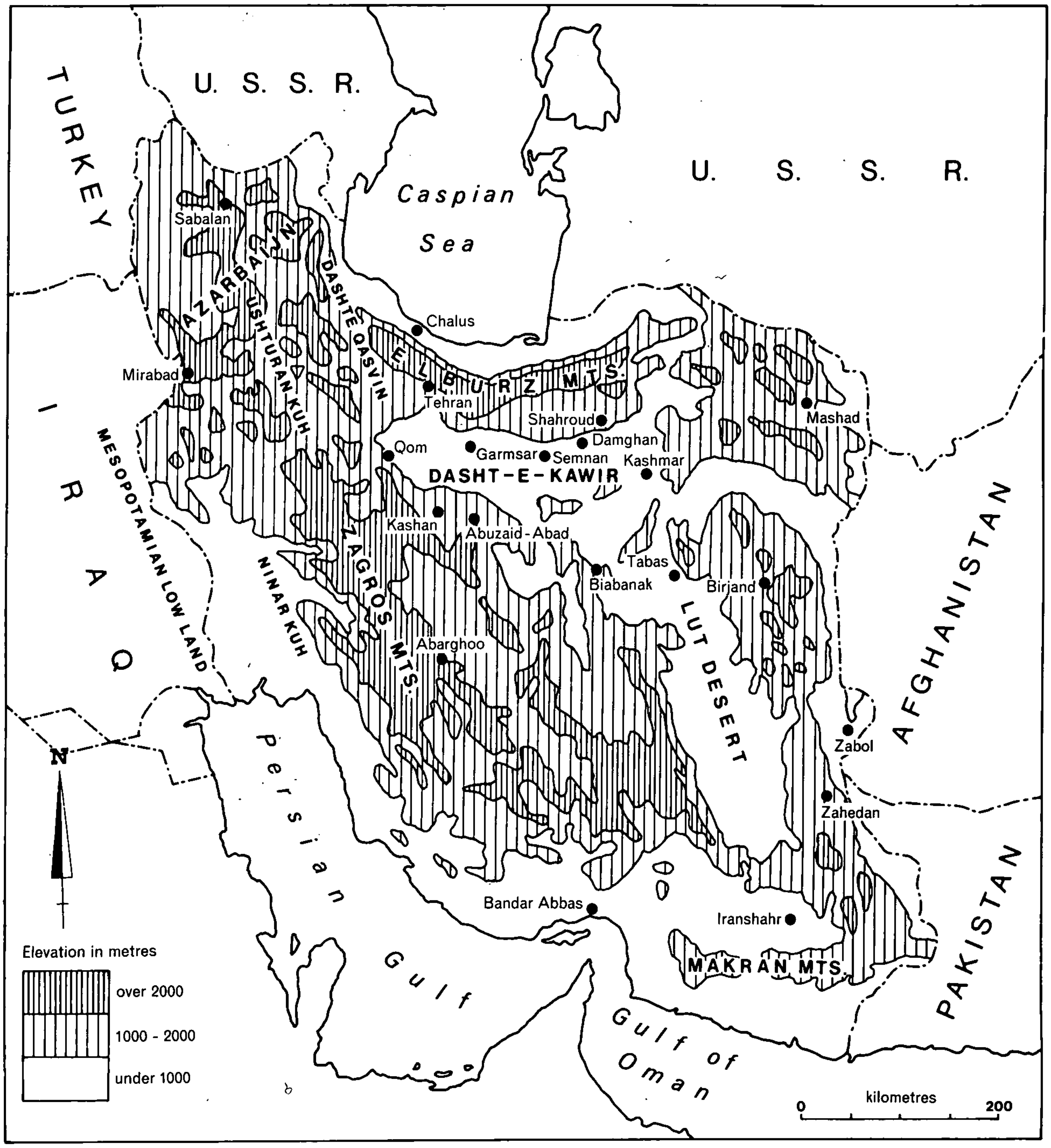
When the Iran Desert Research Center was established by the University of Tehran in 1975, basic facilities for rural research were prepared by the Center. Through the exigency of my own job in the university, my personal interest and the encouragement of the Desert Research Center, I started three years of rural investigation in the margin of Dasht-e-Kawir.

The main aim of my research in the margin of Dasht-e-Kawir in addition to preparing some articles for the Center, was to gather raw data for use in research for a higher degree. In this investigation I had to start from the beginning because the limitation of official and private data had restricted geographical investigation. Long distances and few facilities are the main reasons for the limitation of information about the margin of Dasht-e-Kawir, although the Desert Research Center has started detailed research in 1975, by Tehran University especialists into arid areas, as well as in the margin of Dasht-e-Kawir.

I.2 Selection of the area

The interior of the Iranian highland encloses a central area of irregular shape consisting of a very large number of basins. The Dasht-e-Kawir or Kawir-e-Bozorg (great Kawir) is a collection of these basins (Fig.I.1). Bobek (1959)[1] has described this in his research in the Dasht-e-Kawir -

Fig. 1.1 IRAN


U. S. S. R.
TURKEY
Caspian Sea
U. S. S. R.
Sabalan
AZARBAIJAN
USHTURAN KUH
DASHTE QASVIN
Chalus
ELBURZ MTS.
Mirabad
Tehran
Shahroud
Mashad
Damghan
Qom
Garmsar
Semnan
Kashmar
DASHT-E-KAWIR
IRAQ
MESOPOTAMIAN LOW LAND
Kashan
Abuzaid-Abad
Tabas
AFGHANISTAN
NINAR KUH
ZAGROS MTS.
Biabanak
Birjand
LUT DESERT
Abarghoo
Zabol
N
Zahedan
Persian Gulf
PAKISTAN
Bandar Abbas
Iranshahr
MAKRAN MTS.
Elevation in metres
over 2000
1000 - 2000
under 1000
Gulf of Oman
0 kilometres 200

"The great Kawir is divided into two main hydrographic basins, a western one and an eastern one. Between them there stretches an extensive area mainly composed of erosional surfaces covering a lot of anticlines, and including several smaller basins partly independent and partly attached to the eastern basin by various water courses".

The large eastern basin is divided into the north eastern or Kal-i-Shur Basin and Kal-i-Dastgan Basin. The western basin, which is named Masileh is the lowest of all since its level does not appear to reach much more than 700 m.

Physical features in the arid central basins of Iran are extremely diverse and many have individual Persian names. One of these "Dasht" is described by Deh Khoda(2) as "an extensive level area" . It is not, in fact, a firm and dry desert, although some Eruopean researchers have understood this to be so. Kawir is a large or small basin which is usually swampy or composed of lakes, the run off being dissipated by infiltration into the ground and evaporation from the lakes or swampy areas. If it is salty,the kawir is generally called Kawir-e-Namak, or Kawir-e-Shur, and the sandy kawir is generally named Rig or Dasht-e-Rig.(3) Fisher (1968)(4) says "Kawir denotes an expanse of slime or mud viscous rather than free-flowing with frequent salt efflorescence or continuous thick layers at the surface."

There are several theories as to the formation of the Dasht-e-Kawir. One of these,expressed by Bobek (1956)(5) and supported by others, suggests that the Dasht-e-Kawir as well as other smaller kawirs, should be considered as the last remains of former lakes.

The Dasht-e-Kawir occurs between 32°50' N -

$36^{o}70'$ N and 50^{o} - 59^{o} E. The extent of the Dasht-e-Kawir is about 2910 km^2 [6] and is bordered by the marginal villages and towns. Eleven towns are located at the edge of Dasht-e-Kawir - Qom, Voramin, Garmsar, Semnan, Damgan, Sabzevar, Kashmar, Ferdos, Tabas, Aran, and Kashan. Most of the villages in each part of the Kawir are located close together forming a group that is called Manzomeh [7] (system), in which the major village is usually the administrative centre. The Abuzaid-Abad area and its adjoining village is a good example of a Manzomeh.

During my field observations, I had the opportunity to observe most of the villages in the margin of the Dasht-e-Kawir. Three Manzomeh which attracted me in the margin of the Dasht-e-Kawir are as follows:

1. The Sar-Kawir area in the north of the Dasht-e-Kawir
2. The Biabanak area in the south.
3. The Abuzaid-Abad area in the west (Fig. I.2).

These areas were chosen partly because of their individual attractivness to this author and partly for four main reasons :

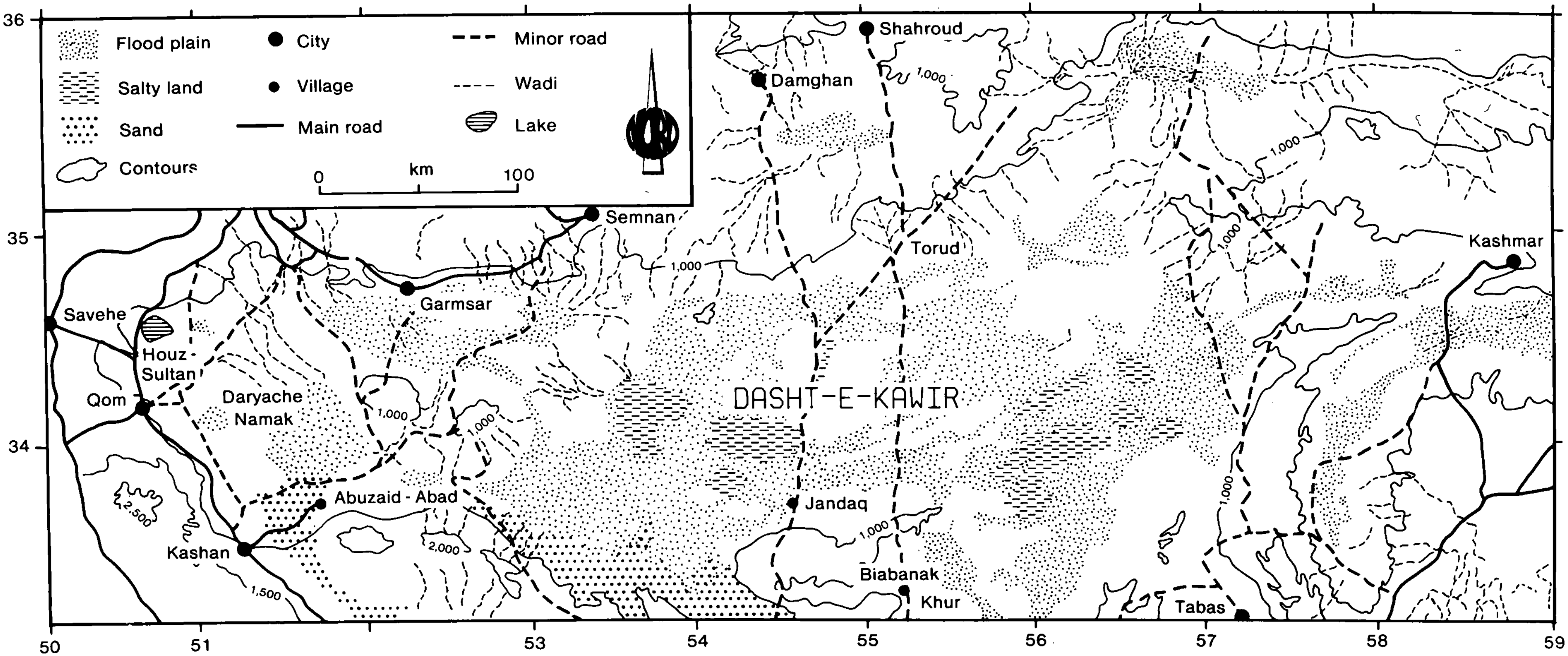
(a) Their location on three sides of Dasht-e-Kawir.

(b) They consist of groups of villages close together, i.e. 3 Manzomeh.

(c) The agricultural systems and economic conditions were similar.

(d) There was little information about the areas and extensive geographical investigation had not been carried out there since 1977.

FIG I.2 THE DASHT-E-KAWIR AND ITS MARGIN



The many similarities in these areas, e.g. climate, soil conditions, water supply systems, agricultural activities, ownership, carpet weaving, population distribution etc. were the reasons for the Abuzaid-Abad area being chosen as a case study. The outline of the two other areas is discussed very briefly in the following pages.

1. Biabanak

Biabanak is the name of a Bakhsh (district). According to the country administration, Biabanak is a Bakhsh of Isfahan Ostan (county) whose centre is Khur. In Biabanak there are 23 villages and 132 Mazreahs (hamlets), with a total population of 18,248.[8] In the old documents of the region, the name of the area is written as Jandaq va Qoraeh Sabeh (Jandaq and the location of seven villages). These major villages are - Baiazeh, Mehrijan, Garmeh, Ordib, Iraj, Farokhi and Khur.

There is a depression in the south of Biabanak named Gude-e-Jigark, about 20 km long and 12 km wide. This is surrounded by low mountains, the brownish colour of which probably gain the depression its name, as the local word for liver is Jigark.

There are 11 deserted villages in this depression, in which only 38 households were living (in 1977). The deepest part of the depression becomes a lake in the rainy season, a marsh in the beginning of spring and a salty flat plain in the summer. An aerial photograph or a map of the area shows plenty of villages but it should be noted that most of them are uninhabited, or have only a few residents. For example 41 Mazreahs of Jandaq has a population of only 505.

Plate I.1 Swelling saline soil 55 km from Jandaq towards Moeleman. In the depression white salt can be seen.

Plate I.2 A dried up bed of a salt lake, 35 km from Jandaq. The salt crust is about 3 cm thick. In the background is the wet zone.

Plate I.3 Leached out basin, 28 km from Moeleman. The basin is filled with wet mud, which has dried showing incipient polygons forming.

Plate I.4 Sand dune in the southern part of the Dasht-e-Kawir (near Chah-Malek village).

However, according to the field investigation carried out by the author in 1977 only 45 of the 132 Mazreahs had been inhabited by a total of 1,300 persons.

This area was important in the past because it was on the caravan routes leading north and south. Hadin described these in his book (1910)[9]

> "North-going caravans are usually laden with silk, cotton, and wool, henna and other dye-stuffs, Indian tea, cinnamon, pepper and other spices,etc. These travelling in the opposite direction carry sugar , naphtha, oil, Russian-cloth, iron and various groceries to Yazd."

Naser Khosroo (1350, 1971)[10] the famous Iranian traveller said in his book

> "This important route starts from Yazd and passes Khranaq, Mafazaq, Jarmaq and Jaudaq , and after passing the Great Kawir it reaches Hosainan, and from there the Semnan route goes on towards Russia."

The extent of Biabank, according to a calculation which was carried out by the author was 8,000 km^2. The density of population of the area was about one person per $\frac{1}{2}$ km^2. It is clear that the severe environmental conditions do not allow for population growth in the region.

Across the Dasht-e-Kawir

The Biabanak area is connected by two desert routes to Sar Kawir in the north. The first one is named the New Route and it has been used by caravans in the past. This track is 148 km long and goes through the centre of the Kawir. This track starts from the Arosan (a small village at the south edge of Dasht-e-Kawir), after passing the salt lake

(10 km wide) connected to Trud in the north. Hedin in 1909, Dr. and Mrs. Gabrial in 1933 used this route. Hosain Shaibani, now an old man, led the Gabrial's caravan through the desert, and has many recollections of his travels with Dr. and Mrs. Gabrial. The second route is named the Old Route, and is 124 km long. It starts from Jandaq in the south and after passing through the centre of the desert, joins Moaleman in the northern part of the Dasht-e-Kawir. I was also fortunate enough to travel this way twice, in April and November 1977.

This route used to be travelled by caravans in 72 hours, and now can be covered by Land rover in 14 to 18 hours without stopping. On this route there are four huoz (water reservoirs), now destroyed. These huozes were named Manzel (house). On most of the Iranian caravan routes in the past there was at every 6 Farsakh (36 km) a Manzel or Caravan Sara (the house of Caravan) for rest, and the number of these Manzel provided a good method of measuring distance. The Manzels of this desert route from south to north are Huoz-e-Dahaneh, Huoz-e-char Farsakh, Bar Andaz-e-Sar Namak and Huoz-e-Aqa . On this route the distance between the Manzels has been reduced from 6 to 4 Farsakhs because of difficult desert conditions.

To cover this route by car took approximately 30 hours. The landscape of the real desert can be seen in this way and it is one of the most wonderful views on earth. The desert sky is magnificant at night, dark and covered with bright stars. In the warm sunny days, between 10 a.m. - 4 p.m., usually nothing can be seen beyond 20 metres distance because of radiation reflection from the salty land.

Within the Dasht-e-Kawir there are no work resources and it is almost impossible to find any form of vegetation or animal life, apparently not even any insect life. Silence often dominates the desert. The Kawir spreads itself out, more and more dominating the landscape with its brown, dark yellow and white strips and flats.

Hosain Shabani, the leader of the Galbrial caravan said to us that if rain falls for an hour, it is impossible to conceive of anything more exhausting and wearisome than walking through the mud. One sinks in up to the knee at every step. He said that the Kawir is like a sea, and that it is a serious undertaking to venture over it. Hedin (1910) says in his book(11)

> "Jandaq is a halting place and point of departure on the southern side for a traveller on the way to the desert and Hosainan in the northern. They are like coast towns on a landlocked sea".

2. Sar Kawir

This district is located in the north of Dasht-e-Kawir. Hosainan is the first village in the western part of this area, and is connected by the desert route to Jandaq on the southern side of Dasht-e-Kawir. There are 9 villages and 30 Kalatehs (hamlets) in this area. The villages are located on the edge of Kawir, but most of the kalatehs are located on the slope of the northern mountains. The major villages of the area are spread out in a line from west to east. Trud being the last village. According to the government administration, the western villages are a part of Semnan Ostan and Trud is a part of Damghan. These villages are from west to east - Hosainan, Moeleman, Siang, Mahdi-Abad, Bidestan, Setveh and Trud.

The area with a population of 4,328 in 1976,(12) is one of the poorest regions in Iran,because in this area, there is no carpet production which plays the main role in the income of other areas, although recently carpet weaving was started at Trud by the Na'in carpet merchants. However, the approach later taken by the author was to reside 2 and 3 weeks in Sar-kawir and Biabanak respectively. The information obtained resulted from questionnaires, surveys and conversation with local people.

3. Abuzaid-Abad

Comprehensive information about the Abuzaid-Abad area has been given, in Chapters 1 - 11 in this thesis.

I.3 Sources of Data

In a developing country like Iran, covering a large area with a variety of environments and social conditions, researchers suffer from the limitation of data. In some cases there are enough scientific and other relevant data, but unfortunately this kind of information does not cover the whole country. For example, there is a huge amount of information about some parts of southern Iran (Khusestan) which has been obtained by the government, oil companies and private researchers. The availability of this information encourages most research workers to multiply existing data. Although this is understandable, the lack of even primary information for a large area like the margin of the Dasht-e-Kawir (except Varamin and Garmsar Plain) is very regretable.

The information which is used in this thesis was taken from the following sources:

1. Travellers' reports

This information comes from some of the travellers who visited the area and have written about their experiences, or some of the old geographers and historians who have provided some general information about the area.

2. Official Statistics

Contrary to the expectations of a researcher, there is little official information about the area; of what there is, some is too general and some is even misleading, especially when compared with the real facts concerning the area. However, in this study I am confident that accurate data have been used and have been checked against the sources.

3. Research Reports

As has been mentioned before, there are a few private researchers in the area, although when this study was carried out, some research, supported by the Iran Desert Research Centre, had started in the region. All of these publications have been studied by the author and reference is made to them, where appropriate.

4. Field work

Understanding the villagers' language, communicating with them and obtaining their acceptance and trust are fundamental elements when studying in rural areas in Iran.

This author comes from a rural area, and familiarity with rural life and subsequently familiarity with some

Plate I.5 The author's interview with the headman of Bidestan village in the northern part of the Dasht-e-Kawir.

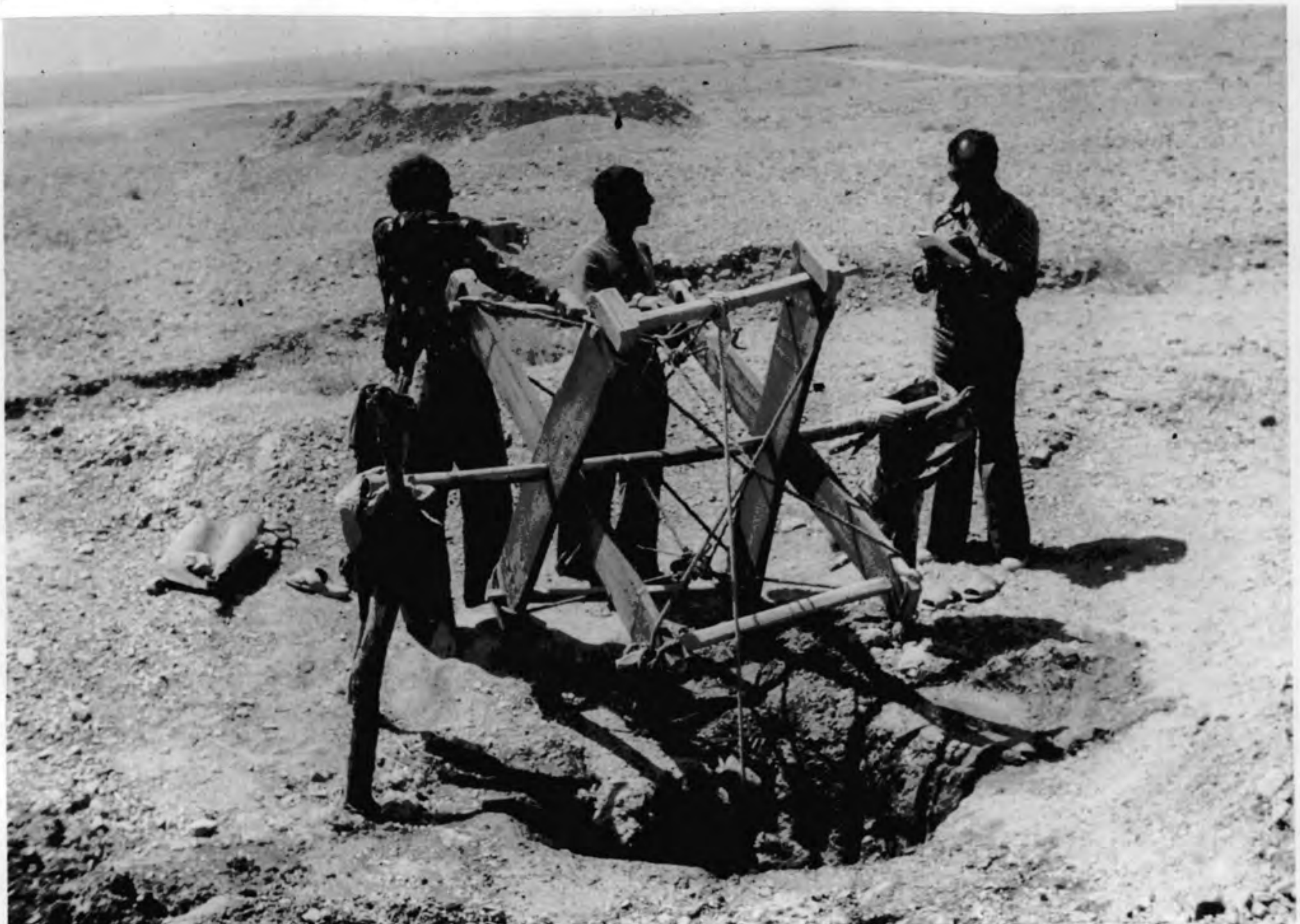


Plate I.6 The qanat maintenance system, and the author's interview with the Moqanis in the Abuzaid-Abad area, western part of the Dasht-e-Kawir.

geographical research methods, as well as attempts to speak their simple language have made possible his research in the region.

The fuller understanding of the area and its problems was achieved in four stages during my field work.

a. Existing information

Before starting the investigation attempts were made to gather the available published information about the area. These attempts were not very successful because of the limited information, but the available maps and aerial photographs were used to get to know the area.

b. Observation

In order to form a general picture of the region, the author visited all the villages in the Biabanak and Sar Kawir at least twice and in the Abuzaid-Abad area three times. An understanding of the location of areas, topographical conditions and the relationship between the villages was necessary for the following stages of research.

c. Questionnaire Survey

To acquire statistical information, two kinds of questionnaire were used. The first asked for general information about the villages, and was usually answered by the headmen and farmers. The second one dealt with detailed information about the households and families' income. So the required information was obtained from the villagers and was gathered by direct interviews in their house or farms by the author.

Excluding the agricultural income and production cost figures,this study has not used samples for statistical purposes,because some people are not used to statistical enquiries and some of them are prone to confuse surveys with pending taxation measures. So in these two cases 20% of each village unit has been chosen from among the informed farms.

d. Laboratory work

For the analysis of soil characteristics and water properties samples were taken to the laboratories after the field survey.

I.4 Organization of the study

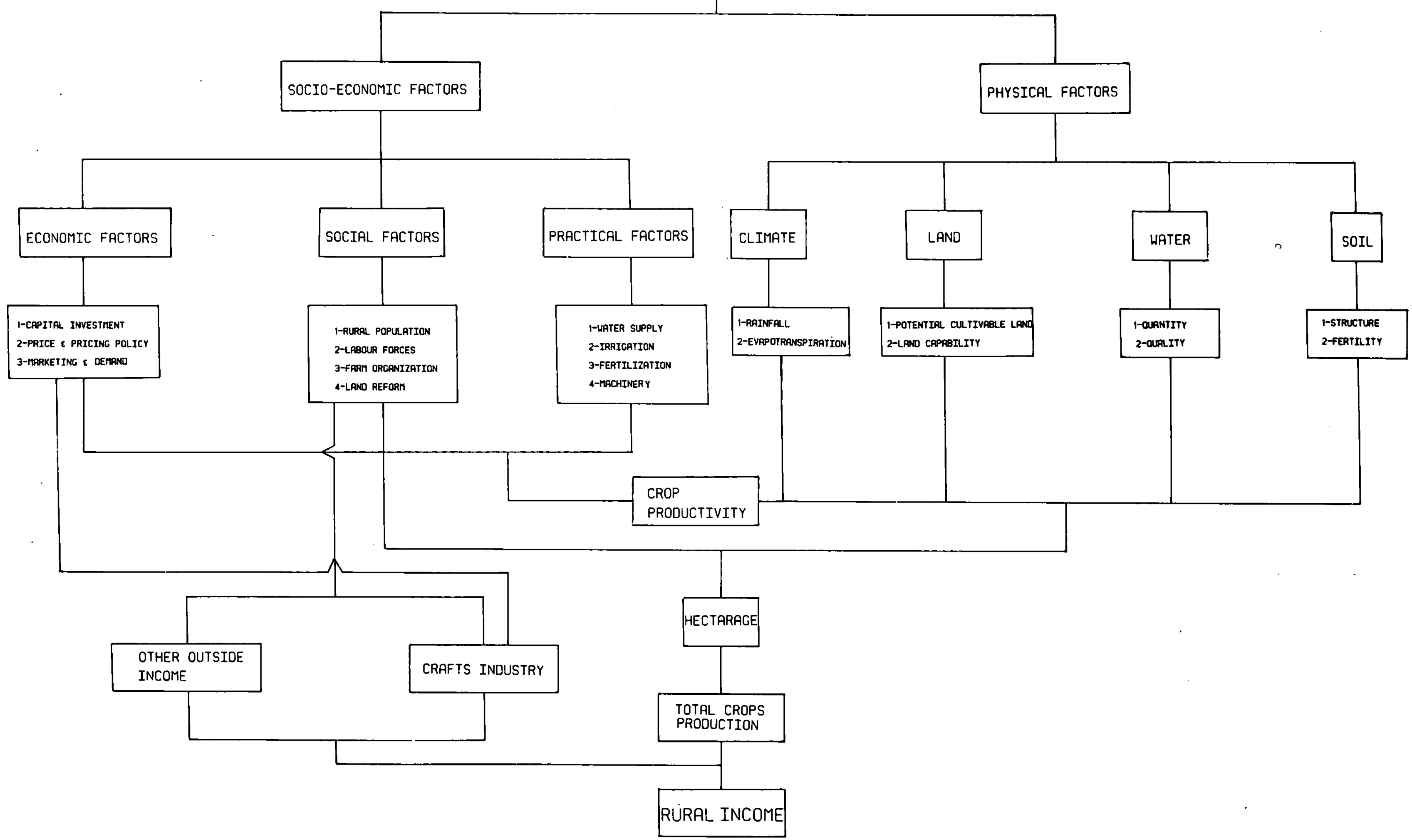
In the margin of Dasht-e-Kawir, as in the whole of Iran, two major factors affect the rural economy, Fig.I.3.

First, socio-economic factors : this category includes three major factors : economic, social and technical factors.

The second category contains mainly physical factors. The main physical factors include weather, land, water and soil factors which directly or indirectly affect the rural economy in the region.

The first section of this thesis, chapters 1-4, covers the physical factors. Chapter 1 deals with the climatology. In this chapter these groups of climatic elements which affect agriculture are discussed, and so the title of agro-climatology has been chosen for this chapter. Information from the 13 available major meteorological stations at the margin of Dasht-e-Kawir has been used. Because an agro-climatic study of the whole region,would have been a long process,

FIG I-3 FACTORS AFFECTING THE RURAL ECONOMY



the methods and the models of investigation have been limited to the Abuzaid-Abad area as a case study. The result of this research is given in several maps and graphs and tables in the appendix 2.

Chapter 2 deals with soil and vegetation, the main subjects being : the land capability classes and the method of controlling desert expansion and shifting sand.

Chapter 3 deals with hydrology, and water conditions, particularly the topography, geology, aquifer and water table conditions and quality of water in the Abuzaid-Abad area.

Chapter 4 deals with the land condition and it should be noted that for the sake of continuity the land use pattern has been studied in this chapter. The main points dealt with in this chapter are : distribution of land, distribution of land under cultivation and size of holdings.

Technical factors are covered in the chapters 5, 6 and 7. Chapter 7 describes the agriculture, covering methods of cultivation, farm labour, livestock and agricultural production.

Chapter 5 deals with the water supply, particularly the method of water supply in the region. This comprises qanats and wells, and includes the method of qanat construction in central Iran in general, and the margin of Dasht-e-Kawir in particular. The other main points concern the factors causing a reduction in the discharge of qanats in the area, the construction of wells and the balance of ground water extraction in the area.

Chapter 6 describes irrigation, dealing with the method of irrigation, water requirement and the cost of irrigation water.

Social factors are covered in the Chapters 8 and 9.

Chapter 8 deals with population and settlement, describing the population characteristics in general, and man-power in particular.

Chapter 9 contains land reform and agricultural credit.

The third section of Part two, Chapters 10 and 11, discuss economic factors.

Chapter 10 deals with the carpet weaving. The Kashan region's carpet is one of the finest carpets in both national and international markets. The production of carpets from the point of view of quality and quantity is significant in the Abuzaid-Abad area. This chapter mainly concentrates on the technique of carpet weaving, availability of labour and carpet production.

Chapter 11 deals with the rural economy. The main sources of rural income in the area are agriculture (crops and livestock), and carpet weaving. In this chapter the gross income and production costs are described and the net income per capita from the different sources is calculated.

The final chapter is the conclusion. Although the whole of the chapters have individual conclusions, the author has attempted to make some overall concluding remarks about the whole region. Also in this chapter, on the basis of the obtained results, some models for the future development of the area have been suggested.

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PART ONE

CHAPTER 1

AGROCLIMATOLOGY

1.1 Introduction

Climate has been studied in order to indicate the influence of climatic elements on the agriculture and human activities in the area.

An accurate study of the climate is extremely difficult because of the lack of meteorological stations in the area. Therefore, in this study the climatic information of Kashan's meteorological station has been used, as it is the nearest to the area, and has approximately similar geographical conditions. However, the data from this station are not adequate or satisfactory because of the shortage of systematic data, and the almost complete lack of information on climatic elements other than rainfall and temperature.

However, in order to obtain a better understanding, the agroclimate of the area has been analysed, together with relevant climatic elements and their impact on the agricultural activities in the area.

The details of climatic factors in the Abuzaid-Abad area are based on 19 year records from the Kashan meteorological station (1961-1979).

1.2 Rainfall

1.2.1 Distribution of Rainfall over the Year in the Abuzaid-Abad Area

The most important features as regards annual rainfall distribution can be summarized as follows:

(a) Rainfall in the Abuzaid-Abad area is confined to the period November to May. About 94.24 per cent of the mean annual rainfall occurs in this period in the area. The season of reliable rainfall starts at the beginning of November (1st - 10th).

(b) The dry season period occurs from June to October and rain in this period is insignificant, being 5.76 per cent of the total annual rainfall.

(c) Maximum rainfall occurs in the Abuzaid-Abad area in January, February and March 27.6, 18.6 and 23.8 mm respectively. Over 50 per cent of the mean annual rainfall occurs during these months. Before this period there is some autumn precipitation (November 12.2 mm and December 15.8 mm). This period has 20 per cent of the average annual rainfall. After the maximum period of rainfall comes the spring precipitation (April 18.3 mm and May 15.5 mm), which accounts for 24 per cent of the mean annual rainfall (Figs. 1.1 and 1.2).

(d) The end of the season of reliable rainfall is influenced by the differences in cyclonic activity to the west and generally, the season of rain ends around the middle of May.

The specification of inter-annual rainfall is given in Tables 1.1, 1.2 and 1.3 and Figure 1.3 shows the distribution of inter annual rainfall.

Table 1.1 : Distribution of Mean Annual Rainfall over the Year in the Abuzaid-Abad Area

Month	Rain-fall mm.	% of annual rain-fall	Month of Ag. year	Rain-fall mm.	% of annual rain-fall	Per Cent	Cum.% of rain fall.	Cum. frequ-ency
J	27.6	19.72	N	12.2	8.7	20	8.7	12.2
F	18.6	13.29	D	15.8	11.3		20.0	28.0
M	23.8	17.0	J	27.6	19.7		39.7	55.6
A	18.3	13.0	F	18.6	13.3	50.2 90.2	53.0	74.2
M	15.5	17.0	M	23.8	17.2		70.0	98.0
J	2.7	1.9	A	18.3	13.0	24	83.0	116.3
J	0.4	0.2	M	15.5	11.0		94.0	131.8
A	0.5	0.3	J	2.7	1.9		95.9	134.5
S	0.05	0.03	J	0.4	0.3		96.2	134.9
O	4.4	3.1	A	0.5	0.4	5.76 5.76	96.6	135.4
N	12.2	8.7	S	0.05	0.03		96.63	155.45
D	15.8	11.2	O	4.4	3.1		99.8	139.9
Total	139.9	100			100		100	

Source: Meteorological Organization of Iran

Table 1.2 : Distribution of Rainfall over the Seasons in the Abuzaid-Abad Area

Winter		Spring		Summer		Autumn	
Rain-fall mm.	Annual %	Rain-fall mm.	Annual %	Rain-fall mm.	Annual %	Rain-fall mm.	Annual %
70	50.0	36.5	26.0	0.95	0.67	32.4	23.1

Source: Table 1.1

FIG1.1 INTER ANNUAL RAINFALL IN THE ABUZAID-ABAD AREA

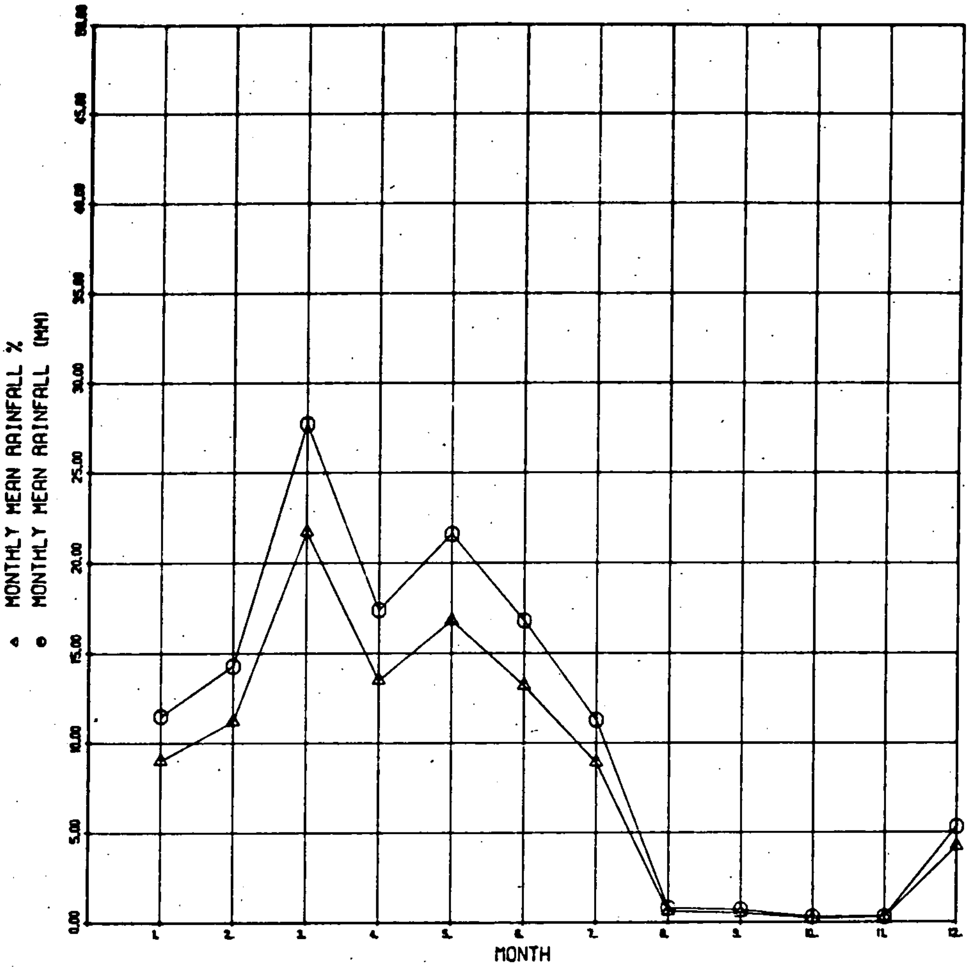


FIG 1.2 DISTRIBUTION OF RAINFALL OVER THE SEASONs IN THE ABUZAID-ABAD AREA

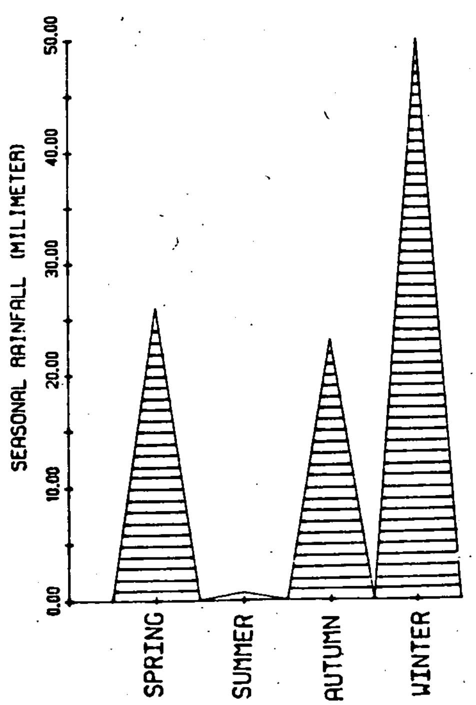


Table 1.3 : Statistical Specification of Interannual Rainfall 1961-1979 in The Abuzaid-Abad Area

Year	Annual rainfall (p)mm.	$p_r-\bar{p}$	$(p_r-\bar{p})^2$	p_r-p_{r+1}
1961	112.1	- 18.8	343.4	- 44.4
1962	156.5	16.6	275.5	8.7
1963	147.8	7.9	62.4	82.9
1964	64.9	- 75.0	562.5	-122.8
1965	187.7	47.8	2284.8	20.6
1966	167.1	27.2	739.8	87.1
1967	80.0	- 59.9	3588.0	- 79.5
1968	159.5	19.6	384.1	- 11.2
1969	171.0	31.1	967.2	45.0
1970	120.0	- 13.9	193.2	- 6.1
1971	132.1	- 78.0	60.8	-119.9
1972	252.0	112.1	12566.4	204.0
1973	45.0	- 94.9	9006.0	-148.0
1974	193.0	53.1	2819.6	85.9
1975	107.1	- 32.8	1075.8	- 52.1
1976	159.2	19.3	372.4	- 17.4
1977	176.6	36.7	1346.8	71.8
1978	104.8	- 35.1	1232.0	- 12.0
1979	116.8	- 23.1	535.6	

Source : Meteorological Organization of Iran.

Median = 156.5 mm

Mean = 139.9 mm

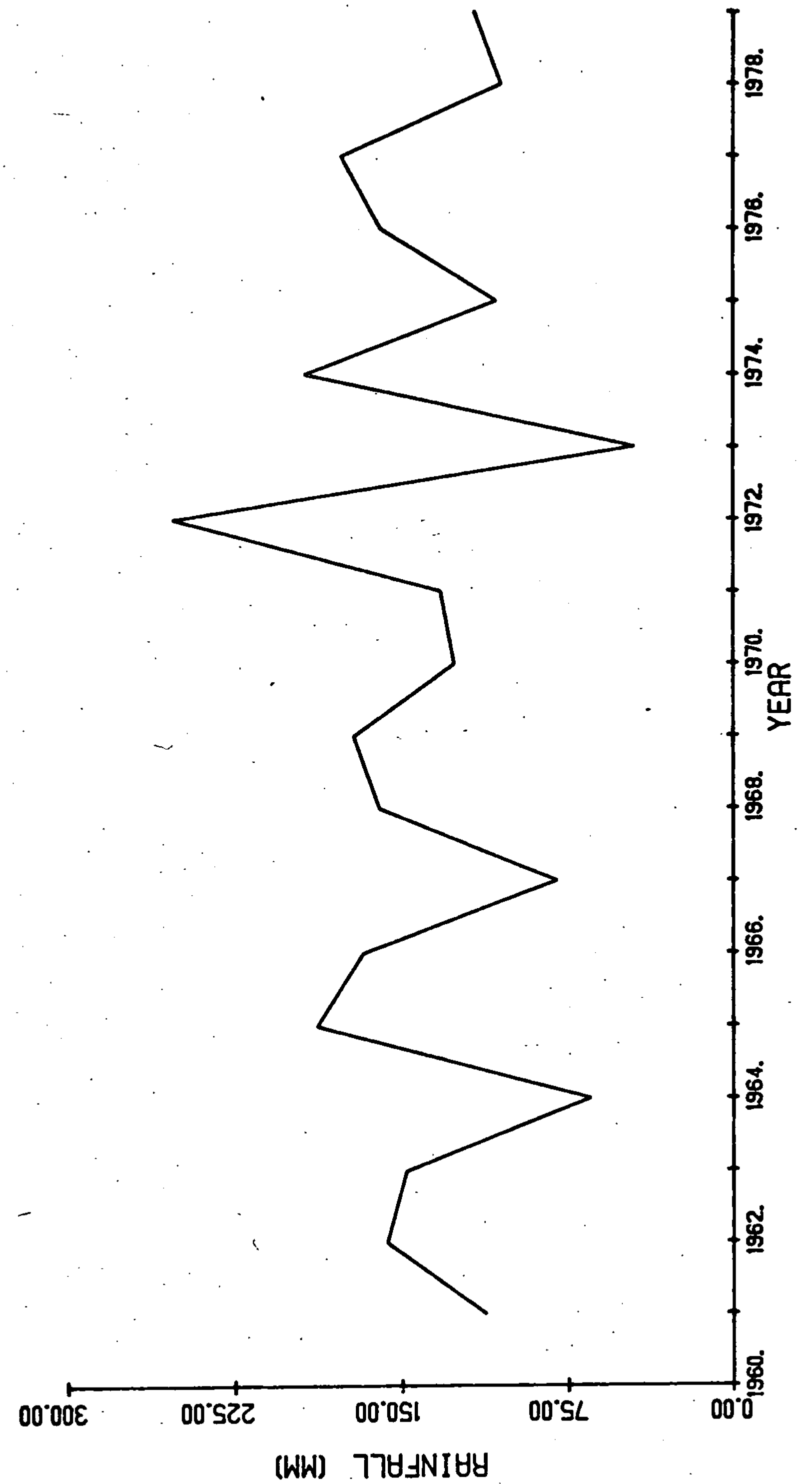
Mean deviation $|e|$ = 42.2

Varians = 1694

Standard deviation = 41.15

Mean sequential variation $\frac{\Sigma(p_r-p_{r+1})}{n-1}$ = 67.9

FIG 1.3 ABUZAID-ABAD (KASHAN) ANNUAL RAINFALL (MM) 1961-1979



1.2.2 Probability Estimates and Variability of Annual Rainfall

(a) An Estimate of the Confidence Limits for Annual Rainfall in the Area

The function most commonly used for determining annual rainfall probabilities at the ranges found in the area under investigation, is the Gauss-Laplace or normal distribution, which has been used for determining annual rainfall in the area.

Probability estimates of annual rainfall in the area have been calculated at different confidence levels (60%, 70%, 80%, 90%, 95% and 99%) by the author - Table 1.4 and Figure 1.4 show the estimation of probability. The probability confidence limits of annual rainfall in the area have been calculated from the formula as follows -

$Cl_p = \bar{p} \pm z\sigma$, where Cl_p is the confidence level, $\bar{p}$ is the mean annual rainfall z is z-scores $[z = (p - \bar{p})/\sigma]$ and σ is standard deviation.(1)

(b) Estimate of the Confidence Limit for Mean Annual Rainfall

An estimate of confidence limits for mean annual rainfall is one of the most important agroclimatology factors for agricultural planning in arid areas and in this study it has been calculated by:

(i) Estimates from Large Sample Measurement (Normal Distribution)

An estimate of the confidence limits for the mean annual rainfall using the formula as follows _

$Cl_p \doteq \bar{p} + z.SE\bar{x}$, where $SE\bar{x}$ is called the standard error of mean, and it is calculated as $SE\bar{x} = \sigma/\sqrt{N-1}$, where N is the size of sample. The estimate of confidence limits for mean annual rainfall for the abuzaid-Abad area is shown in Table 1.5. In this estimation, the confidence interval is changed from 137.7 mm - 146.7 mm by a confidence level of 60% and 99.9% respectively.

(ii) Estimate for Small Sample Measurements (t-student)

This method is often suggested when N > 30.[2] The author has tried to use this method even though there is 19 years data on interannual rainfall in the Abuzaid-Abad area. This 19-year period has been chosen as a small sample, and an estimate of the confidence limit of annual rainfall has been calculated using students' t distribution and this is shown in Table 1.6.

The confidence interval in normal distribution is wider than students' t distribution which ranges from 131.6 to 177.1 mm for 60% to 99.9% respectively. Figure 1.4 shows the confidence limits of annual rainfall in the area.

1.2.3 Graphical Estimation of annual rainfall probability for the area

It is possible to estimate graphically, the mean of annual rainfall with the use of normal graph paper. It has been created by using 19 horizontal lines spaced at equal probability intervals for the Abuzaid-Abad area with 19 years data of rainfall, (Appendix 1). Where the straight line cuts the 50 horizontal line the mean value is read.[3] Figure 1.5 shows the mean value of annual rainfall as 140 mm in the Abuzaid-Abad area.

It is also possible to estimate the probability of the occurrence of values within intervals, symmetrical about the mean e.g. the 60% horizontal line intersects the oblique line, and its

Table 1.4 : Estimate of Confidence Limits for Annual Rainfall (normal distribution)

Confidence level / Station	60%	70%	80%	90%	95%	99%
Abuzaid-Abad	129.2-150.5	118.1-161.6	105.3-174.4	88.8-192.9	72.0-207.7	44.1-235.6

Table 1.5 : Estimate of Confidence Limits for the MEAN Annual Rainfall (normal distribution)

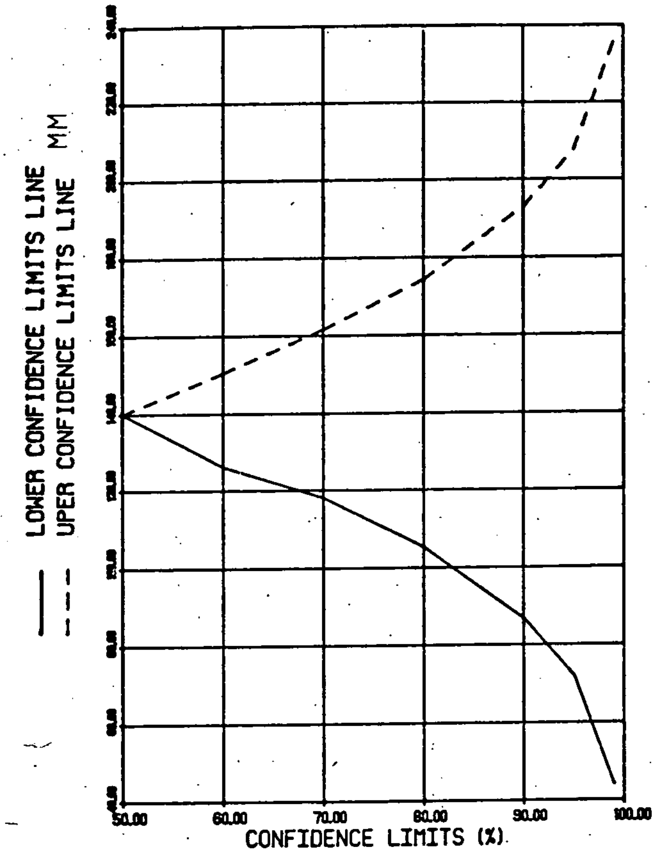
Confidence level / Station	60%	90%	95%	98%	99%	99.9%
Abuzaid-Abad	137.7-142.1	137.1-142.9	136.2-143.5	135.5-144.2	134.7-145.0	133.0-146.7

Table 1.6 : Confidence Limits of MEAN Annual Rainfall (Student's method)

Confidence level / Station	60%	80%	90%	95%	99%	99.9%
Abuzaid-Abad	131.6-149.5	127.1-152.6	123.3-156.4	119.8-159.9	112.4-167.3	102.6-177.1

FIG 1.4

CONFIDENCE LIMITS (%) OF ABUZAID-ABAD ANNUAL RAINFALL (NORMAL DISTRIBUTION)



CONFIDENCE LIMITS (%) OF ABUZAID-ABAD MEAN ANNUAL RAINFALL (NORMAL DISTRIBUTION)

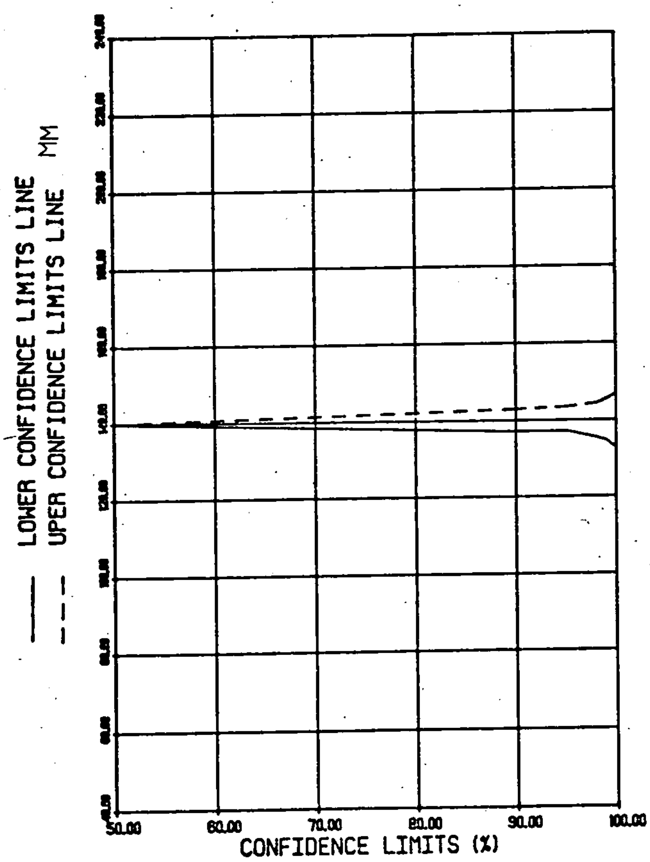
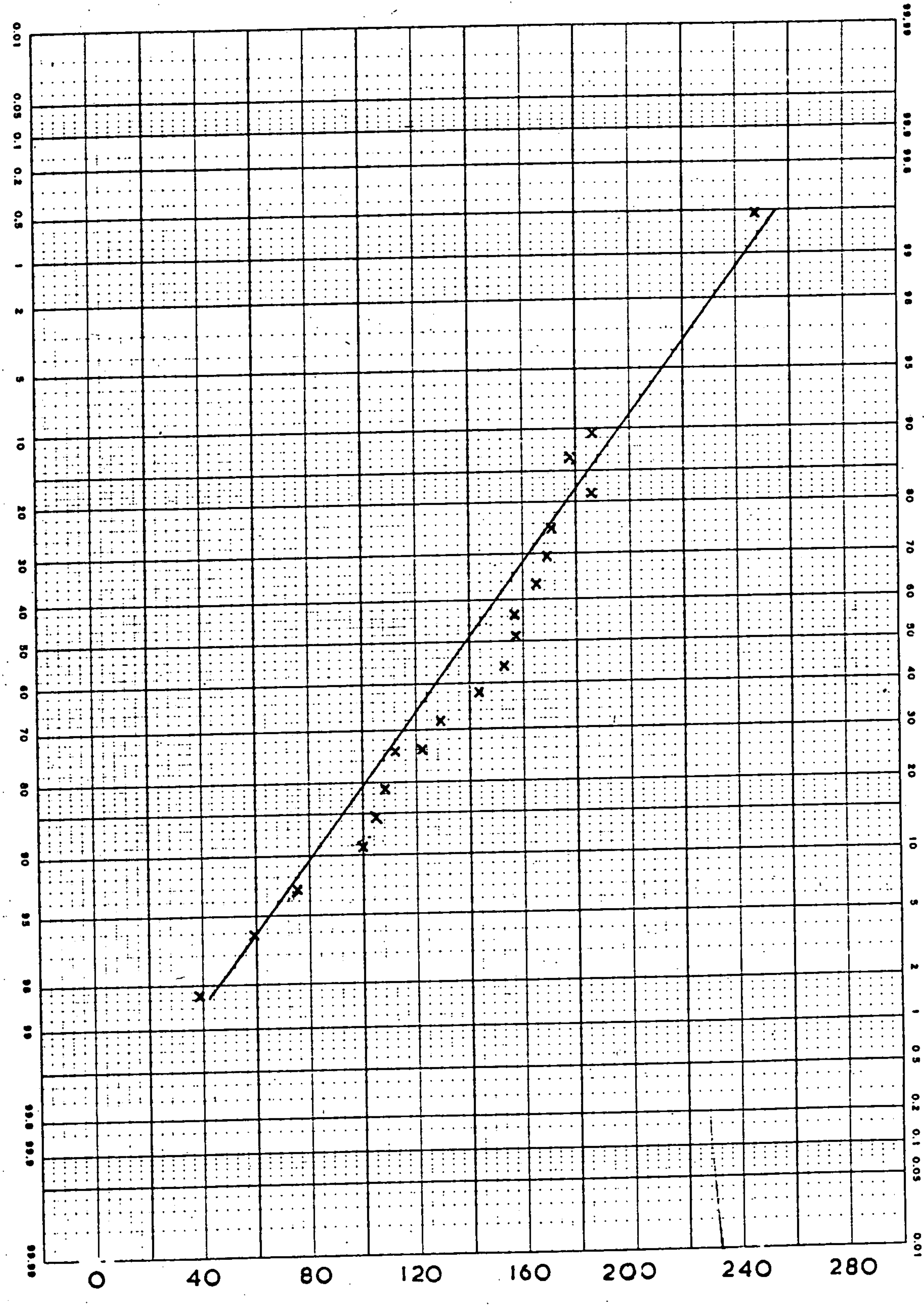


FIGURE 1.5 GRAPHICAL ESTIMATION OF ANNUAL RAINFALL PROBABILITY IN THE ABUZAID-ABAD AREA



value which is found in the rainfall scale at the bottom, is about 128mm.

1.2.4 Fitting a Normal Curve to the Interannual Rainfall Data

The work is organized as in Table 1.7.[4] In calculating z for class mark (x) we use $z = (P-\bar{p})/\sigma$. The fourth column of the table shows the frequency of the curve on the z point, it is shown by (y) the width of the points of the curve. It has been obtained by using a normal distribution table. In the fifth column the expected frequence (Fe) has been calculated as follows $Fe = \frac{IN}{\sigma} y$, where I is the size of class and N is the size of sample. The sixth column shows the observed frequence.

If we compare the expected frequency, and the observed frequence we will find a difference between the frequencies in some of the classes, and we can draw a normal curve. Figure 1.6 shows the distribution of observed frequence and expected frequence.

1.2.5 Rainfall Variability

Rainfall variability is an inherent characteristic of rainfall itself in arid zones. Rainfall varies greatly both in time and space, and the importance of the variability of rainfall in time is of particular interest in agriculture. In research into this variability, the length and availability of reliable records is highly significant, so their lack causes a big problem in agroclimatology. Variability of rainfall can be expressed in a few ways. In this investigation variability is calculated using two of the methods as follows:

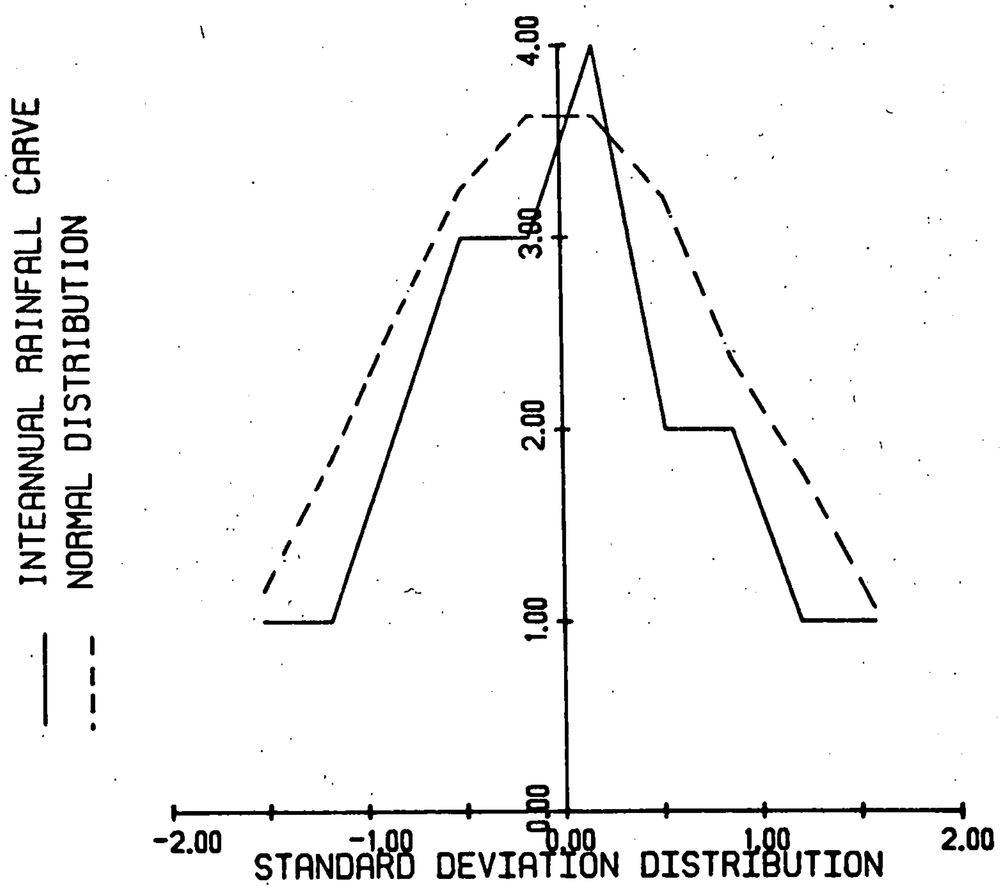
a. Interannual relative variability, which may be

Table 1.7 Fitting a Normal Curve to the Interannual Rainfall Distribution in the Abuzaid-Abad Area

Mass	Class boundaries x	$z=p-\bar{p}/\sigma$ z for class boundaries	y	Expected frequency y	Observed frequency y'
220-<	230	1.57	0.1163	1.07	1
200-220	210	1.20	0.1942	1.79	1
180-200	190	0.86	0.2556	2.36	2
160-180	170	0.52	0.3485	3.21	2
140-160	150	0.17	0.3932	3.63	4
120-140	130	-0.16	0.3939	3.63	3
100-120	110	-0.50	0.3521	3.25	3
80-100	90	-0.84	0.2803	2.58	2
60-80	70	-1.18	0.1989	1.83	1
>-60	50	-1.52	0.1257	1.16	1

FIG 1.6

FITING A NORMAL CARVE TO THE INTERANNUAL RAINFALL IN THE ABUZAID-ABAD AREA



expressed by IaVrel $= 100 \frac{\Sigma |p_r - \bar{p}|}{\bar{p}(n-1)}$, where IaVrel is inter-annual relative variability (per cent), p_r is the annual rainfall.[5]

Interannual relative variability is calculated by the author for the Abuzaid-Abad area, and its value is 31.8%. It is known that variability generally increases as the total rainfall decreases.

b. Interannual coefficient of variability - this is more reliable than the IaVrel because in order to calculate the coefficient of variation, standard deviation is used whereas mean deviation is used in IaVrel. Therefore, the latter is not as reliable as standard deviation because mean deviation uses the absolute value of a number.[6,7] The interannual coefficient of variability can be defined as follows -

$$cv = \frac{\sigma}{p} 100$$

where cv is the interannual coefficient of variability in per cent. The cv has been calculated for the Abuzaid-Abad area, and its amount is 29.4%.

1.3 Radiation

Solar radiation is of interest to use, since it is the source of different forms of energy used by crops for their metabolic processes.

The quantity of energy arriving at the top of the atmosphere depends on the angle of the rays of the sun and on the length of the day. Various yearly and seasonal amounts for some latitudes (including the area in question) taken from The Smithsonian Tables (1966)[8] are tabulated in Table 1.8.

1.3.1 Estimate of global radiation in the Abuzaid-Abad Area

Of the solar radiation reaching the earth's surface, after crossing the atmosphere, called global radiation, 2 - 4 per cent controls photosynthesis.[9] This radiation is also a factor in evapotranspiration (in Penman's method, and others). Thus it is important to measure or estimate this radiation as accurately as possible. Hardly any direct measurements of global radiation have been made available from the area under investigation. No observation station has the necessary instruments to measure global radiation directly. Therefore a method has had to be found to estimate global radiation in the area. To do this, recourse had to be made to an empirical formula based on the radiation incident outside the atmosphere and a proportion between the observed and the maximum possible sunshine (Table 1.8).

Many research workers e.g. Penman (1948)[10], Black (1955)[11] and Devries (1955)[12] have derived estimates of global short-wave radiation at the earth's surface (Rg) in terms of the solar radiation (Ra), with the maximum possible daily duration of bright sunshine (N),(Fig.1.7) and the observed duration (n) (Table 1.8), using a simple linear regression of the form $Rg = Ra(a+b\ n/N)$ eq. (1)
Recently Rietveld (1978)[13] suggested that the values of (a & b) varied in accordance with the appropriate mean values of n/N.

Table 1.8 : Mean Monthly and Daily Actual and Possible Sunshine in the Abuzaid-Abad area

Sunshine / Months	Monthly Actual sunshine Hours	Daily Actual sunshine Hours and min.	Monthly Possible sunshine Hours	Daily Possible sunshine Hours and min.	Per cent of mean possible sunshine
January	140	4,40	301,8	10,06	46.3
February	160	5,19	330,9	11,03	48.3
March	181	6,01	360,0	12,00	50.2
April	204	6,48	377,0	12,58	54.0
May	252	8,24	406,2	13,54	62.0
June	285	9,30	420,0	14,19	66.9
July	308	10,15	422,0	14,09	72.8
August	313	10,23	396,0	13,19	79.1
September	303	10,06	368,0	12,26	82.3
October	300	10,0	336,0	11,20	89.2
November	175	5,49	308,0	10,28	56.7
December	145	4,49	288,0	9,59	50.4

Source : Meteorological Organization of Iran and List, R.J. (1966) Smithsonian Meteorological Tables

Analysis of a 25 months (1971-1973) series of observation of sunshine and radiation at Badjgah (Iran) by Malek (1979),[14] provides some support for this hypothesis. He gives the values of the constant a & b in e.q. (1) as a = 0.31 and b = 0.55 with a correlation of 0.91 between the observed and estimated value of (Rg). These values are, however, somewhat higher than those suggested by Rietveld, (1978)[15] which are a = 0.26, b = 0.50.

In the present study Malek's (1978), constant values for the general Angstram formula e.q. (1) have been chosen to estimate the global radiation in Abuzaid-Abad because Abuzaid-Abad and Bajgha have mostly similar geographic conditions. Using the above method, the seasonal and annual global radiation has been calculated to be for the winter period 55.4 k cal/cm^2, and the summer period 120.4 k cal/cm^2. The annual value was 175.8 k cal/cm^2. for the Abuzaid-Abad area.

1.4 Temperature

1.4.1 Classifying of Climate

Temperature has been used as a basis for classifying the regions, and in order to classify climate, especially as it relates to agriculture, various systems have been derived.

In this study the method of de Martonne[16] has been used because he has paid attention to the desert classification.

De Martonne proposed a coefficient of dryness [17] as follows:

$$M = \frac{N}{T+10}$$

where N is the annual precipitation in millimeters, T is the annual mean temperature in degrees centigrade, and M is the coefficient of dryness. The table of coefficient M gives the values 0 to 10 desert areas, 10 to 20 for steppe regions and 20 and above for forest areas.

The coefficient of dryness for the Abuzaid-Abad area has been calculated using the method of De Martonne by the author, its value is 4.8. In addition, according to this classification desert regions can be divided into two types, weak and strong desert areas. The De Martonne coefficients of 0 to 5 represent strong desert areas with a total rainfall of between 16-167 mm, and an annual absolute minimum temperature of between -20 and +7 °C, while coefficients between 5 and 10 represent weak desert.[18]

According to this method the Abuzaid-Abad area is classified as a strong desert.

1.4.2 Temperature Conditions over the Year in the Area

(a) In spring (March, April, May) it can be seen that the highest mean temperature recorded in this season is found at Abuzaid-Abad, 24.3°C in May, and the lowest mean temperature is registered as 13.1°C in March, (Table 1.9).

(b) The general climate in summer (June, July, August) is hot, dry and rainless and clear skies prevail. In this season the Dasht-e-Kawir and its margins are one of the

Table 1. 9 : Specification of Monthly Temperature of Abuzaid-Abad (Kashan)

Station	Abuzaid-Abad(Kashan)	Long.	51°27 E
Lat.	33° 58 N	Year	1960-1979
Alt.	955 m.		

Mth. \ Temp.	Max	Min	Range	Mean	Abs max	Abs min
January	10.0	-0.8	10.8	4.6	19.0	-10.0
February	13.3	1.4	11.9	7.2	27.0	-10.0
March	19.8	6.5	13.3	13.1	32.0	- 2.0
April	26.3	11.0	15.3	18.6	36.0	- 1.0
May	31.4	17.1	24.3	24.3	42.0	11.0
June	37.7	21.8	15.9	29.7	48.0	15.0
July	41.2	24.6	16.6	32.9	48.0	19.0
August	39.46	22.0	17.4	30.7	46.0	17.0
September	37.1	16.9	20.2	27.0	41.0	11.0
October	27.9	12.6	15.3	20.2	37.0	7.0
November	14.4	4.7	13.7	11.6	31.0	- 3.0
December	13.2	1.6	11.6	7.4	21.0	-12.0
Ann.mean	26.3	11.6	14.7	18.9		

Source : Meteorological Organization of Iran.

hottest regions in the country. The highest recorded mean temperature for summer was found at the Abuzaid-Abad area at 32.9°C in July, and the lowest mean temperature of 29.7°C in June has been recorded at the Abuzaid-Abad area.

(c) In autumn (September- November) the highest mean temperature which has been recorded in the Abuzaid-Abad area is 20.2 in October, and the lowest mean temperature which has been registered is 11.6°C in November in this season.

(d) In winter (December - February) the lowest mean temperature has been recorded as 4.60 in January and the highest 7.4°C in December.

(e) Maximum Temperature. It is noticed that the mean maximum temperature at Abuzaid-Abad during June, July and August are 37.7, 41.2 and 39.4° C respectively. The highest absolute maximum temperature was registered on the 29th June, 1970, as 48.0°C. The highest mean maximum temperature usually occurs in July.

(f) Minimum temperature. The lowest absolute minimum temperature was recorded as -12.0°C on 27th December 1972, while the mean minimum temperature in the area occurs during December, January and February, 1.6, -0.8 and 1.4°C respectively. (Fig.1.7).

1.5 Evapotranspiration

Potential evapotranspiration is one of the important agroclimatic factors. It is defined as the combined loss of water by evaporation from water surfaces and soil, and

FIG 1.7 SUNSHINE CONDITION IN THE ABUZAID-ABAD AREA

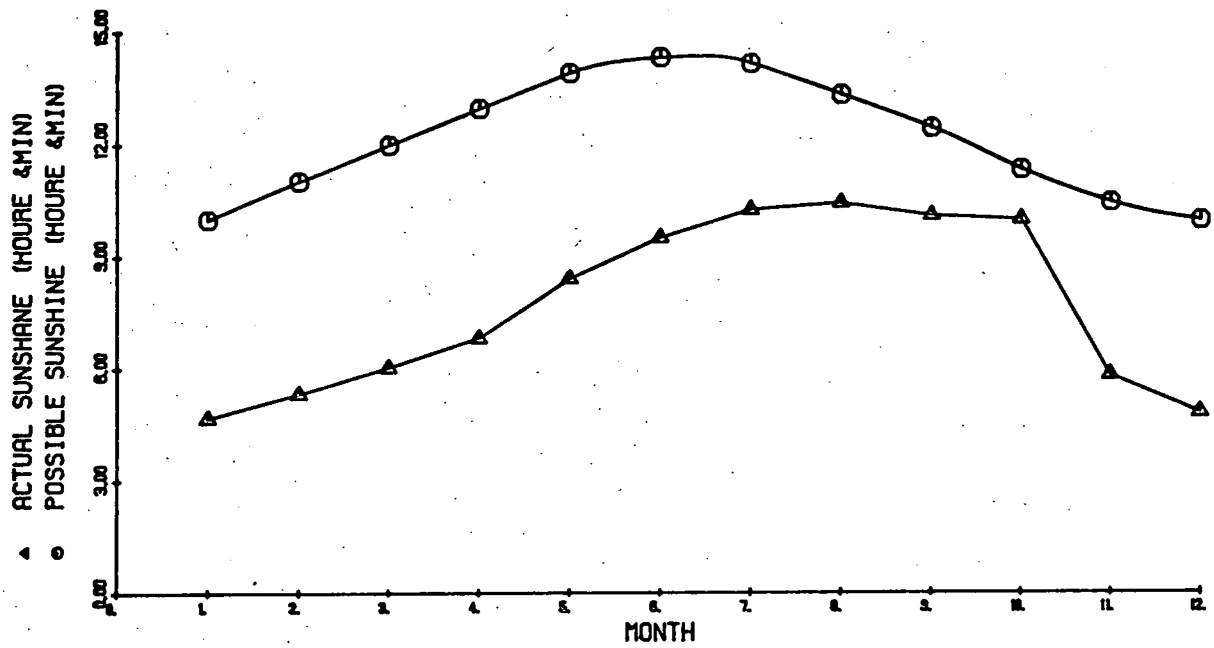
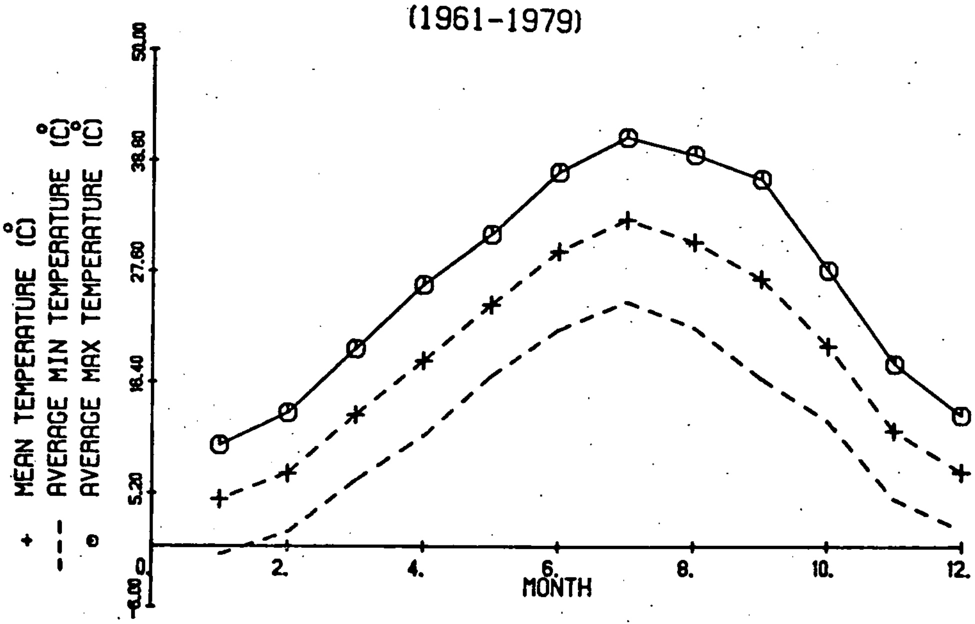


FIG 1.7.1 MONTHLY TEMPERATURE (°C) IN THE ABUZAID-ABAD AREA (1961-1979)



transpiration by vegetation under conditions of unlimited or plentiful water supply.[19] The classic definition of potential evapotranspiration was provided by Penman (1956)[20] who considered it as the "... evaporation from an extended surface of short green crops, actively growing, completely shading the ground, of uniform height and not short of water".

In an agroclimatology study, direct measurement and accurate estimates are necessary. Unfortunately, there is no direct measurement of this element in the area. Use has been made of various formulae which have been devised for its estimation from routine meteorological observation.

The methods of estimating evapotranspiration may be divided into three main groups, theoretical methods, empirical methods and water balance methods.[21] To estimate evapotranspiration in the region, empirical methods have been used. Various empirical formulae have been suggested for the prediction of evapotranspiration. The development of these equations has been based on the correlation of evapotranspiration with two or more climatic factors.

In this investigation the Thornthwaite's method, which suits the available meteorological observations, has been chosen. In fact, it is not the best method because it has been criticised for neglecting vital meteorological factors, such as solar radiation, humidity, wind speed etc. which affect evapotranspiration directly.

Unfortunately, the solar radiation, humidity, wind speed etc. have not been measured in the region, and owing to the lack of information on these meteorological factors ,the Thornthwaite's method, which in spite of certain deficiencies is still in active use in arid areas, has been chosen.

Thornthwaite (1948)[22] suggested an empirical formula for the estimation of potential evapotranspiration. The simplicity of the formula and the availability of temperature data for long periods at many locations has been the main reason for its widespread use. In fact it is the best known and most widely used of all the empirical formulae in places where there is insufficient data on other meteorological factors.

Thornthwaite's formula is of the form -

$$ET = 1.6(10\ T/I)^m$$

where ET is the potential evapotranspiration in mm, T is the mean monthly air temperature in °C, and I is the annual heat index. The latter is a summation of the monthly heat indices, which is as follows:

$$I = \Sigma^{12}\ t \quad \text{where } t = \left(\frac{T}{5}\right)^{1.514}$$

where m is a cubic function of I and is empirically determined, being equal to $(0.675\ I^3 + 77I^2 + 17920\ I + 492.390) \times 10^{-6}$
ET is unadjusted potential evapotranspiration based upon a 12 hour period, and a day, and a 30 day month. By adjusting for the actual day length (h) (Table 1.8) and the true number of days in the month (D), the actual evapotranspiration is obtained from the expression -

$$PE = ET\ \left(\frac{h}{12}\right)\left(\frac{D}{30}\right)$$

Potential and actual evapotranspiration has been calculated by the author according to the above method for the Abuzaid-Abad area (Table 1.10).

Table 1.10 : Monthly Potential & Actual Evapotranspiration in the Abuzaid-Abad Area

E / Months	ET Potential	ET Actual	Range
January	2.7	2.3	0.4
February	7.7	7.0	0.7
March	29.9	30.8	- 0.8
April	66.4	70.0	- 3.6
May	124.1	143.7	-19.6
June	192.1	227.1	-35.0
July	287.8	337.9	-50.1
August	336.4	382.0	-45.6
September	154.4	158.0	- 3.6
October	80.0	77.1	2.9
November	22.7	19.4	3.3
December	8.1	6.6	1.5
Total	1312.6	1461.2	-149.4

Source : Field Survey by author.

The estimation results of PE show clearly that June, July and August have the highest values of evapotranspiration, and January, February and December have the lowest values in the Abuzaid-Abad area. In only three months of the year - January, February and December, is PE less than rainfall in the area (Fig. 1.8).

1.6 Water Balance

The water balance can be assessed in the area from the results obtained in previous sections, e.g. precipitation, temperature and evapotranspiration. In conformity with Thornthwaite's method (1965)[23], the following equation[24] may be used for estimating the water balance in the area -

$$P - ET + WD - WS = 0$$

where P is precipitation, ET is evapotranspiration, WD is water deficit and WS is water surplus.

An estimation of water balance, according to the above equation, has been investigated in two sections in the Abuzaid-Abad area, i.e. a section on the season when rainfall predominates and one on the season when evapotranspiration predominates.

(1) The rainfall season lasts from December to March, during this period, precipitation exceeds evapotranspiration. Thus there is water surplus, the value of which is in excess of rainfall over evapotranspiration, WS = P - ET. This water surplus occurs in the Abuzaid-Abad area in December, January and February, 9.2, 25.3 and 11.6 mm respectively (Table 1.11).

FIG 1.8

ACTUAL EVAPOTRASPIRATION (MM)
IN THE ABUZED-ABAD AREA

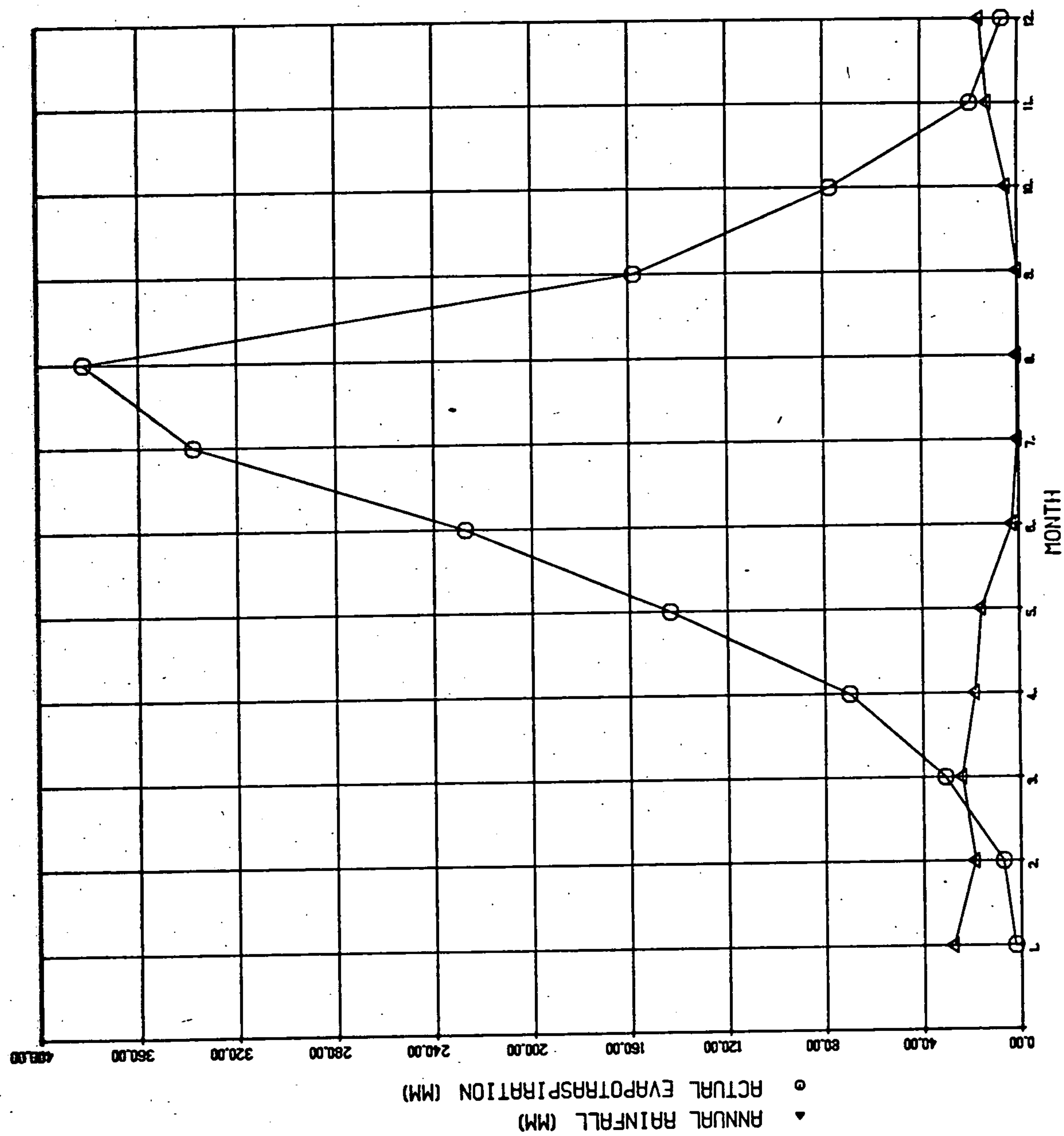


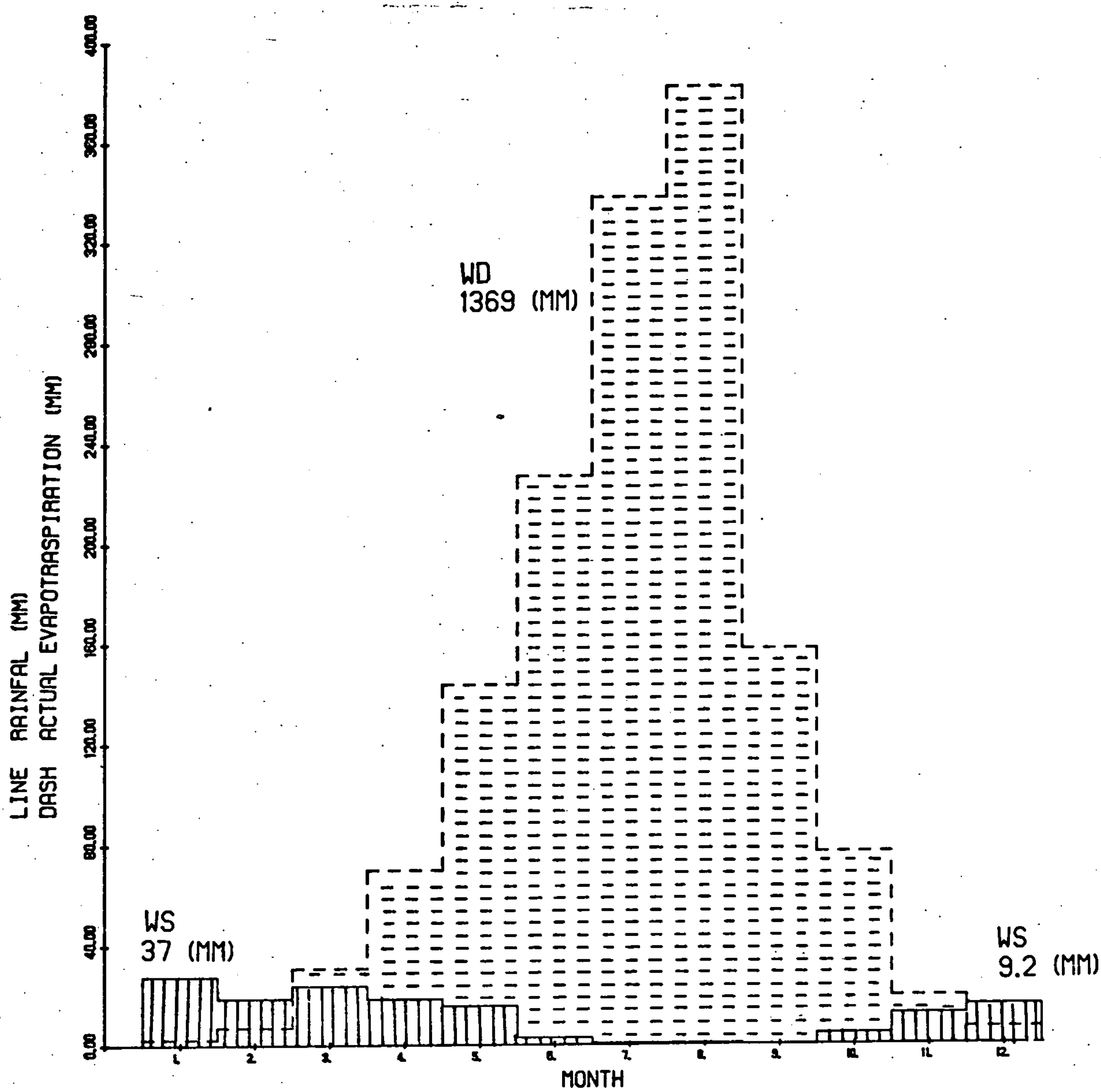
Table 1.11 : Water Budget of Abuzaid-Abad

Parameters / Month	Evapotranspiration ET (mm)	Rainfall P (mm)	Water Deficit WD (mm)	Water Surplus WS (mm)	Evap. Loss EL (mm)	Ground Charge (100 mm storage)	Ground Storage (100 mm storage)	Run off (100 mm storage)	Effect. Rainfall (100 mm storage)
January	2.3	27.6		25.3		25.3	34.5		2.3
February	7.0	18.6		11.6		11.6	46.1		7.0
March	30.8	23.3	7.0			-6.1	40.0		23.3
April	70.0	18.3	52.7			-50			18.3
May	143.7	15.5	128.2						
June	227.1	2.7	222.4						
July	337.9	0.4	337.5						
August	383.0	0.5	381.5						
Sept.	158.0	0.0	158.0						
October	77.1	4.4	72.7						
November	19.4	12.2	7.2						
December	6.6	15.8		9.2		9.2	9.2		6.6
Total	1461.9	139.9	1369.2	46.1					58.0

Ratios $\frac{P}{ET} = 0.09$ $\frac{WD}{P} = 9.7$ $\frac{WS}{P} = 0.35$ $\frac{WS}{ET} = 0.03$ $\frac{WD}{ET} = 0.93$

Source : Field investigation by author

FIG 1.9 WATER BALANCE IN THE ABUZED-ABAD AREA



WD WATER DEFICIT (MM)

WS WATER SURPLUS (MM)

The WS does not recharge the ground storage (GS) and so run-off does not occur in the area "(...ground storage was assumed to be the maximum amount of water which could be stored in the ground. It is realized that this storage capacity varies with the texture and structure of the soil. Specific storage capacity can only be taken into account in local study"[25] and this has been taken to be 100 mm in the region by the Ministry of Power of Iran.[26]

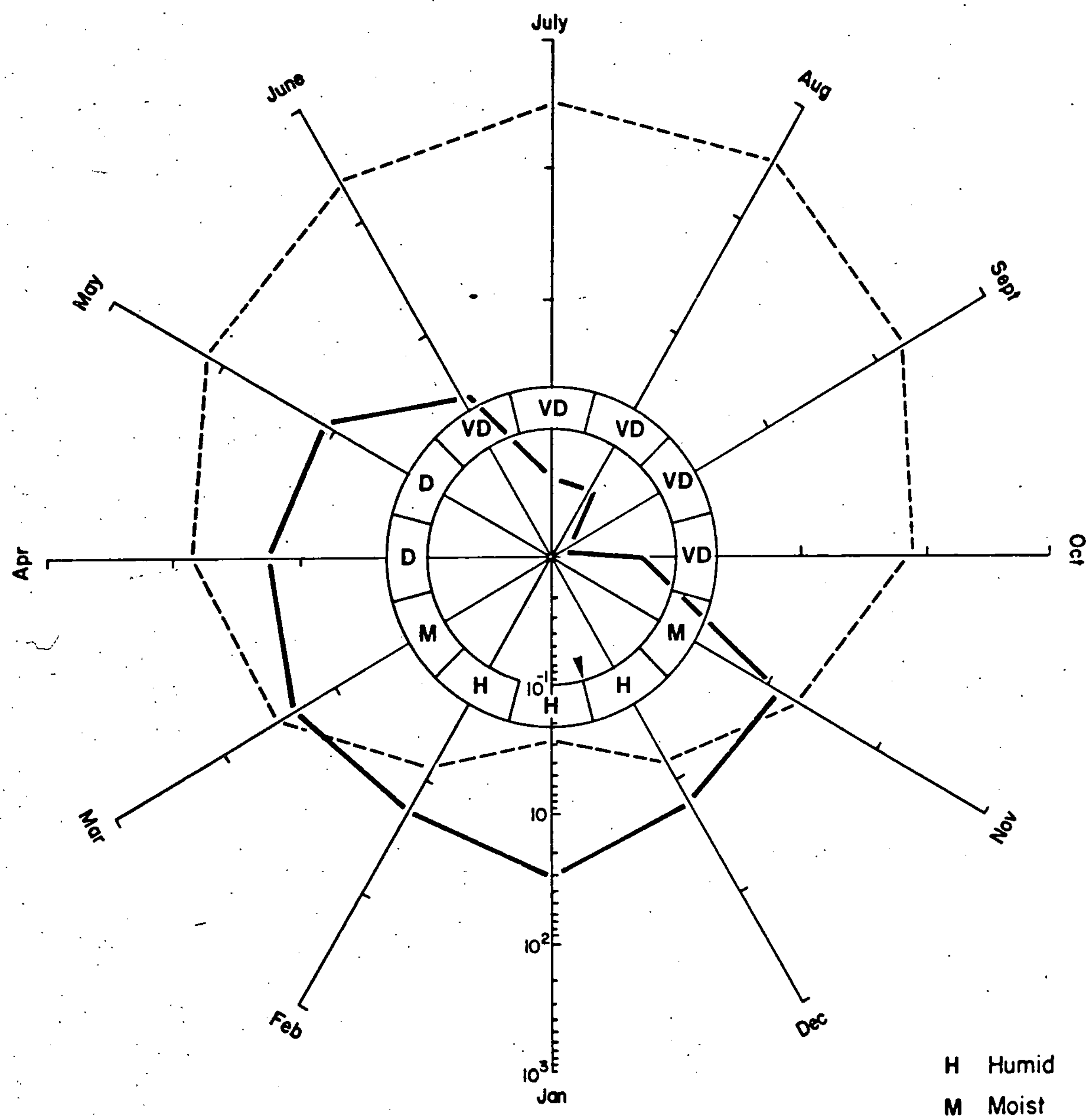
(a) The second period conforms with the dry season, April to November. During these months evapotranspiration exceeds precipitation. In these conditions, there is a water deficit (WD) which can be represented as WD = p - ET. The total value of WD is 1369.2 mm during the dry season in the area.

Using these values monthly water balance characteristics have been estimated in Table 1.11, see also Figure 1.9 . Water balance can be presented by another method as follows -[27]

$P > ET$ for periods called humid during December, January and February; when the mean annual rainfall exceeds evapotranspiration, $P > ET/2$ for moist periods. This condition occurs in November and March, $P < ET/4$ to $ET/10$ for dry periods, which occurs in May, and finally $P < ET/10$ for very dry periods, which occur during June, July, August, September and October. This method is shown in Figure 1.10.

The full details of agroclimatology in the margin of Dasht-e-Kawir are given in Appendix 2.

Fig 1.10 Circular log diagram representing the monthly mean rainfall and evapotranspiration at Abuzaid-Abad area



Rainfall: ——— 139·9mm (1960-1979) annual rainfall

Evapotranspiration: - - - - - - 1461·9mm (1960-1979) annual ET

1.7 Conclusion

The west of Dasht-e-Kawir is one of the driest parts of Iran , the mean annual rainfall in the Abuzaid-Abad area is 139.9 mm. Although precipitation is not the main source of moisture supply for the crops of the area, it has, nevertheless, an important direct effect on the growing of crops during the period of active growth, and it also affects indirectly crop yields and development of qanats and wells.

About 24 per cent of the mean rainfall occurs during April and May. This rainfall is very important for agriculture, especially winter crops, if it continues for a long time. On the other hand it would be much better if it occurred intermittently at this time.

It is obvious that the length of the rainfall season, as well as the amount, and its variability, are factors of extreme importance to the agricultural possibility for winter crops in the region. Although the average annual rainfall in the area is low, and it is not enough for active growth, it does contribute to irrigation in the area.

The variability of rainfall is one of the most important parameters in agroclimatology.Variability of rainfall in the area has a high value,and as a result it is difficult for a research worker to make a definite estimate about the rainfall in the area.

The interannual relative variability and coefficient of variability are 29.4 and 31.8 per cent respectively, but, according to experience in arid areas by research workers,[28,29] the area cannot be classified as one of dry land farming because successful agriculture without irrigation requires at least 240 mm. annual rainfall and an interannual relative variability of 37 per cent. Therefore dry land farming occurs very rarely in the area.

If the value of variability has been described accurately (the rainfall has been recorded for 19 years only in the Abuzaid-Abad area) we cannot logically use the rainfall in agricultural planning as a basic factor because the value of rainfall variability of about 30 per cent makes agricultural production somewhat chancy. On the other hand the confidence limit for the mean annual and annual rainfall in the 99.9 per cent confidence limit are 133.o - 146.7 mm and 44.1 - 235.6 mm respectively, so the range between the lower and upper limit in annual rainfall is about 190 mm.Therefore, as agricultural activity cannot rely on rainfall, cultivation must be irrigated during the growing season at short intervals.

The mean monthly temperature throughout the year is above zero in the region - the mean minimum temperature occurs in January and the mean maximum in July. However, crops are rarely damaged by frost during the cold season. Occasionally in winter, frost damages fruit trees or the temperature drops in spring which is quite dangerous for flowering fruit trees and vegetable crops.

An absolute maximum of 48°C and absolute minimum of -12°C have been recorded in the Abuzaid-Abad area. There is also a wide range of temperature difference between day and night because surface temperatures are high and humidity is extremely low. These are the characteristics of arid areas. In these conditions crops which are sensitive to a range of temperatures cannot be grown, i.e. tomatoes[30]. Therefore suitable crops must be chosen together with native crops,which have adapted to these conditions.

In order to summarise and calculate the main results of this study on water balance, evapotranspiration should be taken into account.

Evapotranspiration has been calculated for the area - its value exceeds 1460 mm. and it is 10.4 times the mean annual rainfall. The annual potential evapotranspiration value is high in the crop growing season, being about 2.6 times that of rainfall in this period. Evapotranspiration goes up dramatically before the heading of winter crops, just at the time when they require irrigation more than at any other time. At this time water deficit for irrigation usually reduces crop production. With the start of the summer season the evapotranspiration value increases greatly in the area, and it limits the development of summer crops in the area.

There is a water surplus (WS) during the winter season, but its value is small, and it is unable to recharge the ground storage (the specific storage capacity has been determined at 100 mm. in the area) so runoff does not occur. In this situation, with the start of the summer season, the rainfall no longer recharges the ground storage and a water deficit (WD) occurs for nine months of the year. The total WD has been calculated at 136.9 cm by the author in the area. When WD starts, crops usually should be irrigated at short intervals. Under these conditions agricultural production is limited by the quantity of water available in the area. WD is one of the biggest problems for agriculture in the arid and semi arid areas, in general, and in the Abuzaid-Abad area in particular.

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CHAPTER 2

HYDROLOGY

2.1 Introduction

The Abuzaid-Abad area lies within the eastern part of the Kashan catchment basin. In order to study the hydrology of the area, especially the geology and topography, data from the basin has been used.

To study the hydrology in the area two aspects should be noted : physical conditions and the influence of man on the ground water - this last aspect will be discussed in the water supply chapter.

2.2 Physical conditions

Physical conditions are comprised of the following:-

Location of the area with respect to the catchment basin.

Climatic conditions[1].

Topographic and geological conditions.

Aquifer and water-table conditions.

Quality of underground water.

2.2.1 Location of the Area

According to the hydrological investigation which has been carried out by the Ministry of Energy, Iran (1971)[2] Iran has been divided into nine drainage basins - Table 2.1 shows the specifications of the basins and Figure 2.1 shows their location.

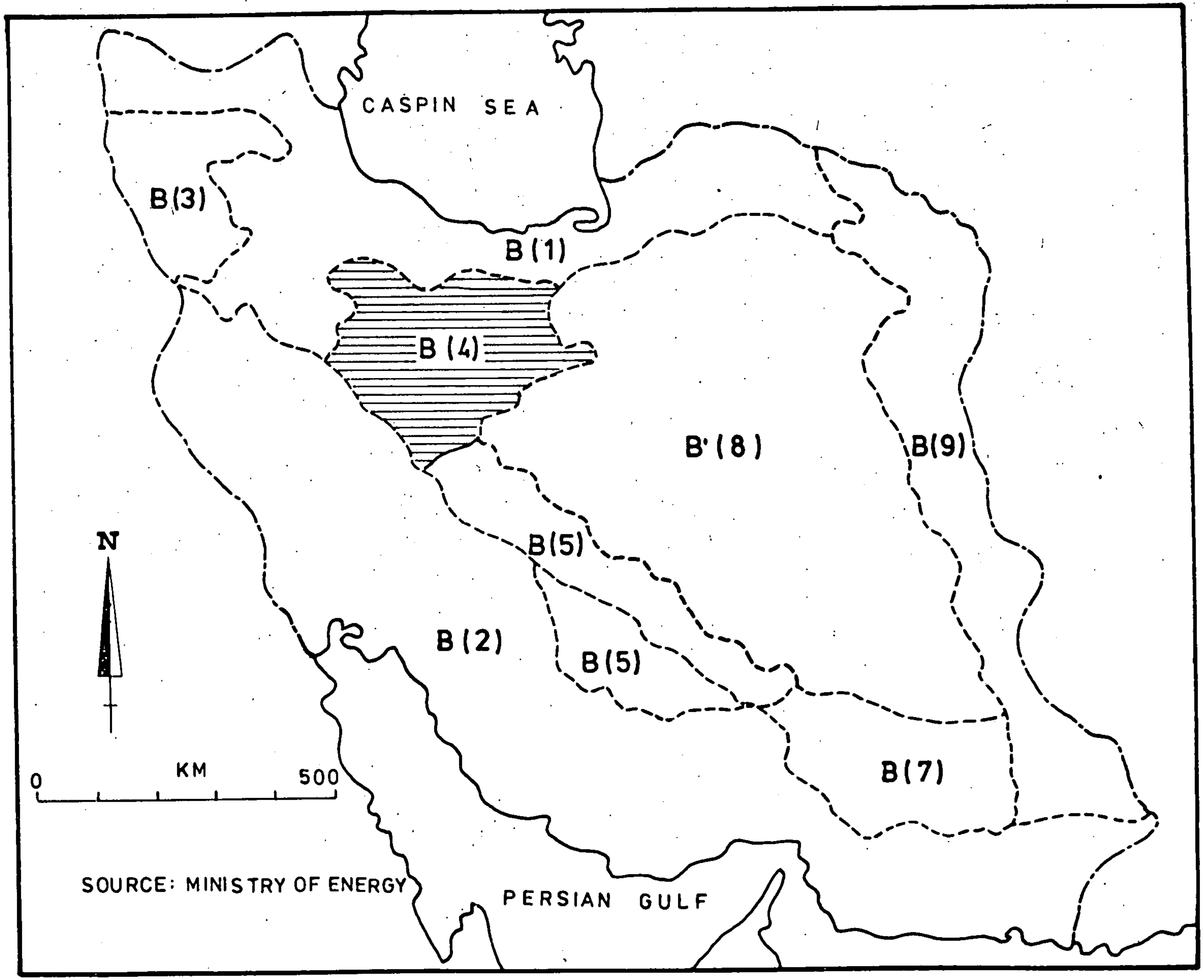
The Hoz-e-Soltan drainage basin (B4, Fig 2.1) which is located in the centre of Iran is about 126,000 km^2 in area. This drainage basin is divided with respect to their watersheds

Table 2.1 Specification of Iran Drainage Basin

No. of basin	Name of Basin	Area 1000 km^2	Rain Water $10^9 m^2$	Percentage of country's total area	Percentage of country's total rainfall
B1	Caspian Sea	179	83.60	10.90	22.70
B2	Persian Gulf	410	115.20	24.90	31.20
B3	Lake Rezaeyey	56	25.40	3.40	6.90
B4	Lake Hoze-Soltan	126	30.30	7.80	8.20
B5	Gavkhuny	100	15.4	6.10	4.20
B6	Lake Bakhtegan	35	10.70	2.10	2.90
B7	Jazmurian	69	10.20	4.20	2.80
B8	Central Basins	5	53.00	31.10	14.40
B9	Eastern Basins	156	25.00	9.50	6.70
	Total	1645.5	368.80	100.00	100.00

Source : Gudarzinejad (1977)(3)

FIG 2.1 MAIN RIVER BASINS IN IRAN



into 21 regions.[4] The Kashan region lies in the south-east of the basin and comprises about 1600 km^2. This region receives annual rainfall of about $324 \times 10^6 m^3$. There are 92 villages and Kashan City in the region. The Abuzaid-Abad area is located in the south east of the region.

2.2.2 Topography and Geological Conditions

(a) Topography

In the Kashan region there are a few anticlines and synclines which occur in the Oligocene limestone and Pliocene formations, and their axes usually run from the north west to the south east of the region.

In the region two important faults have been recognized. First, to the south west of Kashan City there is a fault which is formed between the Pliocene formations. It runs north west to south east. It would appear that this fault affects the ground water flow of the Feen area, which comes from the limestone deposits. The Feen spring, with a discharge of 540 m^3/day[5] was formed by tectonic action. Another fault is exposed beside the southern mountains of the region in the south west of the Abuzaid-Abad area.

(b) Geology

The oldest formation in the Kashan region is andesite which is of Eocene age. This igneous rock contains metamorphosed Oligomiocene limestone in some places.

Oligocene formations are exposed in the southern mountains of the region and these formations are permeable and contribute to the recharge of ground water in the region.

The springs which are situated on the slopes of the mountains in the area arise from Oligocene limestone.

Miocene formations occur along the north boundaries of the region (Kashan-Qom road). These formations consist mostly of sandstone, intercalated by layers of gypsum and rock salt. Some parts of the centre of the region are produced by this formation. There is a higher level of salinity in the ground water in this area because these formations occur in company with salt masses.

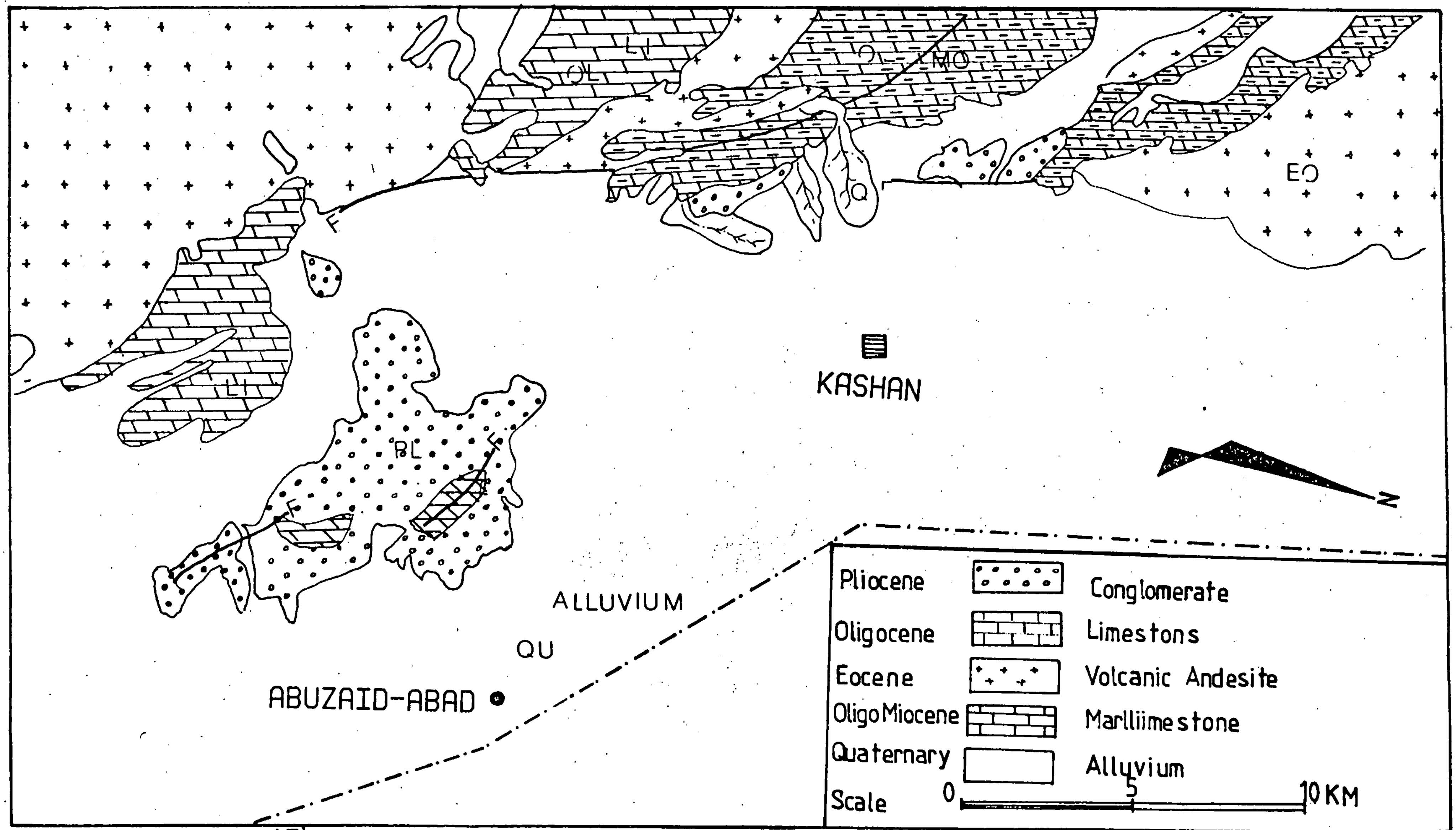
Pliocene. The formations of Pliocene are exposed in the north around the village of Kadish in the margins of Kawir-e-Kashan and west of Kashan City. This formation is also exposed in the south of Khorm-Dasht, in the west of the Abuzaid-Abad area.

Plio-Pleiostocene. The formation of the Plio-Pleiostocene represents the oldest alluvium. This formation is situated in the north west and south east of the region. It consists of big stones cemented with clay and it has very low permeability, and, from the point of view of the ground water, recharge is not important.(6)

Holocene. This formation comprises the bulk of the sediments filling the basin and covers the entire central part of the region. It consists of poorly stratified sand, gravel and boulders, becoming finer-grained to the east and north east.

The younger layers of alluvium are recent deposits along the rivers, flood passes and the alluvial fans of the south and southwest mountains of the region. These deposits contribute to the high infiltration rate for the surface

FIG 2.2 GEOLOGICAL MAP OF KASHAN REGION



SOURCE: M.WP(7)

water. This formation does not occur in the plain. Figure 3.2 shows the geological characters of the Kashan region.

2.2.3 Aquifer and Water Table Conditions

According to geophysical investigations and exploratory wells which have been carried out by the Ministry of Water[8] in the Kashan region there are four aquifers. The qanats and shallow-wells use the phreatic aquifer (first aquifer).

Using measurements taken at the observation wells, the contours of the water table (first aquifer) were drawn by the author in 1977 (Fig.2.3).

(a) Direction of Ground Water Flow

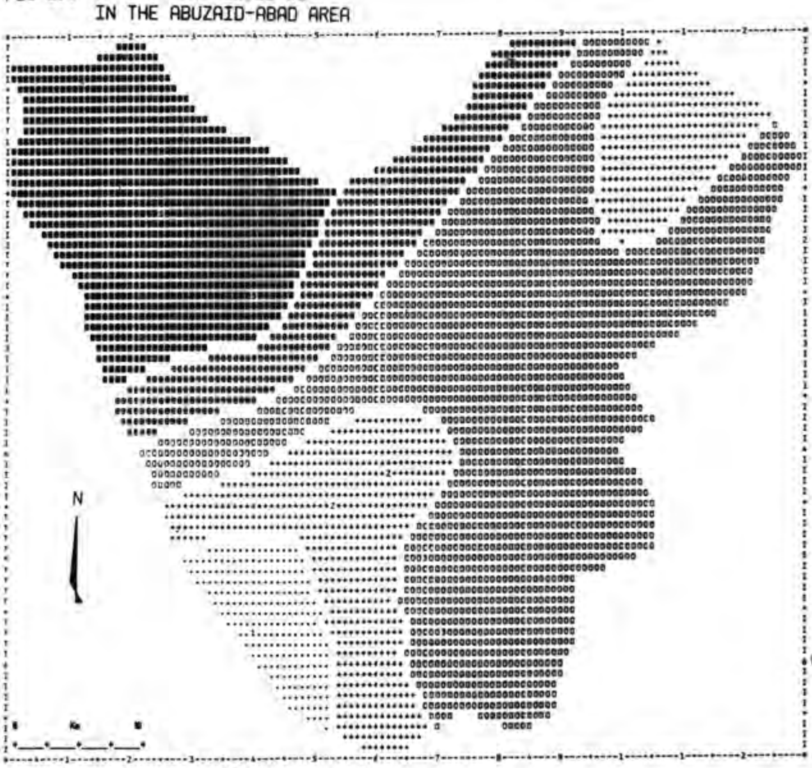
It is a basic law of hydrology that the direction of ground water flow is perpendicular to the contours of the water table.[9] From Figure 2.4 it can be seen that the ground water flows from the south and south west towards the north and north west.

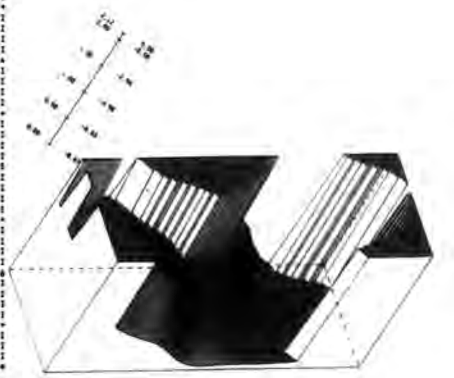
It can be seen (Fig. 2.4) that the direction of the qanats is exactly the same as that of the ground water flow in the Abuzaid-Abad area. More details about the qanat direction will be discussed in Chapter 5 on water supply.

(b) Depth of Water Table

The water table in the area is found to vary as is shown in Figure 2.3. At the west of the area it lies at a depth of approximately 10-12 m. below the land surface, in the middle part of the area it lies between 8-10 m. below the land surface and at the edge of the desert the water table

FIG 2.3 WATER TABLE LEVEL (M)
IN THE ABUZAID-ABAD AREA



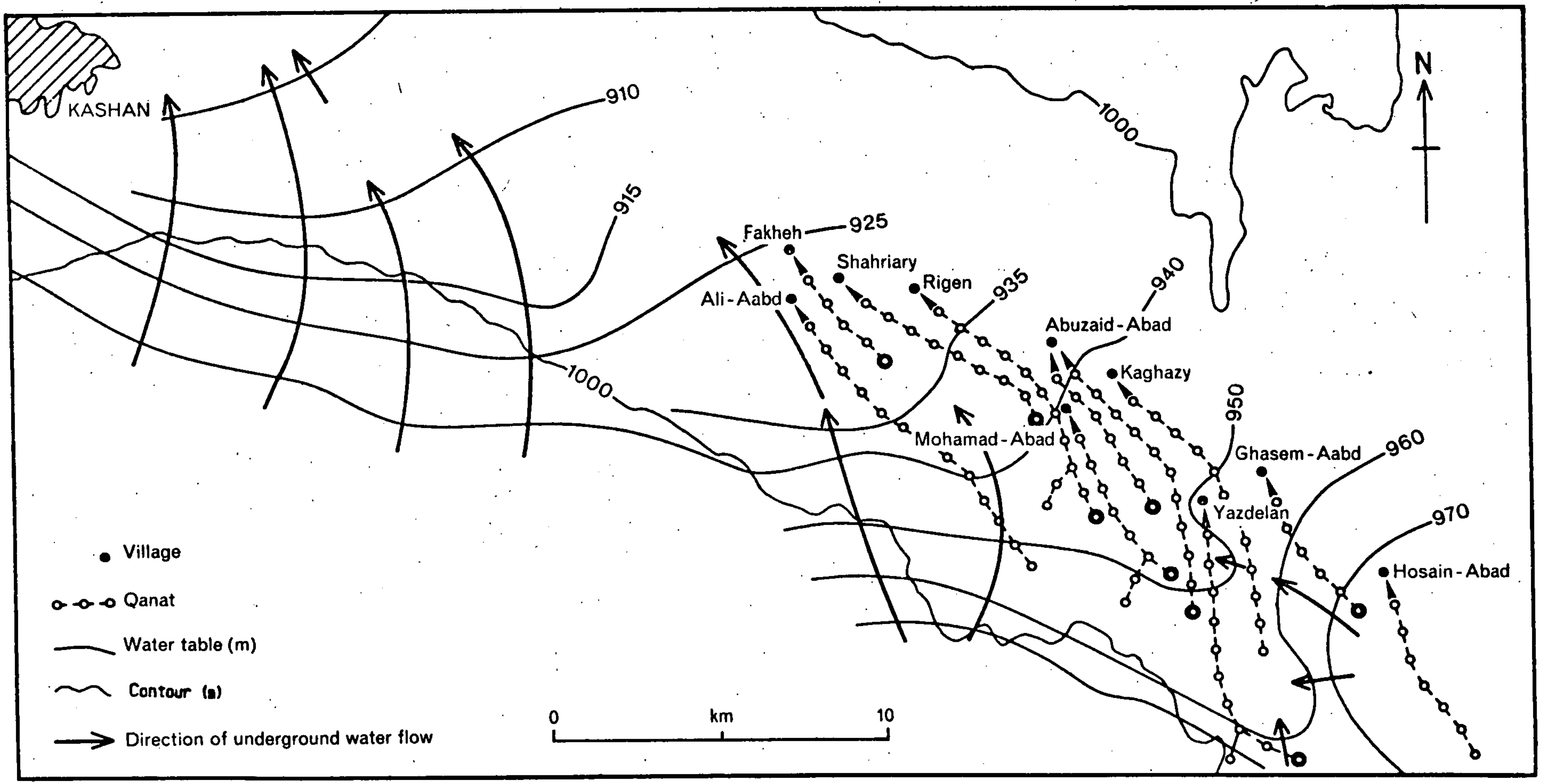


MINIMUM	-12.50	-10.20	-8.40	-6.60	-4.80
MAXIMUM	-10.20	-8.40	-6.60	-4.80	-3.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
FREQ.	1	1	2	1	2

Fig. 2.4 DIRECTION OF GROUND WATER FLOW



Source : Field Survey

is very shallow and can be found, at many places, to be 5 to 8 m. below the land surface.

(c) Water Table Gradient

The gradient continues gently from south east to north west. In the south west of the area it is about 4:1000,in the centre of the area (around the Abuzaid-Abad village), it is about 2:1000 and it is reduced toward the north west, until is reaches 1.5:1000 in the Fakreh villages.[10]

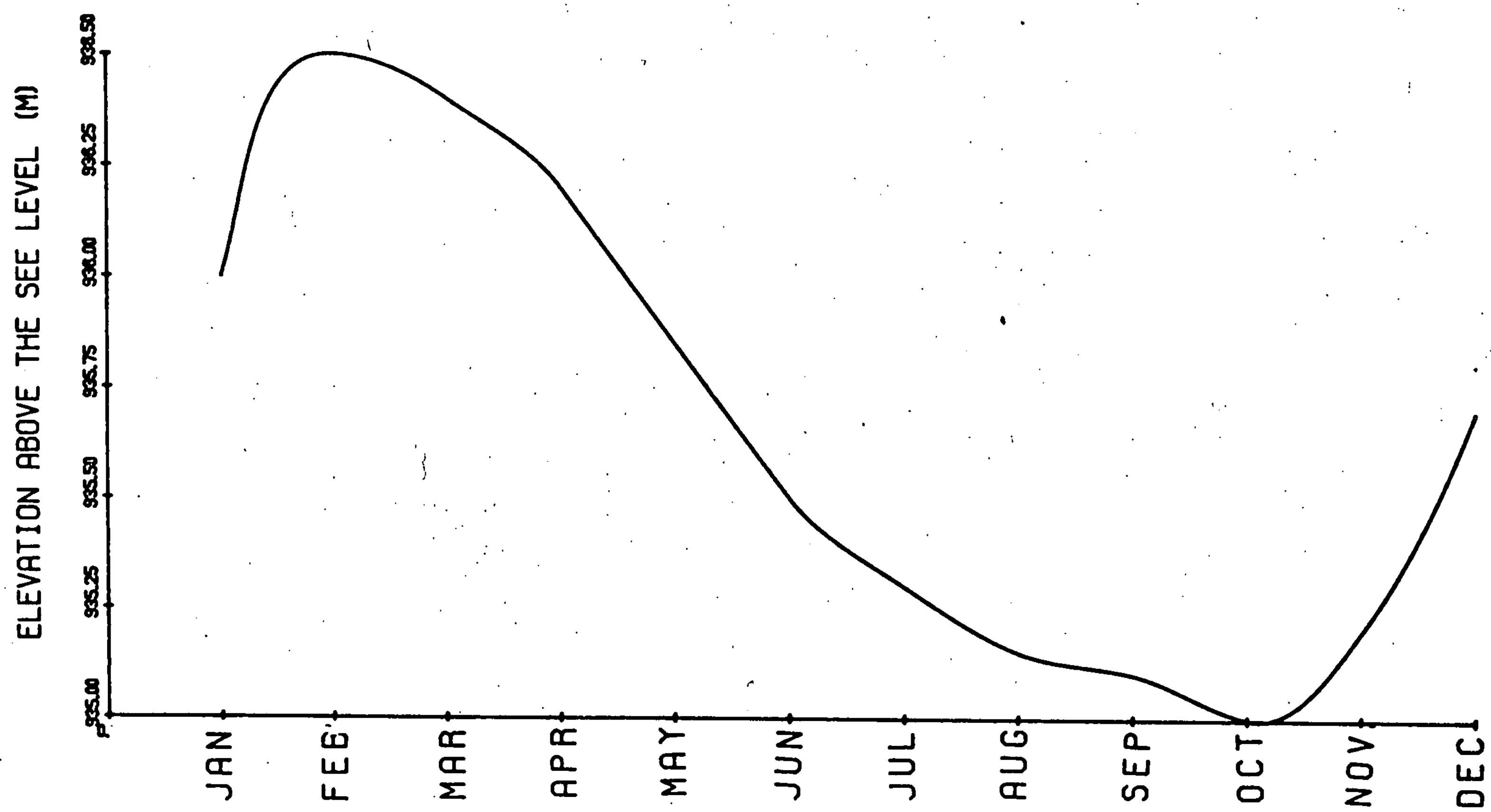
(d) Water Table Fluctuation

In normal years the annual change in the water table is of the order of 2-3 metres. The maximum level of the water table occurs at the beginning of October and the minimum occurs at the end of February, and then it returns to the maximum condition. Therefore the water year starts in October and continues until the end of September.[11] According to investigations carried out by the author in the area, fluctuations occur. In the west of the area, namely 2 metres (normal years), in the middle of the area about 1 metre and along the outer limits of the area in the east the fluctuation is less than 1 metre. The monthly water table variation has been obtained by the author in the shallow observation well at Abuzaid-Abad in 1977 (Fig. 2.5).

2.2.4 Ground Water Quality

With a view to studying the properties of ground water quality in the Abuzaid-Abad area, 10 water samples of water resources were taken by the author to the laboratory in order to carry out chemical analyses. The results are given in Table 2.2.

FIG 2.5 THE MONTHLY WATER TABLE VARIATION IN THE SHALLOW WELL IN ABUZAID ABAD



The chemical analyses of the ground water have been used for determination of the water quality in the area. The distribution of the ground water properties (T.D.S, S.A.R & E.C) has been given in Figures 2.7, 2.8, 2.9.

2.2.6 Classification of Ground Water

The ground water can be classified according to different methods. In order to classify the ground water of the area with respect fo available data, two methods were chosen -

(a) Richard's classification

This classification, often used in agriculture, is based on the so-called Richard diagram(12). The principal factors which govern the suitability of ground water for irrigation of crops, are the total concentration of soluble salts, expressed in terms of electrical conductivity, EC, and exchangeable sodium, expressed in terms of sodium absorption ratio, S.A.R. The Richard diagram is shown in Figure 2.10.

According to this diagram the salinity hazard of the ground water is high in the area. All water samples belong to class C4 (very high salinity). This means that the ground water is not suitable for irrigation purposes unless salt-tolerant crops are selected, soil and drainage conditions are adequate and irrigation water is supplied in excess to leach the salts from the soil, and suitable fertilizers used.

As was mentioned, in the Abuzaid-Abad, Mohamad-Abad and Kaghazi villages, the sodium hazard of the ground water is low and water can be classified as C4-S_1, (low sodium hazard and very high salinity hazard). In the rest of the villages the ground water in the cultivated part of the area belongs to class C4-S_2 or medium sodium and very high salinity hazard

Table 2.2 Properties of ground water in the Abuzaid-Abad Area

No.	Water Properties / Village	T.D.S. mg/L	S.A.R. %	E.C. mmho/cm²	Cation mg/L			Anion mg/L		
					Na	Mg	Ca	So	HCo	Cl
1	Fakhreh	2755	10.10	4170	669.3	59.5	228.4	744.4	189.1	918.0
2	Shahriary	2900	12.92	4370	754.4	63.2	154.3	1056.6	128.1	737
3	Rigen	2950	14.44	4256	809.6	68.09	126.2	965.4	317.2	751.7
4	Ali-Abad	3760	13.60	4700	1035	115.5	255	1628.0	244.0	1010.6
5	Mohamad-Abad	3518	9.19	3228	713	136.8	230.5	1286.2	350.8	739.2
6	Abuzaid-Abad	2014	7.2	3147	920	58.3	116.2	623.3	280.6	280.6
7	Kaghazi	2129	8.1	4848	501.4	72.9	164.3	868.4	262.3	505.3
8	Yazdelan	3101	11.3	4694	841.8	122.8	216.2	1598.9	244.4	613.4
9	Qasam-Abad	5400	19.41	7059	1460	124.0	224.4	2108.5	335.5	1226.9
10	Hosain-Abad	5500	13	6970	1260	24.7	320.6	1969.2	28.67	1577.9

Source : Field investigation 1977.

SPECIFICATION OF GROUND WATER
IN THE ABUZAID-ABAD AREA

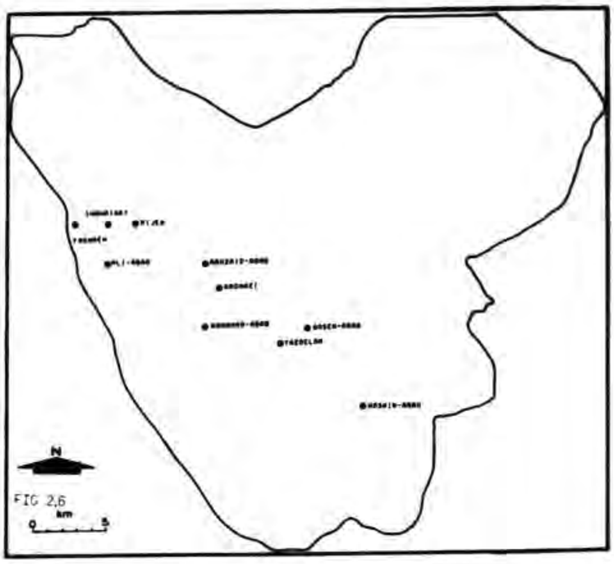


FIG 2.6

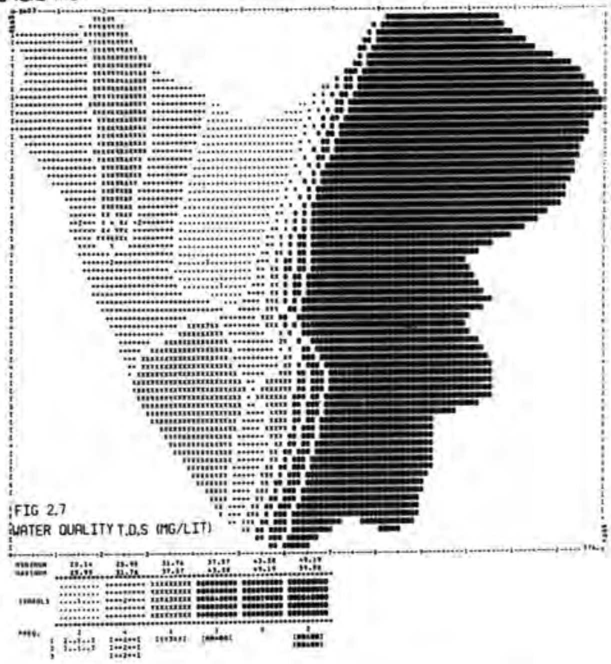


FIG 2.7
WATER QUALITY T.D.S (MG/LIT)

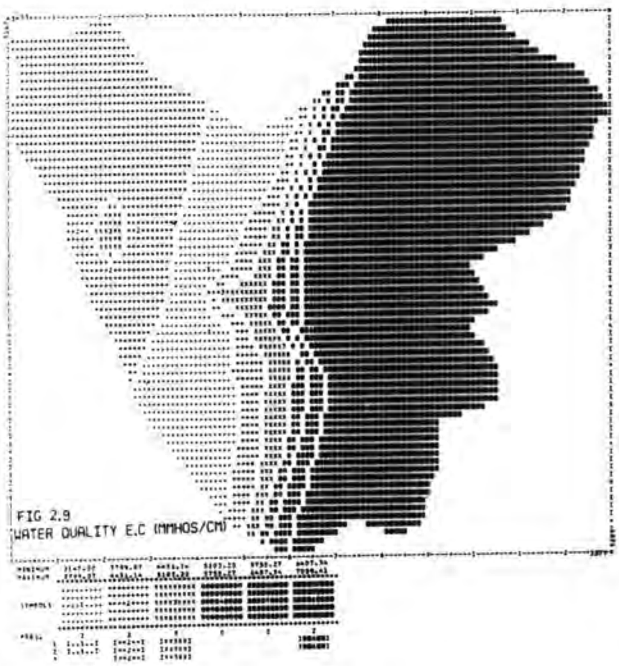


FIG 2.9
WATER QUALITY E.C (MMHOS/CM)

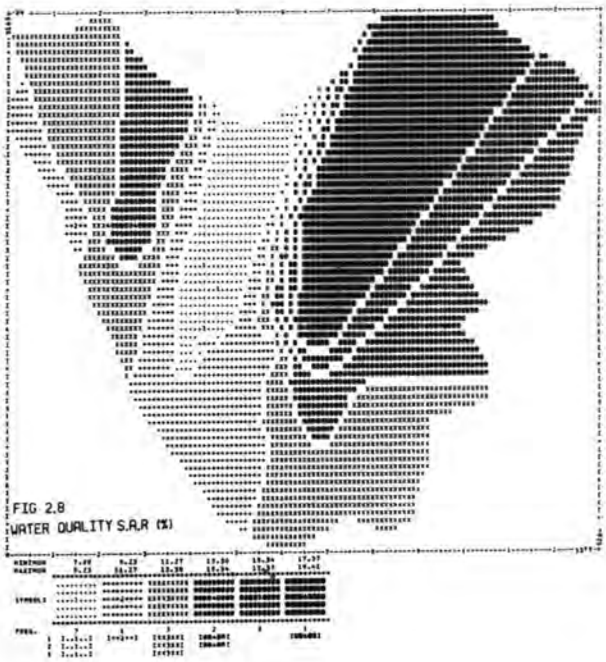


FIG 2.8
WATER QUALITY S.A.R (%)

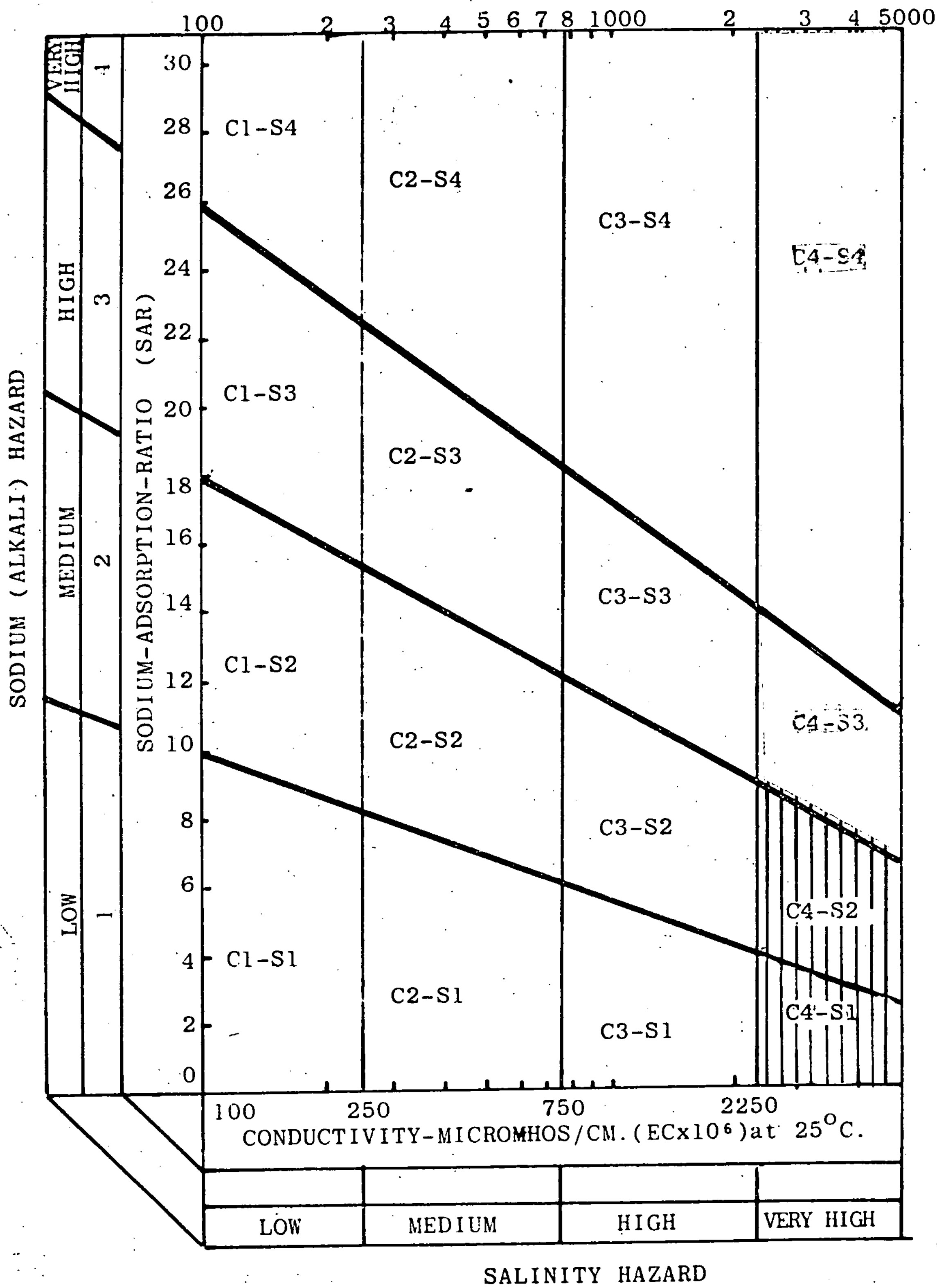


FIG. 2.10 Diagram for the Classification of Irrigation Waters (12)

Figure 2.11 shows the classification of ground water.

(b) If the total concentration of dissolved solids (T.D.S) is used, the ground water is called fresh when the T.D.S. is less than 1,000 ,g/L, brackish when the T.D.S. ranges from 1000 to 10,000 mg/L and salty when the T.D.S. is more than 10,000 mg/L.[13]

Thus, bearing in mind the values of T.D.S. in the samples, the ground water is brackish in the area because the amount ranges between 2014 - 5400 mg/L in the Abuzaid-Abad area.

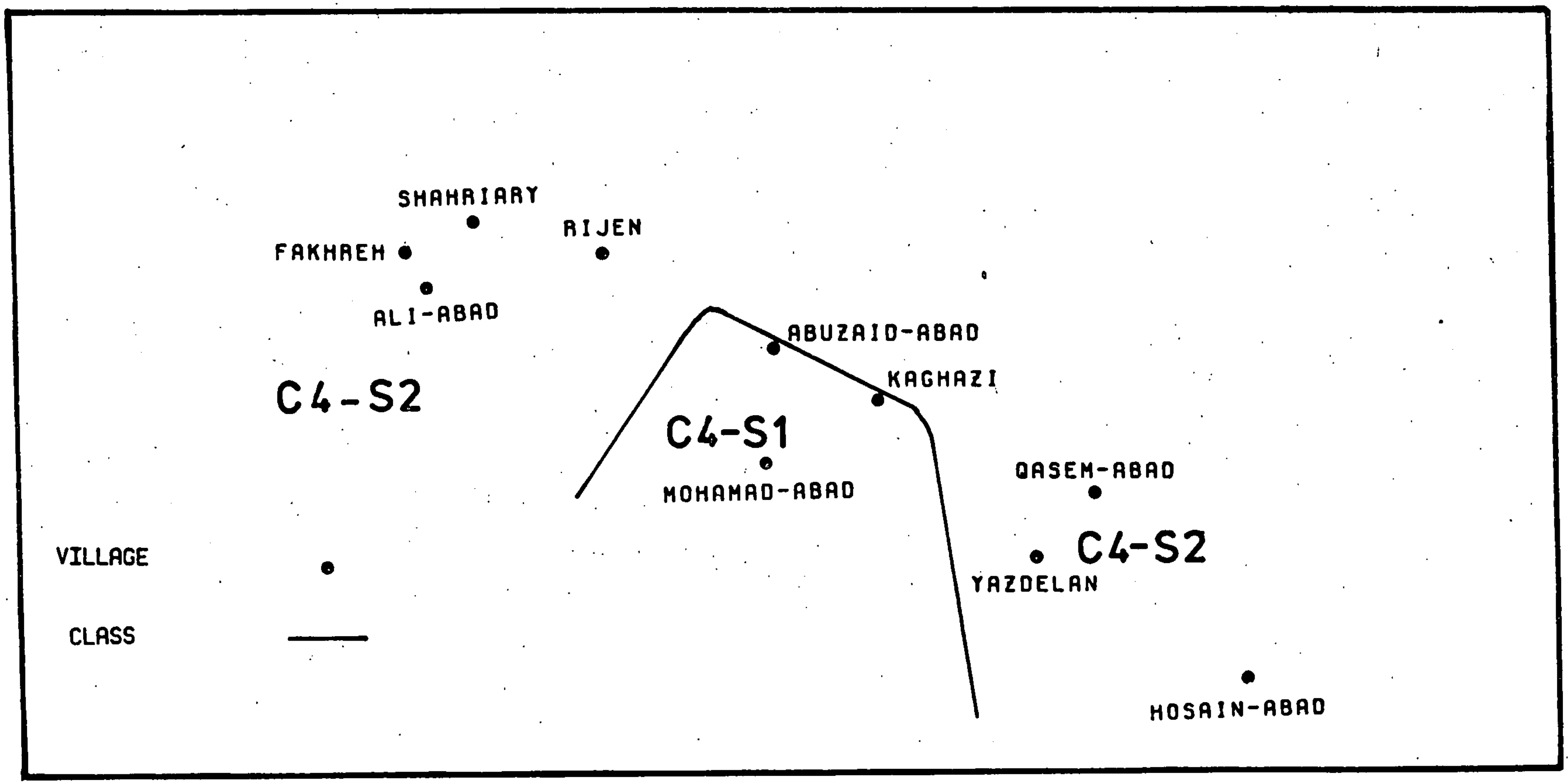
2.3 Conclusion

The Kashan basin is bounded in the west and south by the central mountains of Iran and in the east by the Dasht-e-Kawir and in the north by the Darya-y-Namak (salty sea).

This basin is filled with the sediments brought down from the western elevations. The basin sediments are very thin in the west and south in the high part of the basin, and about 120 m in Mohamad-Abad village[14] in the down slope.

The sediments in the western and southern parts of the basin are, in general, coarse-grained, thus important aquifers have been formed in this area. In the downslope direction they become finer grained and extensive clay layers are formed at different depths. However, in former flood channels, coarse materials have been transported far down slope of the alluvial fan, and have been seen in some parts of the Abuzaid-Abad area.

FIG 2.11 CLASSIFICATION OF WATER IN THE ABUZAID-ABAD AREA



From the slopes of the mountains (the apex of the alluvial fan) the ground water flows to the north and north east, following the general slope of the land. In the west and south of the Kashan basin the water table is found far from the surface, in the downslope direction it comes closer to the land surface and in the lower parts it is found at a depth of 2-5 metres below the land surface. In a normal hydrological year the water table changesfrom less than 1.5 m in the Abuzaid-Abad area in the east. In a wetness year the fluctuation of water table is less than one metre. However, the amount of annual rainfall directly affects the ground water quantity as well as quality. Therefore in a year with high rainfall, the discharge of wells, particularly shallow wells is higher than in a year with low rainfall in the Abuzaid-Abad area.

The quality of ground water varies from place to place and also with depth. There is clear evidence that the shallow ground water has a higher salinity than the deep ground water due to the leaching of the salts from the surface. For irrigation purposes, and for domestic use it is advisable to use deep well ground water, or qanat water, which often comes long distances. Therefore the shallow wells' discharge are not suitable for irrigation and construction of new shallow wells is not recommended in the Abuzaid-Abad area, because of the water quality and low discharge. However, the best quality is found in Mohamad-Abad and Abuzaid-Abad villages, where the electrical conductivity varies between 3147 - 3228 micromhos/cm^2. and SAR values are about 10-19%. This water belongs to $C_4 - S_1$ (medium Sodium - Alkali - hazard and very high salinity hazard) in the Richard's classification. Towards the desert, the salinity of ground water increases rapidly in this part of the region, as the water table is very shallow and the EC lies between 6900 to 7059 micromhos/cm^2 in the Qasem-Abad and Hosain-Abad respectively. The SAR values also increase rapidly and extremely high SAR values have been found in the Qasem-Abad (19.41%).

As a result the ground water of the area is, in general, brackish and the ground water becomes mineralized. Therefore, bearing in mind the above discussion, the Abuzaid-Abad village ground water is, in general, better than other villages.

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6. Ministry of Water & Power, Iran (1973) op.cit., p.29.

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12. Richard, L.A. (1954) Diagnosis and improvement of saline and alkali soils U.S.Dept, of Agriculture Handbook 60, .

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CHAPTER 3

SOILS AND VEGETATION

3.1 Introduction

According to the soil map of Iran, which was produced in 1961[1] the soils of the area have been presented as follows:

Calcareous Lithosols. Desert and Sierozem soil in the area is surrounded by sand dunes.

Unfortunately the scale of this map is very small and cannot provide a detailed analysis. Also the soil potentiality map of Iran, expressed in terms of soil limitations for agricultural production[2], shows the soil of the area to belong to the type of desert soils, which limit agriculture because of the moderate to large deficit of water and the shallow depth of the soil. Although it has been known for a long time in Iran and in other semi arid regions that desert soils are unable to produce satisfactorily under dry farming and that in their natural condition they have a low potentiality for forage, they can be made highly productive with irrigation. There are large areas of the desert soils under qanat irrigation in Iran, in general, and in the Abuzaid-Abad area in particular, and they can be highly productive if the quality of the irrigation water is suitable.

Apart from the above two studies, which were carried out for the whole of Iran, there is no other information about the soils of the area.

3.2 Soil Characteristics

With a view to studying the soil in the area, six soil pits were examined throughout the field by the present writer. The location of the pits has been selected with respect to the location of the villages. It must be noted that the villages of the Abuzaid-Abad area form three groups - the first group in the west, the second in the middle and the last group is located in the eastern part of the area. Two pits were selected in each group, in both cultivated and uncultivated land. The location of each profile is given in Figure 3.1. 12 samples were taken by the author to the laboratory in order to carry out physical and chemical analyses. The results are given in the following pages.

Location	South of Ali-Abad	Pit No.1
Elevation	951 m.	
Vegetation	Tamarix, Alhagi camelarum, Salicarnia herbacea & Suaeda Sp.	
Cultivation	Uncultivated land	
Soil classification	Order : Aridisol Suborder: Orithid (3)	
Soil type	Moderate texture, (4) saline-alkali soil (5)	

Profile Description

0 - 22 cm	10YR (6) 5/4 (yellowish brown) Sandy loam crumb structure. hardness is low, clear change
22-45	7.5 YR 4/4 (dark brown) clay, massive structure with a very high hardness

Profile	Sample	Depth cm	Organic matter %	Calcium Carb. %	Gypsum %	Cation exchangeable cap. m.e/100g	Exchangeable Sodium % E.S.P.	Sodium Absorption Ratio S.A.R	Structure			
									Clay %	Loam %	Sand %	Texture
1	1	0-22	0.86	21	9	9.8	66	26.8	20	19	61	S.L
	2	22-45	0.15	23.2	0.4	-	-	11.4	49	39	12	C

PH	EC mm/hos cm	Saturation %	Soluble Cations m.e/litt				Soluble Anions m.e./litt			
			K+	Na+	Ma++	Ca++	So--	Cl-	HCo-	Co--
7.4	14.2	38.6	0.5	391.3	3.7	50.2	465.1	1000	-	-
7.5	14.9	33.5	0.2	152.1	1.6	2.2	27.2	122.5	1	1

Location Rigen Pit No.2

Elevation 945

Vegetation -

Cultivation Cereal, cotton.

Soil classification Order : Aridisol Suborder : Orithid

Soil type Light texture, normal soil

Profile Description

0 - 25 cms 10 YR 6/3 (pale brown), gravel sand, single grain without hardness, gradual change.

25 - 45 10 YR 7/4 (very pale brown) sandy, clay loam with a little hardness, moderate structure, clear change

Profile	Sample	Depth cm	Organic Matter %	Calcium Carb. %	Gypsum %	Cation ex-changeable cap.m.e/100g	E.S.P %	S.A.R	Structure			
									Clay %	Loam %	Sand %	Tex-ture
2	3	0.25	0.15	28.3	1.9	3.2	9.3	0.4	8	2	90	S
	4	25-45	0.15	21	1.7	7.1	7	1.1	21	27	56	S.L

PH	EC mm/hos cm	Sat-ur ation %	Soluble Cations m.e/litt				Soluble Anions m.e./litt			
			K+	Na+	Mg++	Ca++	So--	Cl-	HCo-	Co--
7	1.1	1.6	0.4	1	1.8	8.9	12.2	0.7	1	-
7.4	0.2	27.5	0.2	1.1	0.6	1.2	5.3	0.7	2	-

Location Abuzaid-Abad Pit No.3

Elevation 948 m

Vegetation Stipagrostic pennata & Stipa Sp.

Cultivation Uncultivated

Soil classification Order : Aridisol, Orithids

Soil Type Light texture, normal soil

Profile Description

0 - 15 10 YR 6/3 (pale brown), fine sandy, single grain, horizon boundary change gradually smooth (gradual 6-13)

15-35 10 YR 5/4 (yellowish brown) sandy loam, abrupt change (0.5-2.5cm)

Profile	Sample	Depth cm	Organic Matter %	Calcium Carb.%	Gypsum%	Calcium ex-changeable cap m.e/100g	E.S.P%	S.A.R	Structure			
									Clay %	Loam %	Sand %	Tex-ture
3	5	0-15	0.39	23.6	0.9	3	3.3	0.4	18	10	72	S.C
	6	15-35	0.31	18.9	0.9	3.4	10.5	0.6	12	23	65	S.L

PH	EC mmhos/cm	Sat-uration %	Soluble Cations m.e/lit				Soluble Anions m.e/lit			
			K+	Na+	Mg++	Ca++	So--	Cl-	HCo-	Co--
7.4	0.3	24	0.5	0.6	0.8	2.2	3.2	0.7	2	-
7.5	0.1	26.5	0.6	0.6	0.6	1.1	4.5	0.25	2	-

Location North of the area Pit No.4

Elevation 941 m

Vegetation -

Cultivation Cereal, Alfalfa, cotton

Soil classification Order : Aridisol, suborder : Orithids

Soil Tyne Moderate texture, non saline-alkali soil

Profile Description

0 - 25 cms 7.5 YR 5/4 (brown), sandy crumb structure, distinctness of horizon boundary is irregular, relatively few gypsum crystals.

25 - 55 7.5 YR 4/4 (dark brown) sand, moderate hardness, a lot of prismatic and cylindrical gypsum crystals, very rarefied roots.

Profile	Sample	Depth cm	Organic Matter %	Calcium Carb.%	Gypsum %	Cation ex-changeable Cap.m.e/100g	E.S.P %	S.A.R	Structure Clay %	Loam %	Sand %	Texture
4	7	0.25	0.07	20	2.37	6.5	30	0.5	2	2	96	S
	8	25-125	0.23	21	34.4	6.9	37.6	2.4	6	4	90	S

PH	EC mmhos/cm	Saturation %	Soluble Cations m.e/lit K+	Na+	Mg++	Ca++	Soluble Anions m.e/lit So--	Cl-	HCo-	Co--
7	0.9	31	0.4	1	1	7.2	5.9	0.9	1	-
6.6	3.2	32.3	0.8	9.5	3.3	27.5	31.4	5	1	-

Location Yazdelan Pit No.5

Elevation 980 m

Vegetation -

Cultivation Barley, Alfalfa, cotton

Soil classification Order : Aridisol, suborder : Orithids

Soil Tyne Light texture, saline-alkali soil

Profile Description

0 - 23 cms 10 YR 6/3 (pale brown), loamy, single grain weak structure, horizon boundary change sharp (0.5 cm thick), rare fine roots.

23 - 53 10 YR 7/3 (very pale brown) fine sandy, single grain, loamy sand, rare fine roots, horizon boundary change clear (2.5-6)

Profile	Sample	Depth cm	Organic matter %	Calcium Carb.%	Gypsum %	Cation ex-changeable Cap. m.e/100g	E.S.P. %	S.A.R	Structure			
									Clay %	Loam %	Sand %	Tex-ture
5	9	0–23	0.33	20.7	13.9	7.9	81.5	27	10	40	50	L
	10	23–53	o.23	14.5	30.3	9.1	72.5	22.6	9	36	54	S.L

PH	EC mmhos/cm	Sat-uration %	Soluble Cations m.e/lit				Soluble Anions m.e/lit			
			K+	Na+	Mg++	Ca++	So--	Cl-	HCo-	Co--
7.1	11.9	35	1	92.1	1	21	83.1	40	1	-
7.4	11.9	35	0.9	83.4	1.5	25.7	42.5	60	1	-

Pit No.6

Location Desert area, East of Housain-Abad village

Elevation 987 m

Vegetation Tamarix Sp. Alhagi camelarum & salicornia herbacea

Cultivation Uncultivable land

Soil classification Order : Aridisol, Suborder : Orithids

Soil type Light texture, saline-alkali soil

Profile Description

0-17 cms 10 YR 6/4 (light yellowish brown) sandy loam, single grain, hardness is very low, clear change.

17-30 10 YR 7/4 (yellowish brown) loamy, granular texture, clear change, there are particles of gypsum (not crystals)

Profile	Sample	Depth cm	Organic matter %	Calcium Carb. %	Gypsum	Cation ex-changeable cap.m.e/100g	E.S.P. %	S.A.R	Structure			
									Clay %	Loam %	Sand %	Tex-ture
6	11	0-17	0.39	18.3	39	7.6	-	39.3	10	25	55	S.L.
	12	17-30	0.23	21	0.4	7.6	36	46.4	17	43	40	L

PH	EC mmhos/ cm	Sat-ura tion %	Soluble Cations m.e/lit				Soluble Anions m.e/lit			
			K+	Na+	Mg++	Ca++	So--	Cl -	HCo -	Co--
7.4	34.4	29.6	1.8	212.3	9.5	51.5	4.3	320	2	-
7.4	17.4	27.2	0.8	160.8	10	14	150.8	17	1	-

The following results were obtained from an analysis of the soil samples -

(a) The soil pH in most of the samples represents over 7.00,so the soils of the area vary from normal to alkaline.

(b) The sand percentage in the whole of the samples is more than 50 per cent. On the other hand the percentage of clay does not exceed 22 per cent, so the texture of most of the soils is moderate to light in texture, i.e. sandy, sandy loam and loamy.

(c) The electrical conductivity in the samples of uncultivated land is significantly high.

(d) The percentage of organic matter is very low in all the samples.

(e) The percentage of calcium carbonate in the profiles lies between 17.4 to 28.3%.

Consequently, the soils of the Abuzaid-Abad area can be described as sandy to sandy loam (Figs. 3.2, 3.3, 3.4) with a light texture and very calcareous(7) saline, saline-alkali soil, non saline-alkali soil,(8) poor in humus in uncultivated land and entirely brown. So the soils of the Abuzaid-Abad area are entirely within the pedocal soil group. Thus, according to the U.S Comprehensive System of Soil Order(9) the soils of the area have been classified by the author in the order, Aridisol and sub order, Orithids.

This is equivalent to brown soil, desert soil, saline soil and Sierozem in the U.S great soil groups, to Arctic soils in the Soviet system, to desert browns in the Australian

SPECIFICATION OF SOIL TEXTURE
IN THE ABUZAID-ABAD AREA

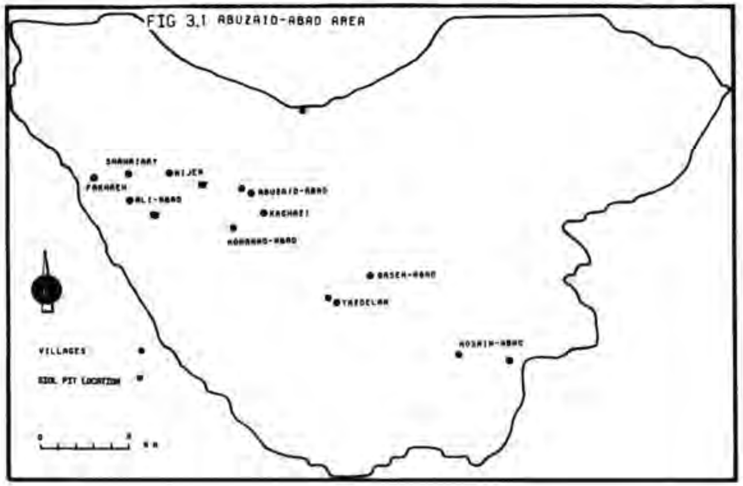


FIG 3.1 ABUZAID-ABAD AREA

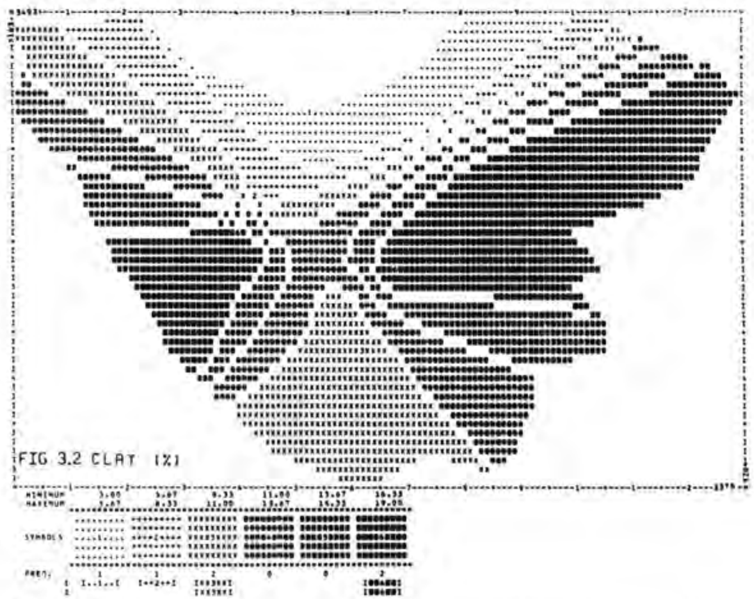


FIG 3.2 CLAY (%)

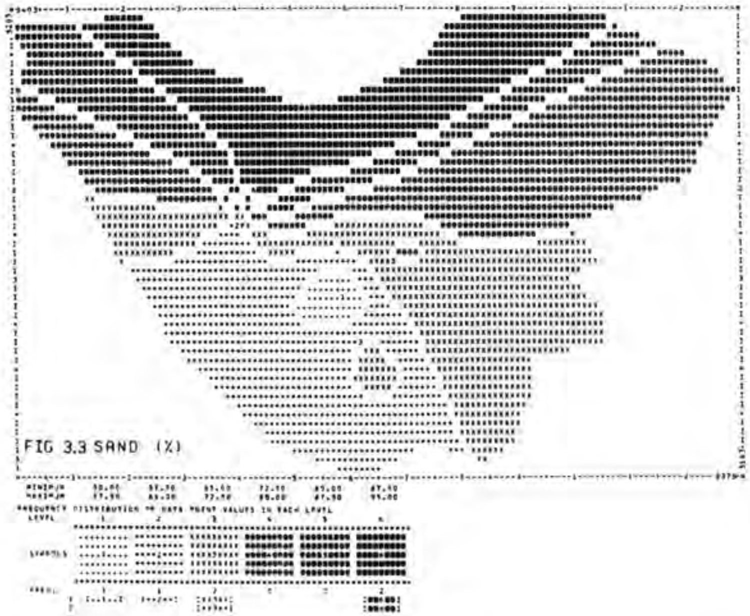


FIG 3.3 SAND (%)

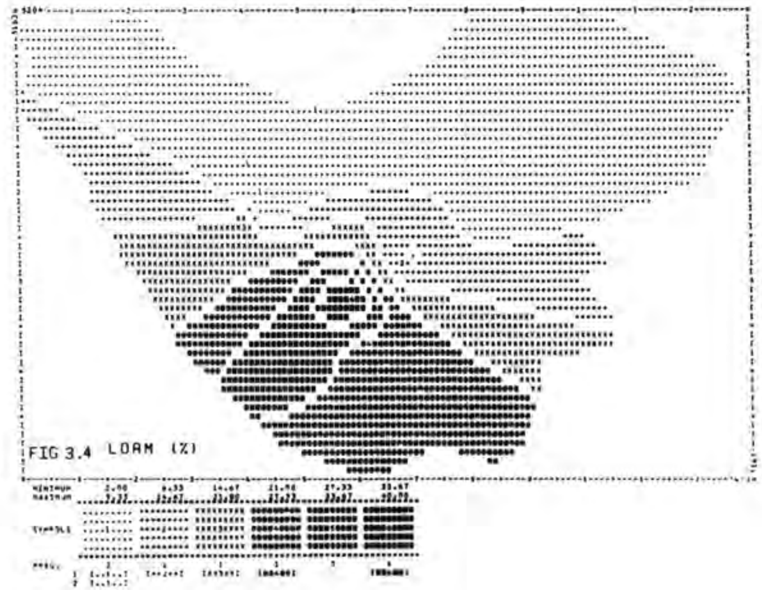


FIG 3.4 LOAM (%)

great soil groups and to xerosols in the F.A.O system.[10]

The soil of the area, in general, comprises :

A. The soil of cultivated land. The agricultural value of this soil, in general, is low because of the climatic conditions in the area. Thus, without irrigation no agriculture is possible. It should be emphasised that water is the limiting factor in agricultural productivity and not the intrinsic fertility of the soil of cultivable land, because these soils were developed by using animal manure for many years. Notwithstanding, it should be further emphasised,that irrigated farming on this type of soil is not profitable unless there are inputs of fresh water, fertilizers and applied good management. Thus, any immediate hope for better agricultural development depends on fresh water availability and the application of animal manure, or chemical fertilizers in accordance with the opinions of experts as a result of soil analysis. Of course, it should be noted that to get the best results the soil analysis results must be applied uniform for each soil type in the area.

B. The soil of uncultivated land. This is divided into three kinds of soil :

(a) Saline soil. At the edge of the desert, the ground water table is shallow (see the Chapter on Hydrology) and can be found in many places within 6-8 m. of the land surface. Under conditions of high evaporation these high water tables cause severe salinization of the soil. The salt content of this kind of soil in different horizons varies considerably with the seasons; in the rainfall season the salt is less, but in summer the salt is abundant due to the loss of water by evaporation. Therefore, agriculture in this part of the area would seem to be impossible because of the lack of fresh water and the unsuitable soil. The elevation of this part of the area is about 1,000 m., so bringing fresh water in a qanat system from the western parts which should be at least 950 m. elevation, is impossible.

(b) Regosols or sand dune soils. This type of soil is dominant in the northern part of the area (profile 4). These soils are young soils formed on fine sand. Their profiles are generally undeveloped because of the shifting sand, and the limited amount of rainfall. This part of the area is not suitable for agricultural activity because of the high proportion of sand (about 96% in sample 4) while the clay content is very low (about 2%). These soils have very low water capacity and very high permeability.

(c) The soil of grazing land. These kinds of soil can be classified as yellow-reddish steppe soils. In general, these soils are shallow. Texturally, these soils range from sandy loam to sandy clay (profile 1). The electrical conductivity is about 14 mmhos/25°C. Therefore, salt tolerant crops (alfalfa and barley) should be selected for cultivation on this soil. Extraction of fresh water in the area, which is occupied by this type of soil, is possible. With the application of fresh water, animal manure or chemical fertilizer, this kind of soil is suitable for agriculture.(11) In other words the best way of using this area is to restrict it to grazing, bearing in mind the capacity of available forage.

3.3 Vegetation

The distribution of natural vegetation cover depends on (a) the quality of soils (texture, structure and depth) (b) climatic conditions and (c) human interference.

(a) The quality of Soil

Vegetation cover in the area decreases from west to east and increases from north to south because the northern part of the area is dominated by rogosol and sand dunes. The vegetation cover of this part of the area is very poor, especially at times when the scattered vegetation is covered by shifting sand,as growth is restricted. On the other side in this part of the area, the soil profiles are generally undeveloped, and the youth of the soil is the other main factor which limits the vegetation cover.

In the east of the area the vegetation cover is very thin because of the salinity of the soil. Although some salt tolerant plants grow in this part, they are very thin and scattered. The soils of the west, south and central part of the area are relatively more developed than in other parts , so the vegetation cover is richer. Hence these parts have usually been selected for grazing since 1975 but at the present time about 90% of the area has been protected by the government to prevent desert extension.

(b) The climatic conditions

The climatic conditions are almost uniform because of the smallness of the area (703 km^2), but the vegetation cover varies in response to the annual rainfall in the area. In the dry years the drought restricts the growth of annual plants. If they grow, they dry up in the middle of spring (April), but in the wet rainy years, they remain until the early summer (July).

(c) Human Interference

Unfortunately, human interference has been very considerable in the past in the area. The residents of the area, by cutting down bushes and shrubs and by the unsuitable use of vegetation as forage and grazing, have largely destroyed the vegetation cover, and have made what remains very thin.

However, field investigation shows that seven plant communities dominate in the area, and they seem to correspond with the soil types. These plants can be described as follows:-

1. Tamarix Sp., which is called Gaz in the area, is relatively widespread in the east and north of the area. It grows mainly on saline soil.

2. Salicorina herbacea Sp. This species dominates in the east, north and centre of the area.

3. Suaeda Sp. This species grows widely in the south and central part of Abuzaid-Abad area.

4. Prosopis stephaniana. This plant grows in the south and western parts of the area.

5. Alhagi camelorum, Carthamus oxycatha, Peganum harmala and Echinops Sps. all of which grow in the central, southern and western parts of the area.

6. Artemisian herba alba, grows in the west of the area.

7. Stipa Sp is widespread in the whole of the area, except

in the eastern part. It grows widely in sandy soil.

Economically, the vegetation comprises of grazing land. After the ground has been watered by winter rains, grasses, flowers and herbaceous plants grow in spring and early summer only to wither during the summer drought. The quality of pasture and its duration vary considerably from north to south and east to west. In the Abuzaid-Abad area grazing practice is traditional, and the grazing lands are bounded by the frontiers of each village. The extension of grazing land and the quality of vegetation cover have a direct impact on livestock and the rural economy in each village.

The vegetation cover helps to control the shifting sand, and as a result it prevents the cultivated land being damaged by the shifting sand.

The vegetation cover prevents the extention of the desert, and helps to develop the soil horizons. It also has a direct impact on the climate of the area.

3.4 Land Capability Classes

The land capability in the Abuzaid-Abad area is classified with respect to the soil analyses in order to determine its potential agricultural development.

As a result of detailed field investigation, and bearing in mind the characteristics of soils, the land of the Abuzaid-Abad area has been classified according to the land capability classification as defined by the U.S Department of Agriculture.[12] Six classes of land have been recognised in the area. In order to assess the land capability, the main criteria involve (a) water quality, (b) water availability, (c) soil properties (d) soil limitations, and (e) climatic limitations. These factors are certainly the most important in relation to the agricultural activities in the area. Climatic limitations dominate the whole of the area, but water quality and availability and soil limitations vary from place to place. However, as far as land capability classification is concerned, class I and class II have not been recognised in the area because throughout the area there are severe or very severe conditions that restrict the choice of plants and require very careful management and therefore no land within the area has been placed in these classes. Figure 3.5 shows the distribution of land capability classification in the Abuzaid-Abad area.

The cultivated land of the area is in Class III. Cultivated land is usually located near water resources (qanats and wells) and is often surrounded by land of Class IV. Cultivation occurs mainly in small patches. The total amount of land of this class, which is about 439 ha. or 0.65 per cent of the total area, is generally irrigated and fertilized (Table 3.1).

The climatic and water conditions restrict the choice of crops which can adapt to the area.(13) Thus with reference to the capability subclasses, this type of land is mostly grouped in "Class IIIc".

Class IV areas usually surround Class III areas. These groups of land include fallow land, or patches of land which have been cultivated in the past but which, at present, are

Table 3.1 Distribution of Land Capability Classes in the Abuzaid-Abad Area (1978)

Capability Classes	Capability Subclasses	Total area ha	% of the total area	Ratio to the cultivated land (class III)
I	-	-	-	-
II	-	-	-	-
III	c	439	0.65	1
IV	c	1,320	2.0	3
V	s.c	21,762	31.5	50
VI	e.s.c	13,700	18.4	29
VII	e.s.c	6,353	9.3	14.5
VIII	e.s.c	27,550	38.3	60
Total	c	70,454	100	156

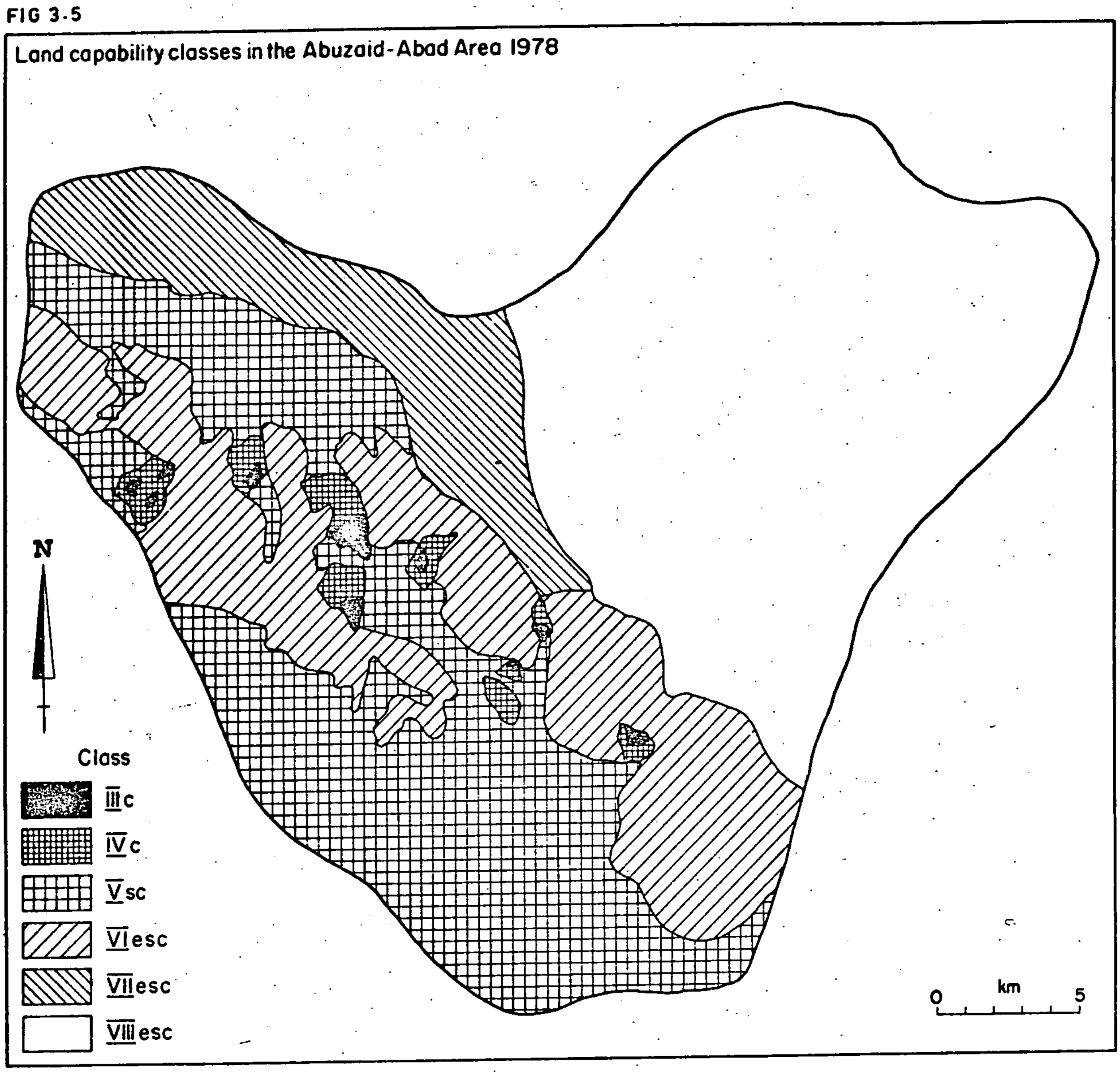
Source : Field survey by author 1978.

c = climate limitation

s = root-zone limitation

e = erosion

FIG 3.5


Land capability classes in the Abuzaid-Abad Area 1978
N
Class
III c
IV c
V sc
VI esc
VII esc
VIII esc
0
km
5

very rarely cultivated because there are limitations for planting e.g. relatively shallow soils, salinity or lack of water.

The total land area of this class is about 1,320 ha. or 2 per cent of the total area. This type of land has great potential for reclamation by irrigation and fertilization.

Class V land is generally not suitable for cultivation. The soils in this class suffer little wind erosion but have other limitations e.g. sandy soil, salinity, lack of water, shallow soil depth and climatic limitations. Such land is only suitable for pasture and woodland. This type of land is located in the south and north west of the area. The total amount of land in this class is about 21,762 ha. or 31.5 per cent of the total area, of which about 3,750 ha. are used for grazing purposes and the rest includes the artificial forest and protected land. The soils in this class are sandy saline and susceptible to wind erosion.

Class VI land which is sandy, surrounds eastern villages. Sandy soils, and shifting sand of this class have severe limitations that make them generally unsuited for cultivation and restrict their use largely to grazing. The total land of Class VI capability is about 13,700 ha. or 18.4 per cent of the total area. In these areas, sand has covered some saline soils and these appear when the sand is removed by the wind.

Huge sand dunes are located in the northern part of the Abuzaid-Abad area. These sand dunes and their foothills comprise Class VII land capability. The total Class VII area is about 6,353 ha. or 9.3 per cent of the total area. Soils in this class have very severe limitations that make them unsuited for cultivation and restrict their use largely to grazing. Soil restrictions in this class are more severe than Class VI because of one or more continuing limitations that cannot be corrected such as steep slopes, shifting sand and unfavourable climate. All of these factors are found in the land in the Abuzaid-Abad area and the land is thus sub-classified as "Class VII esc".

The south west corner of the Dasht-e-Kawir is located in the eastern part of the area and is classified in Class VIII capability. The land in this part of the area is saline with low moisture capacity, and is restricted by erosion hazards and severe climate. This area extends over approximately 26,550 has. or 38.3 per cent of the total area. Soil and land form in this class have limitations that preclude their use for commercial plant production and grazing. Figure 3.5 shows the distribution of land capability class in the Abuzaid-Abad area.

3.5 Erosion

Wind erosion in the Abuzaid-Abad area, as in many semi-arid areas, tends to be more pronounced in the north of the area, where the land is in capability Class VII, because the vegetation of this zone is scattered, and cannot prevent severe erosion. Shifting sand occasionally covers the cultivated land in the northern part, and fills the shafts of the qanats and covers their tracks. The shifting sand also causes problems for the residents of the area. For example, in November 1977, about 15 ha of Kaghazi, Yazdelan and Qasam-Abad villages'

Plate 3.1 Windbreaks in the west of Qasem-Abad village, in the Abuzaid-Abad area.

Plate 3.2 Artificial forest in the east of Abuzaid-Abad village, in the western part of the Dash t -e-Kawir.

cultivated land was covered by shifting sand, and crops did not grow. The sand storm blew for two days. Also, about 25 shafts of Rigen's qanat system have disappeared under sand which has accumulated over the last few years, making maintenance of qanats in that area impossible.[14]

Therefore, due to the absence of vegetational cover, erosion is severe and soil development is very slow. The residents themselves have helped to encourage the situation by their destruction of existing vegetation, by cutting down bushes and shrubs,and using them as fire wood or as forage, and by continuous and excessive grazing of animals, mostly on the outskirts of the villages.

If the vegetation could be protected from unsuitable usage, and shifting sand controlled by the establishment of wind breaks and strip cropping, the soil could be protected from the effects of wind erosion in the area.

3.6 Control of Shifting Sand

Sand dune stabilization activities are relatively new in Iran, having started around 1959.[15] Two main stations were established in two different climatic conditions (Ahwaz and Sabzevar). Subsequently, thirty sub-stations were established, one of which was set up in the Abuzaid-Abad area in 1974. The control of shifting sand has been very effective since the start of development activity in the area. The stabilization of shifting sand,and moving sand dunes has been carried out in the following ways [16]

(a) To protect the hazardous areas comprising 17,860 ha or 25.8 per cent of the total area, no grazing or other means of destroying the vegetative cover is allowed in the area.

(b) 152 ha was selected to the east of Abuzaid-Abad village and successful species of previously tested plants, namely Tamarix, were planted in the area, with irrigation. The result of this treatment was encouraging and a very good cover of trees obtained in the area.

(c) The erection of mechanical windbreaks for 10 km in the north east of the area between Qasam-Abad and Yazelan villages.

(d) The planting of about 150,000 seedlings in an area near Abuzaid-Abad.

(e) The sowing of seeds on 17,860 has. of the protected land in the centre, south and western parts of the area.

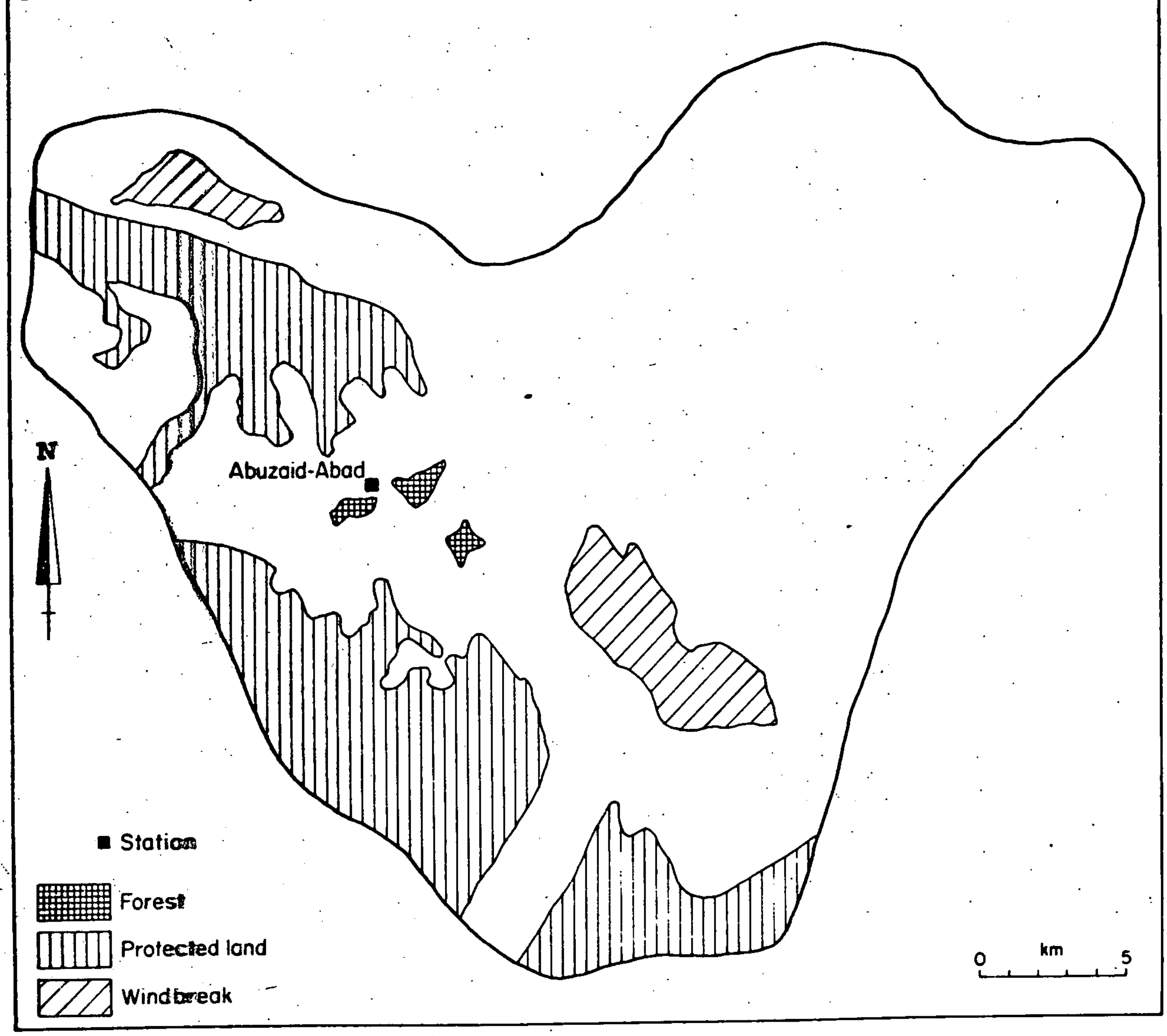
Although the policy of the sand stabilization has succeeded in some parts of the area, it has, in turn, caused problems as follows:-

1. The cultivated and grazing land has been limited by the protection restriction of the hazardous area in 17,860 ha., and development of the artificial forest over 152 has. Figure 3.6 shows the distribution of development activity for soil protection in the area (1977).

Recently, residents' incomes have increased, mostly by carpet making. They prefer to invest their capital in the agricultural activity by construction of wells and maintenance of qanats and development of the husbandry. Thus they need more cultivated and grazing land, but the government does not allow them to make use of the land under protection.

FIG 3.6

Distribution of development activities for soil protection in the Abuzaid-Abad Area 1977



2. The trees planted in the artificial forest usually have long vertical roots (Tamarix and Haloxylon), which extend to a depth of 5-10 m. These trees feed naturally from the first water table.

These water tables often feed the pust-ab qanat (see the chapter on Hydrology). As a result these trees, which usually cover some parts of the qanats, have an effect on the yield of the qanats.

3. According to the villagers' responses when interviewed by the author during the field survey, with the development of artificial forest there has been an increasing number of wild animals, such as mice, snakes, and rabbits which previously had been of little significance, but now often damage crops and fruit trees.

3.7 Conclusion

According to the soil analysis, the texture of most of the soils is moderate to light and the soils can be described as sandy loam and loamy. The percentage of organic matter is very low because of the limited vegetation, but in contrast the pH of the soil averages over 7.00. The conditions of high evaporation, low rainfall and the use of brackish irrigation water cause salinization of the soil. However, the best type of soil is found on the cultivated land where soils have been improved by the use of animal manure over many years. The soils in the western part of grazing and protected land are suitable for agriculture if fresh irrigation water is supplied and the soils are manured by chemical fertilizers according to the opinions of experts and as a result of soil analysis.

First of all the climatic conditions have caused the limited vegetation, but the residents themselves have helped to encourage the situation by their destruction of existing vegetation, because of the limited vegetation, the shifting sand sometimes covers the cultivated land and causes problems for residents.

Although the Government's decision for controlling the shifting sand had succeeded in some parts of the area, nevertheless it was not the best method for soil protection because it meant that some of the cultivated and grazing land had been protected, thus restricting agricultural activities. Also, the residents had been upset because of the high penalties imposed for disobeying Government regulations.

In fact the best protection against desert expansion is provided by the marginal residents of the desert if they have been properly educated. With increasing agricultural facilities available in the area, they will develop more interest in village life and this will prevent migration to the cities.

However, the total suitable land for agriculture is about 1,759 ha. or 2.65% of the total land, of which 1,320 ha. has great potential for agriculture, after reclamation by irrigation and fertilization. The rest of the land is not suitable for cultivation even with great expenditure and fertilization.

The class of land comprising grazing and protected land covers 31.5% of the total area. It is suggested that this land is divided into three parts and each part is used for grazing purposes on a triennial grazing rotation. The three year cycle rotation will allow for the growing of vegetables, will prevent desert expansion and will allow the development of animal husbandry in the area.

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CHAPTER 4

LAND USE

4.1 Introduction

According to records of the "The Registration of Documents and Landed Properties Office"[(1)] of Kashan, the Abuzaid-Abad Dehestan (district) is bounded in the north by Band-e-Rig (sandy hills), in the south by the Qohrud Dehestan, in the west by suburbs of Kashan City and in the east by Ardestan and Yakh-Ab mountain and the western part of the Dasht-e-Kawir.

The extent of the area is about 701.6 km^2, and this has been measured by planimeter from the available topographic map of the area on the scale 1:250000[(2)]. According to a calculation, carried out by computer,[(3)] the extent of the area was found 703.50 km^2 (Fig.4.1). These two methods approximately support each other.

4.2 Land Use Pattern

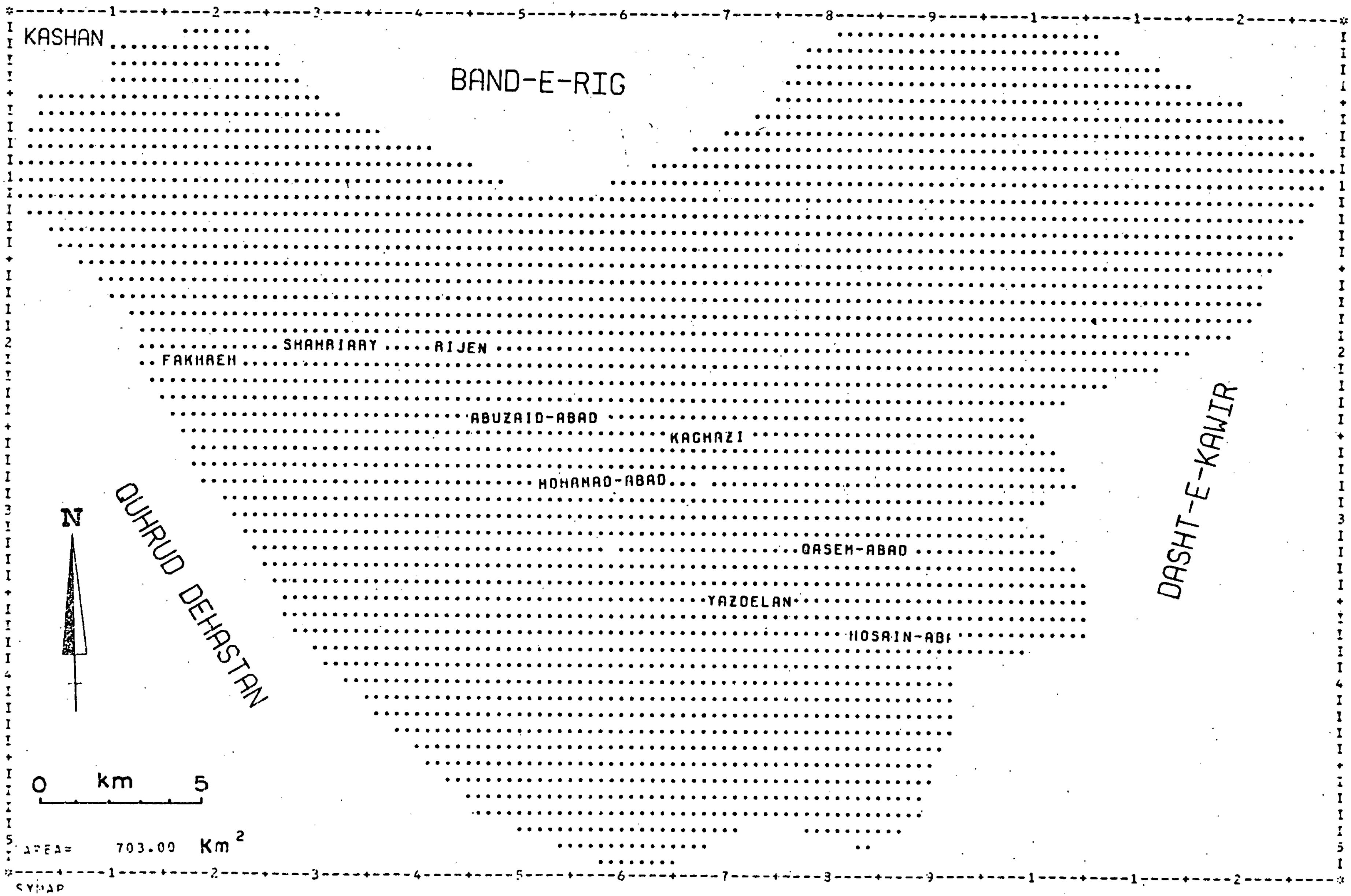
The area is divided according to the field survey and investigation into four divisions :

a) cultivated land, which is about 11.56 km^2, or 1.6% of the total area;

b) uncultivable land, which is about 467.82 km^2, or 66.6% of the total area.

Uncultivated land can be further divided into two parts, the salty and sandy land. The extent of the salty land is about 277.2 km^2 or 39.5% of the total area. The sandy land

FIG 4.1 ABUZAID-ABAD AREA



which is covered by sand and sand dunes is about 190.6 km^2, or 27.1% of the total area.

c) artificial forest, protected and grazing land make up about 215.6 km^2 or 30.4% of the total area. Of this, protected land constitutes 176.7 km^2, or 25.1% and grazing land 37.5 km^2 or 5.3% of the total.

d) settlements and public land - about 6.77 km^2, or 1% of the total area. Table 4.1 and Figure 4.2 show the distribution of land use type in the Abuzaid-Abad area in 1978.

The land use of the Abuzaid-Abad area has not been studied up to now and there is no map or official statistics of land types. The land use map of the area has been prepared by the author using the topographic map(2) as the basis, together with a field and questionnaire survey in 1978.

In the preparation of the land use map (Fig.4.2), the topographic map of the area on the scale 1:250,000 was used as a base map. It was photographed and reduced to a scale of 1:125,000 by the author. The types of the land use, i.e. cultivated land, uncultivated, settlement and public land, artificial forest, grazing and protected land, were recorded on this map in the field.

4.3 Cultivated Land

The total cultivated land, utilized for various agricultural purposes in 1978 was 1,156 ha., or 1.6% of the total area. The cultivated land in the Abuzaid-Abad area comprises; first, the land under perennial and semi-perennial crops; second, the land under annual crops; and finally, fallow land (Fig. 4.3).

Table 4.1 Distribution of Land Use Type in the Abuzaid-Abad Area 1977

Land use Type	Total area ha	% of the total area
Settlements	677	1.0
Cultivated land	1,156	1.6
Grazing land	3,750	5.3
Artificial forest	152	0.2
Protect ed land	17,660	25.1
Sandy land and sand dunes	19,060	27.1
Salty land	27,725	39.5
Total	70,160	100

Source : Field Survey 1977.

FIG 4.2

Land use types of the Abuzaid-Abad Area 1975-1978

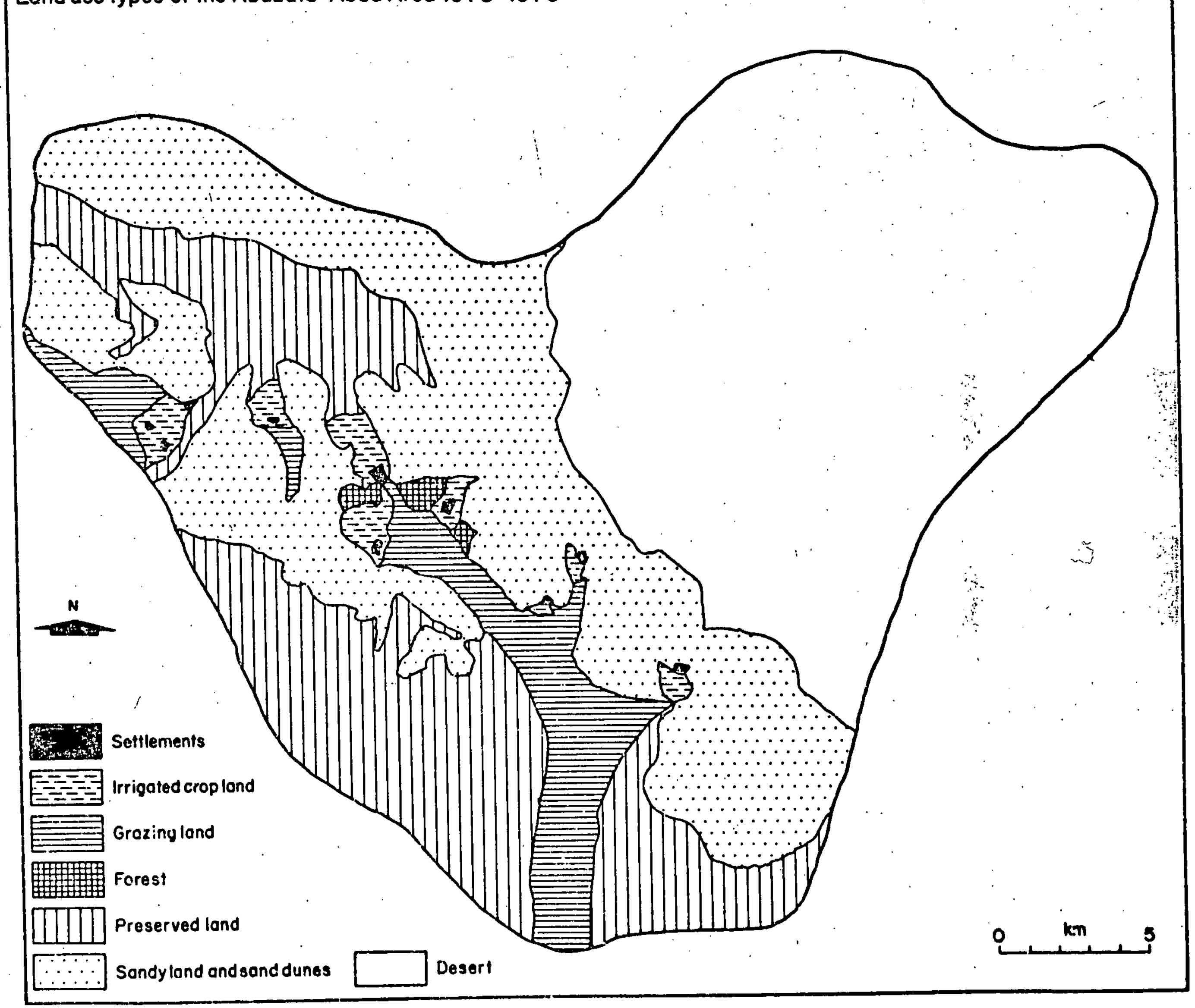
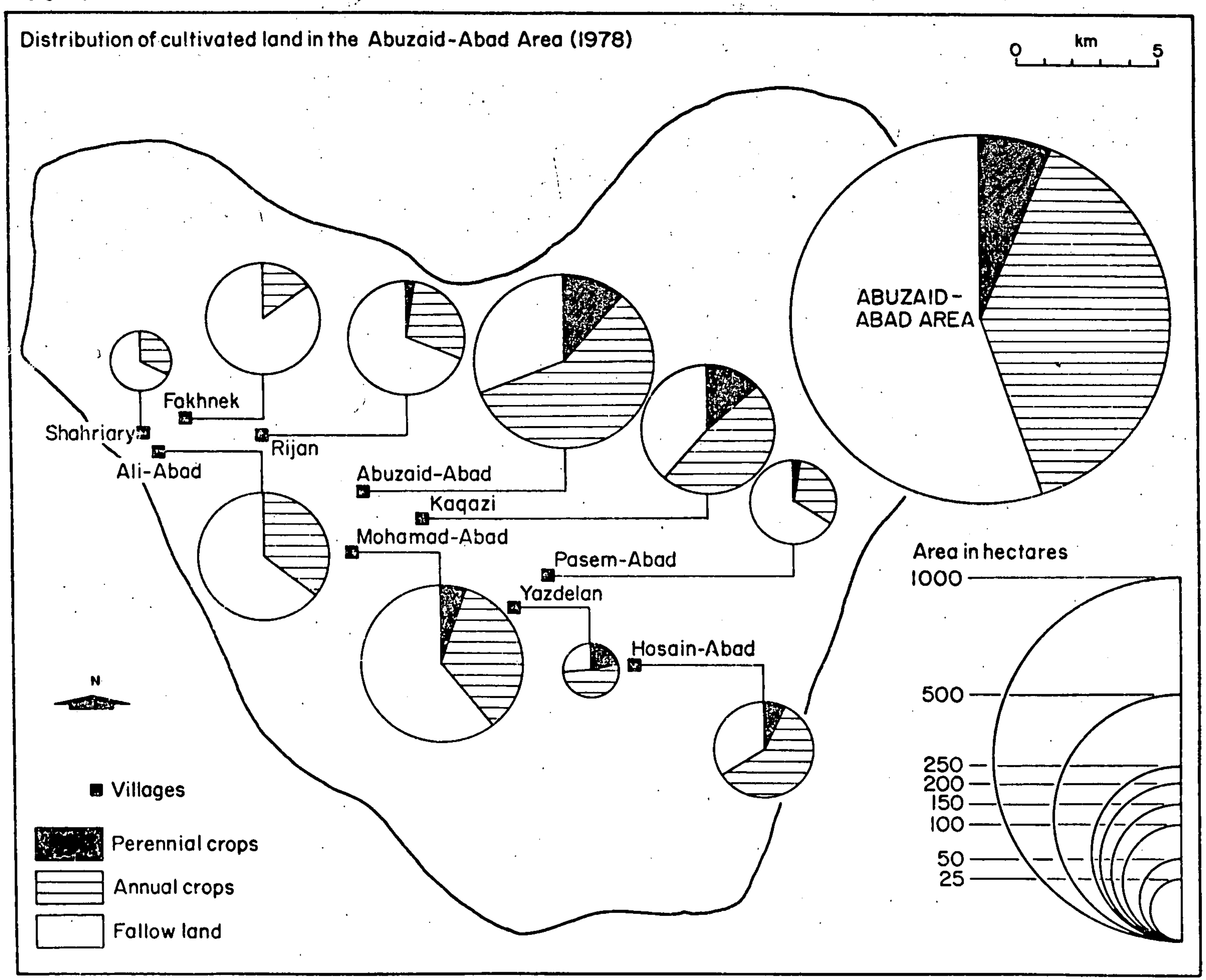


FIG 4.3



Distribution of cultivated land in the Abuzaid-Abad Area (1978)

4.3.1 Perennial Crops

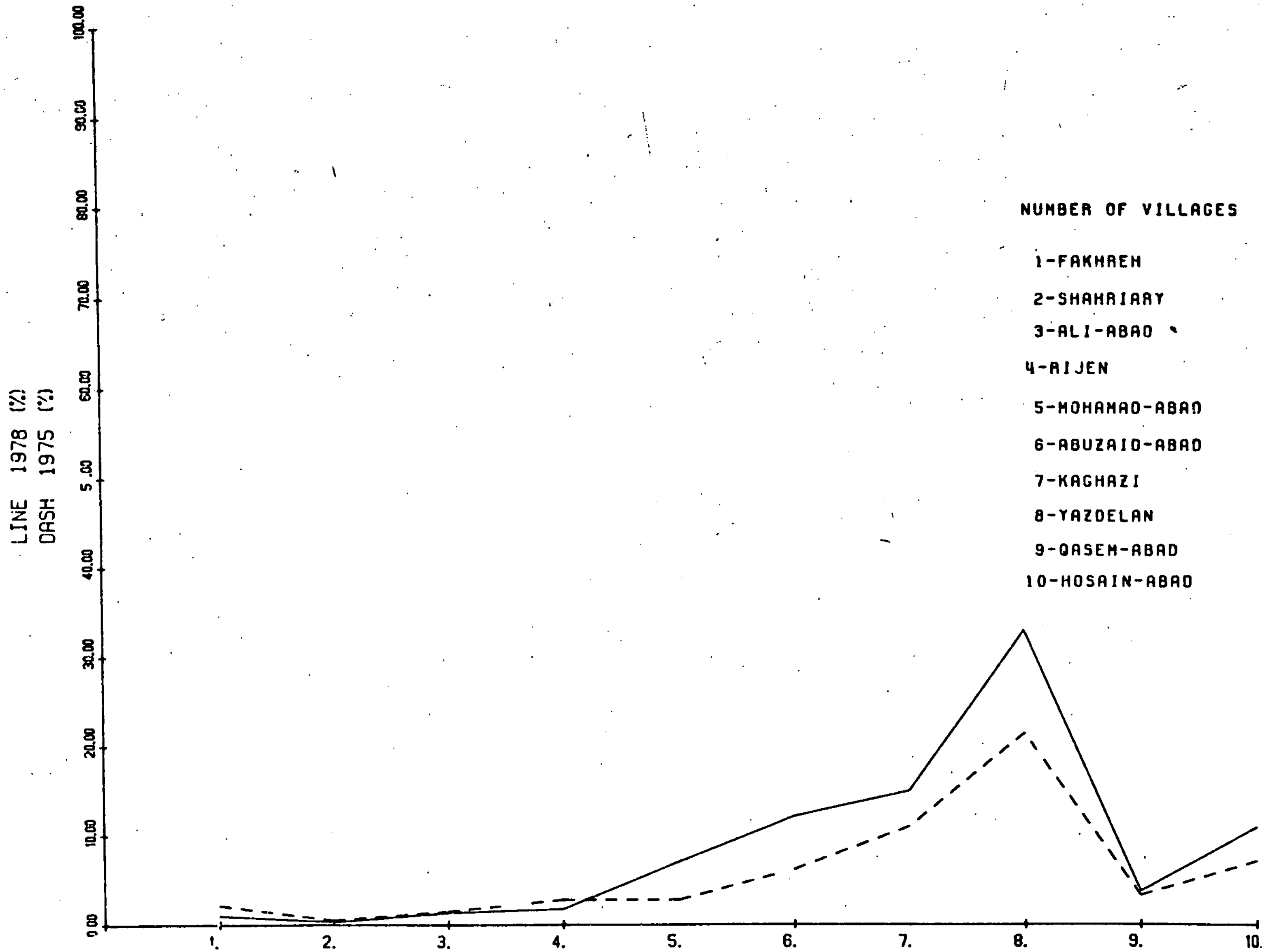
Perennial and semi perennial crops consist of vines, fruit trees and alfalfa, which are usually in fields surrounded by walls, and located usually near the villages, or where the qanat comes to the surface (Mazhar-e-qanat). The soil of this type of land is usually of the best quality in comparison to the soil used for annual crops, because the traditionally preferred system has tended towards the establishment of permanently cultivated fields near the residential areas, where fertility is usually maintained through the application of organic manure. The remoter fields tend to be used for annual crops or to lie fallow. The land under perennial crops is usually irrigated throughout the year, and it is not possible for salt to come to the surface. Perennial crops are usually located within walls and so shifting sand rarely damages them.

The area under perennial crops was 88 ha. in 1978, or 7.6% of the total cultivated land, which showed an increase of 18% relative to 1975 (Table 4.3). This results from the fact that during the last ten years (since 1967 - 1978), six deep wells and five shallow wells have been constructed in the area. The proportion of perennial crops to the total area is very small, about 0.09%. Figure 4.4 shows the distribution of land under perennial crops in the area.

4.3.2 Annual crops

The land under annual crops was 439 ha. in 1978, or 38% of the total cultivated land (0.62% of the total area). Before wells had been drilled in the area, all of the cultivated land was irrigated by qanats, but after the construction of

FIG 4.4 DISTRIBUTION OF LAND UNDER THE PERENNIAL CROPS 1975-1978



wells, 144 ha. of the cultivated land became irrigated from the wells as a result of the reduction of qanat discharge.[4] (Fig.4.5).

Now, with respect to the above discussion, the annual cultivated land in the area can be divided into two parts. Firstly, the land under qanat irrigation, and secondly, the land under well irrigation. The total land under annual crops which was irrigated by qanat discharge in 1978, was 677 ha. or 58.5% of the total cultivated land, of which 293 ha, or 25.3% of the cultivated land was under annual crops and 384 ha or 33.2% of total cultivated land was fallow (Table 4.2). As for the land under well irrigation, although some plots have been reclaimed[5] from uncultivable land which was covered by shifting sand, the majority of the land under well irrigation was previously irrigated by qanats. After the reduction in qanat discharge this land became fallow. In 1978, the total land under well irrigation was 376 ha. The land under annual crops was 144.4 ha.,or 12.5% of the total cultivated land, which shows an increase of 28 ha.,or 8% relative to 1978 to 1975 (Table 4.3). It should be noted that perennial crops are mostly under qanat irrigation, although sometimes they are irrigated by well discharge, but the owners of the wells believe"there is no guarantee of well water". Figure 4.6 shows the distribution of land under annual crops in the Abuzaid-Abad area in 1975-1978.

Using a different system, the land under annual crops can be divided into two different types. Firstly, the land under winter crops (Shatvi) which in 1978 was 374.2 ha., or 85.2% of the total annual crops, of which 258 ha. was

FIG 4.5 DISTRIBUTION OF LAND UNDER THE QANATS & WELLS IRRIGATION

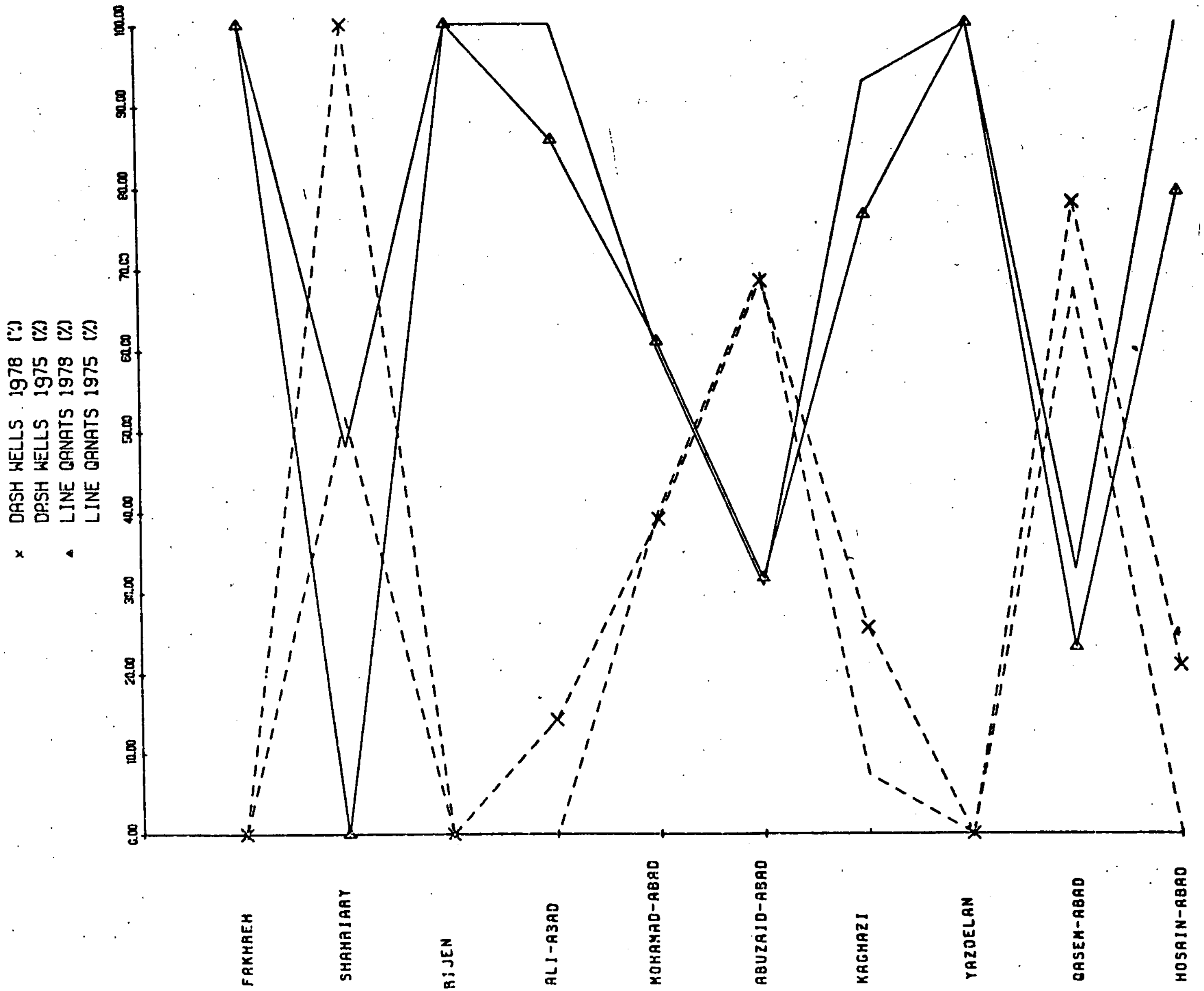
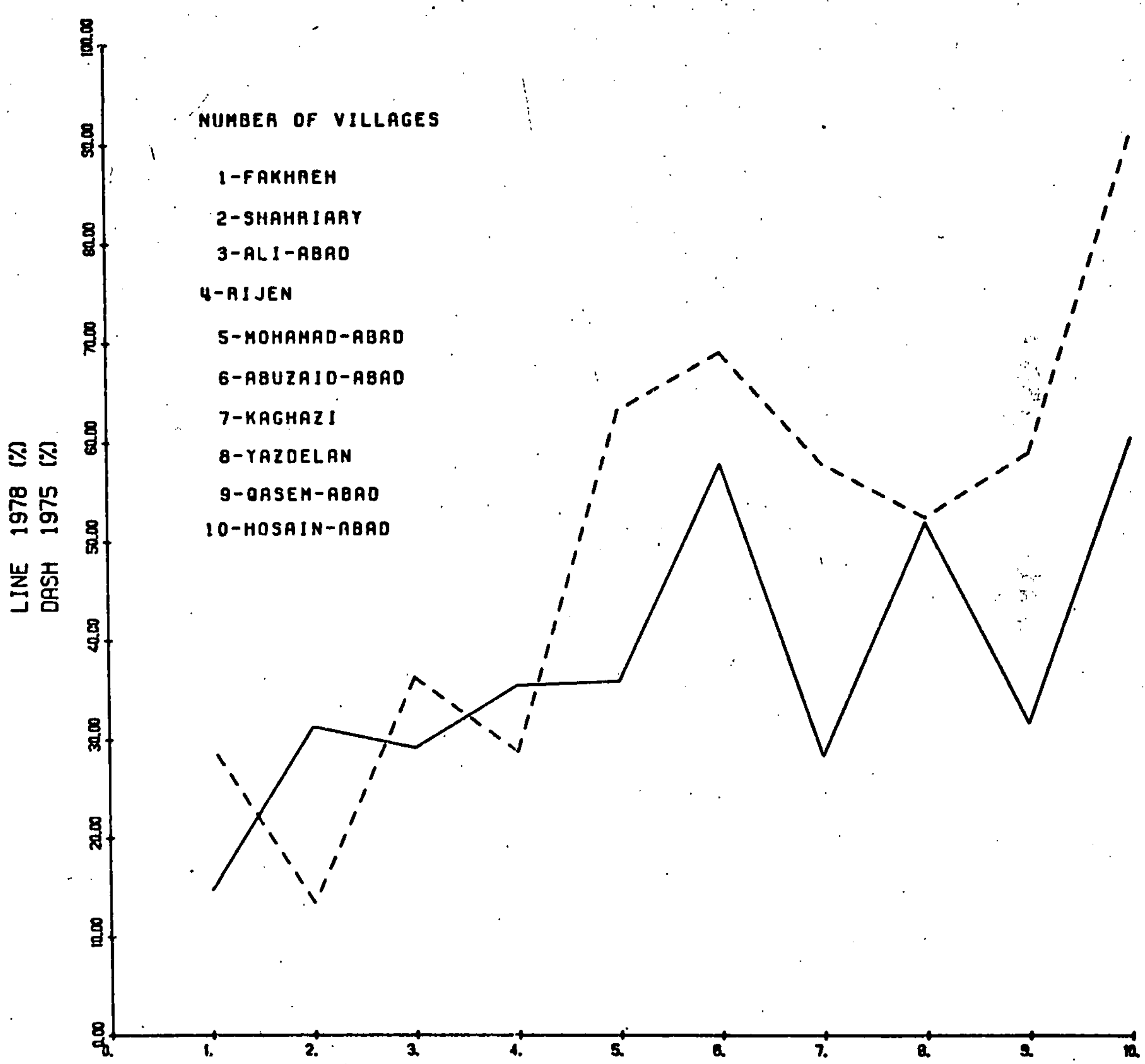


Table 4.2 Distribution of Utilization Land in the Abuzaid-Abad Area in 1978

Land use Type	Total (ha)	Irrigated by the qanats		Irrigated by the wells	
		ha	%	ha	%
The land under annual crops	439.4	295	66.6	144.4	33.4
1. Summer crops	65.2	35	11.9	30.2	6.9
2. Winter crops	372.2	258	54.7	114.2	26.5
Fallow land	630	384	60.6	246	39.4
The land under perennial crop	87.8	87.8	100	-	-
Total	1157.2	766.8	67	390.4	33

Source : Field Survey 1978.

FIG 4.6 DISTRIBUTION OF LAND UNDER THE ANNUAL CROPS 1975–1978



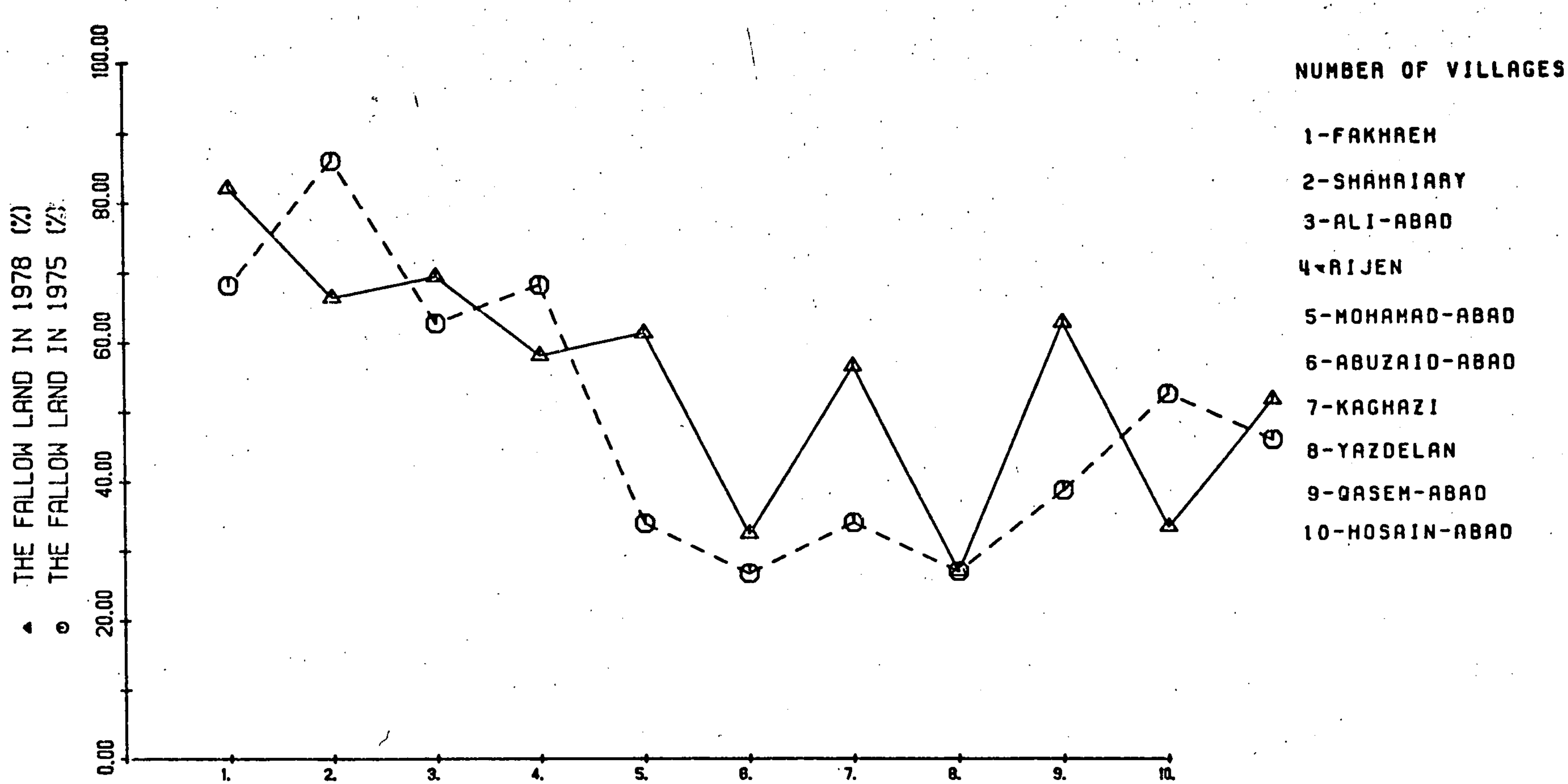
irrigated by qanats and 114.2 ha. by wells, and secondly, summer crops (<u>Safie</u>) which was 65.2 ha., or 15% of the total annual crops, of which 30.2 ha. was under well irrigation and 35 ha. was irrigated by qanats (Table 4.3). It is very difficult to distinguish the land under Safie from the land under Shatvie and hence for a land use map to be of value for two or three years, because these two types of land use are changed for rotation purposes every two or three years, although the land near the villages is usually used for summer crops and the land further from the village is normally allocated to winter crops, mostly wheat and barley.

Although the land irrigated by qanats can be distinguished from the well-irrigated land, sometimes, especially during the summer, wells' discharge are used to irrigate the land that is normally under the qanat irrigation. In the winter when the crops do not need to be irrigated, because of the cold weather the engines of the wells do not work and so qanat discharge is sometimes used to irrigate the land, which was under well irrigation. Occasionally some farmers use both the water which is discharged from qanats and from wells at the same time.

4.3.3 Fallow Land

The total fallow land is 630 ha. or 54.4% of the total cultivated land in the Abuzaid-Abad area, of which 384 ha., or 60% of the total fallow land is under qanat irrigation and 246 ha. is under well irrigation (Table 4.2 & Figure 4.7). A lot of these lands are not kept solely for agricultural purposes, since there is not enough water for their irrigation,

FIG 4.7 DISTRIBUTION OF FALLOW LAND IN THE ABUZAID-ABAD AREA 1975-1978



or the quality of the soil is not suitable for agricultural purposes. Some, albeit unsuitable fallow land, may be cultivated for a period of a few years when it is particularly wet. The land near the villages, or near the water resources is often cultivated yearly, because the farmers have some special reasons for their action. They believe that the low qanat discharge in the remote land under cultivation is unsuitable for irrigation, because a lot of water has evaporated and infiltrated into the ground over a long distance. In this case the water cannot irrigate a large area of cultivated land. The farmers also believe that working near the farm house is very easy and the children may frequently help their father (women usually do not share in agricultural activities).

Use of fallow land will be discussed in more detail in the section on crop rotation. Table 4.3 shows the distribution of cultivated land in the adjoining villages of Abuzaid-Abad 1975-1978.

4.4 Uncultivable Land

The total of unproductive land or non-arable land in the Abuzaid-Abad area is about 456.1 km^2, or 67% of the total area (Table 4.4). Unproductive land comprises; firstly, sandy land and secondly, saline land.

4.4.1 Sandy Land

Sandy land and sand dunes often surround the villages in the area (excluding Fakhreh and Ali-Abad villages). Sand covers about 190.6 km^2, or 27.5% of the total area (schemes to stabilize the sand has been discussed in more detail in the soil and vegetation chapter). The sandy land and sand dunes

Table 4.3 Distribution of Cultivated land on the adjoining Villages of Abuzaid-Abad 1975-1978

Variables / Villages	Land under annual crops				Fallow land				Land under perennial crops				Total land under qanat irrig.		Total land under well irrig.		Total	
	ha		%		ha		%		ha		%							
	1975	1978	1975	1978	1975	1978	1975	1978	1975	1978	1975	1978	1975	1978	1975	1978	1975	1978
Fakhreh	30.12	15.03	29.5	14.75	69.6	84.8	68.2	82.1	2.3	0.7	2.2	-	100	100.4	-	-	99.72	99.72
Shahriary	14.47	9.7	13.46	31.32	92.5	21	86.0	66.45	0.5	0.25	0.5	-	5.2	-	55.5	30.7	107.5	30.7
Rigen	41	33	36.3	29.2	70.9	78.5	62.7	69.4	1.07	2.75	1.5	1.4	113	114.2	-	-	113	113
Ali-Abad	43	53.1	28.8	35.5	101.9	86.7	68.2	58.1	4.3	2.4	2.8	-	149.2	130.6	-	24	149.2	152.3
Mohamad-Abad	126.3	71.7	63.2	35.9	67.8	122.5	33.9	61.3	5.6	14.6	2.8	3.8	120	124.8	80	80	199.7	204.90
Abuzaid-Abad	173.23	154.9	69	57.8	69.2	83.3	26.7	30.4	16.1	31.5	6.2	11.2	82.9	85	176.1	183.1	258.5	257.6
Kaghazi	76	49.5	54.8	28.3	47.2	62.05	34.0	56.5	15.3	15.7	11	15	128.5	98.5	10	30	138.5	128.95
Yazdelan	8.4	8.16	52.4	51.9	4	4.24	27	27	3.38	5.08	21.5	21.5	15.7	17.7	-	-	15.7	15.7
Qasem-Abad	41	19.45	58.9	31.7	27.4	38.4	38.7	62.7	2.35	2.8	3.32	3.8	28.2	14.1	47.55	47.55	70.75	60.9
Hosain-Abad	56.9	43.1	90.8	60.5	25.4	23.8	29.5	33.4	3.7	7.8	9.1	6	86	76.1	-	20	86	96.2
Total	510.4	439.4	-	-	560.5	604.7	-	-	54.6	87.8	4.6	6.2	886.6	764.5	349.1	377.7	1195	1156.2

Source : Field Survey 1976-1978.

stretch from the north west to south east. The main source of these sands is called Siah-Koh (black mountain) and Koh-e-Yakhab. Hans Bobek (1959)[6] said "The sands of Kashan rise immediately from the southern shores of The Masileh, and stretch for more than 50 km. to the south reaching the entrance into the independent basin of Ardestan".

4.4.2 Saline Land

Saline land covers a large part of the area in the east and north east. There are 15 deserted hamlets (Mazreah) in the east and north east, which are located in the saline land. (see the Chapter on settlement). There are no residents in these Mazreahs. Until 1974 some of them were cultivated by the farmers from Hosain-Abad and Qasem-Abad, but at the present time, there is no agricultural activity in this part of the area, because the available water has changed to brackish and is very limited. The total cultivated land, until 1974 was 17 ha. which was barely cultivated, but today the soil of these farms is too salty for any cultivation. The total saline land in the east of the area is about 265.5 km^2, or 38.3% of the total area. The saline land is bounded by the sand dunes to the east of Hosain-Abad and this boundary continues towards the north of the area (Fig. 4.2). Inside the area, either there is no saline land, or else it has been covered by sand or sand dunes.

4.4.3 Artificial Forest

The project to stabilize the shifting sand and to prevent desert expansion in this area was started by the Ministry of Natural Resources in 1975. For this purpose a station (office) has been established in the Abuzaid-Abad village.

There are in fact two projects to stabilize the shifting sand and to prevent desert expansion in the area; Firstly, the planting of artificial forest, and secondly, the protection of land.

The area of artificial forest accounts for 152 ha., or about 0.22% of the total area. Tamarix has proved to be very successful when grown in the sandy land or sand dunes, particularly for sand dune fixation, for they tolerate salt and sand spray and storms. Artificial forest areas have been planted between Abuzaid-Abad, Mohamad-Abad and Kaghazi villages (Fig.3.6) and this policy has been successful in the control of shifting sand, although it has caused some problems for the area i.e. numbers of wild animals and a more important problem, involves the construction of a deep well a few years ago. Before the well was built, some of the cultivable land had been fallow, because there was not enough water for irrigation, and the land was not important to the farmers.However, after the construction of wells, the farmers need more cultivable land in this part of the area, but about 34 ha of cultivable land is now covered by the artificial forest, and the Ministry of Natural Resources will not agree to the destruction of the forest.

4.4.4 Protected Land

To preserve the soil and prevent desert expansion, the Ministry of Natural Resources has decided to preserve some of the land in order to avoid the destruction of the vegetation in 1975. The Ministry of Natural Resources of Iran has preserved about 178.6 km^2 of the area. These areas had previously been grazing land.

4.4.5 Grazing Land

Grazing land in the area is unimproved. The total grazing land is about 37.5 km^2, or 5.4% of the total area, whereas it had been about 215 km^2, or 31.3% of the total area before 1975.

After the protection of 178.6 km^2 of the area in 1975, the amount of grazing land decreased and was limited to the outskirts of the villages and also a relatively wide band which connects the villages to the southern slopes of the mountains in the south of the area. In addition, a few plots of grazing land, which are surrounded by desert and sandy land or sand dunes lie in the east and north of the area.

4.4.6 Settlements and Public Land

Settlements and associated non-agricultural land, comprises built-up areas, roads, railways and qanats occupying about 677 ha. or 0.97% of the total area (Table 4.4).

The village buildings are usually gathered very closely togetherand the shape of the villages follows traditional patterns in the area. Very few old buildings have large yards attached to them, nor is there much public land inside the villages, so the built-up area occupies only a small percentage of the total area. The total built-up area of the adjoining villages in the Abuzaid-Abad area is about 239 ha., or 0.33% of the total area(the settlement situation has been discussed in more detail in the Chapter on population and settlements).

No roads have been built in the area, and the tracks that exist have been made by the traffic itself. About 104 ha. are covered by the roads, in addition to which, the railway

Table 4.4 — Distribution of Uncultivable Land Use Type in the Abuzaid-Abad Area (1978)

Land Use Type	Total area ha	% of each type	% of uncultivable land	% of the area
Unproductive land	45,6101	100	67	65.9
Sand dune	190,601	40.9	28.2	27.5
Salinity land	265,500	59.1	38.8	38.3
Settlement & Public land	677	100	0.99	0.97
Built up areas	239	35.2	0.35	0.33
Road	104	15.3	0.15	0.15
Railway	160	23.6	0.23	0.23
Qanat "Harim"	174.48	25.6	0.25	0.25
Forest and Grazing land	21,762	100	31.9	32.9
Artificial forest	152	0.07	0.22	0.21
Protected land	17,860	82	26.2	25.8
Grazing land	375.0	17.4	5.5	5.4
Total	68,049		100	100

Source : 1978 Field Survey

passes through the western part of the area, and it occupies about 160 ha.

The shafts of the 'qanats", or channels and the strip of land above the channel of the qanats (Harim-e-qanat) occupies about 174 ha. (Table 4.4 & Fig. 4.8).

4.5 Type of Crops and Distribution of area under Each Type

There are three types of crops - S'afie, Shatvie and perennial crops. In this study alfalfa is included in perennial crops because it is usually planted every five to seven years in this area (Table 4.5).

4.5.1 Winter Crops

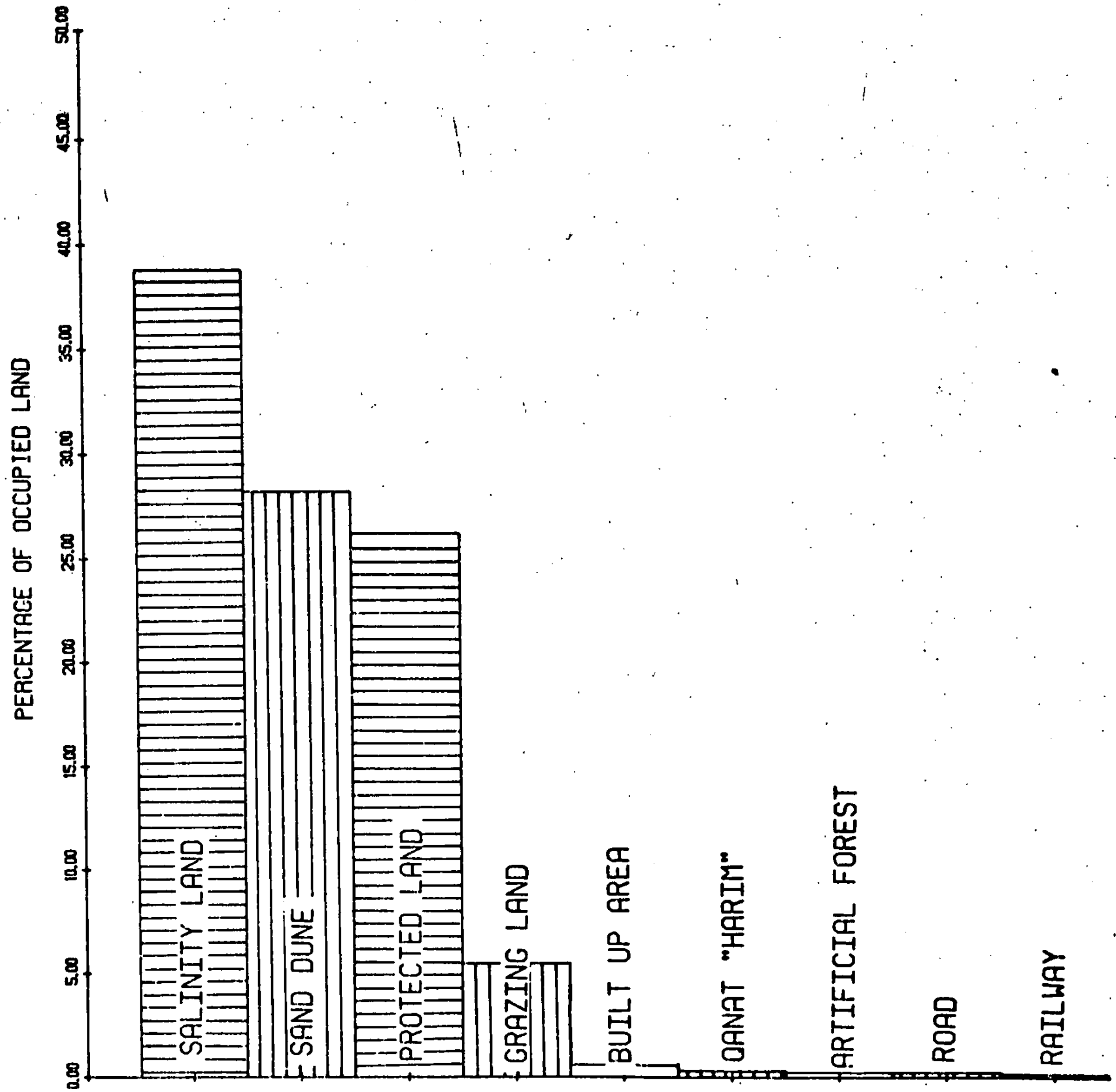
Wheat and barley are the two most important winter crops in all ten villages in the area. Wheat and barley account for 35.8 and 29.3% respectively of the total gross crop land in the area. The total areas under these crops are, wheat 187.3 ha and barley 153.6 ha.

Eight years ago (1975) the last government allowed the planting of the poppy (opium) in two villages (Mohamad-Abad and Abuzaid-Abad) in the area. 25 ha. was planted with poppies every year until 1979, but since the revolution the government has not allowed this crop. Winter crops are planted in all villages, and 71.8% of the total cultivated land, or 365.9 ha, is covered by winter crops.

4.5.2 Summer Crops

Safie is often planted in these groups of villages which have enough water during the hot season. The summer crops in the Abuzaid-Abad area comprise:

FIG 4.8 DISTRIBUTION OF UNCULTIVATED LAND USE TYPE IN THE ABUZAID-ABAD AREA IN 1978



a) <u>Cotton</u>

Cotton is a common crop in the area. A special kind of cotton is particularly suited to this area. It is called <u>wash</u>(cotton)and it covers 4.8% of the cultivated land in the area.

b) <u>Tobacco</u>

Another common cash crop in the area is tobacco. A few years ago tobacco was an important crop in the area, but owing to the fact that there was trouble with the government over the question of payment, in two villages, Rijen and Ali-Abad, the farmers decided not to plant tobacco. However, in the other villages it is still usually planted.

c) <u>Other Summer Crops</u>

Green vegetables, beets, parsnips, onions and corn are other summer crops, and they cover about 65.2 ha or 11.4% of cultivated land in the Abuzaid-Abad area.

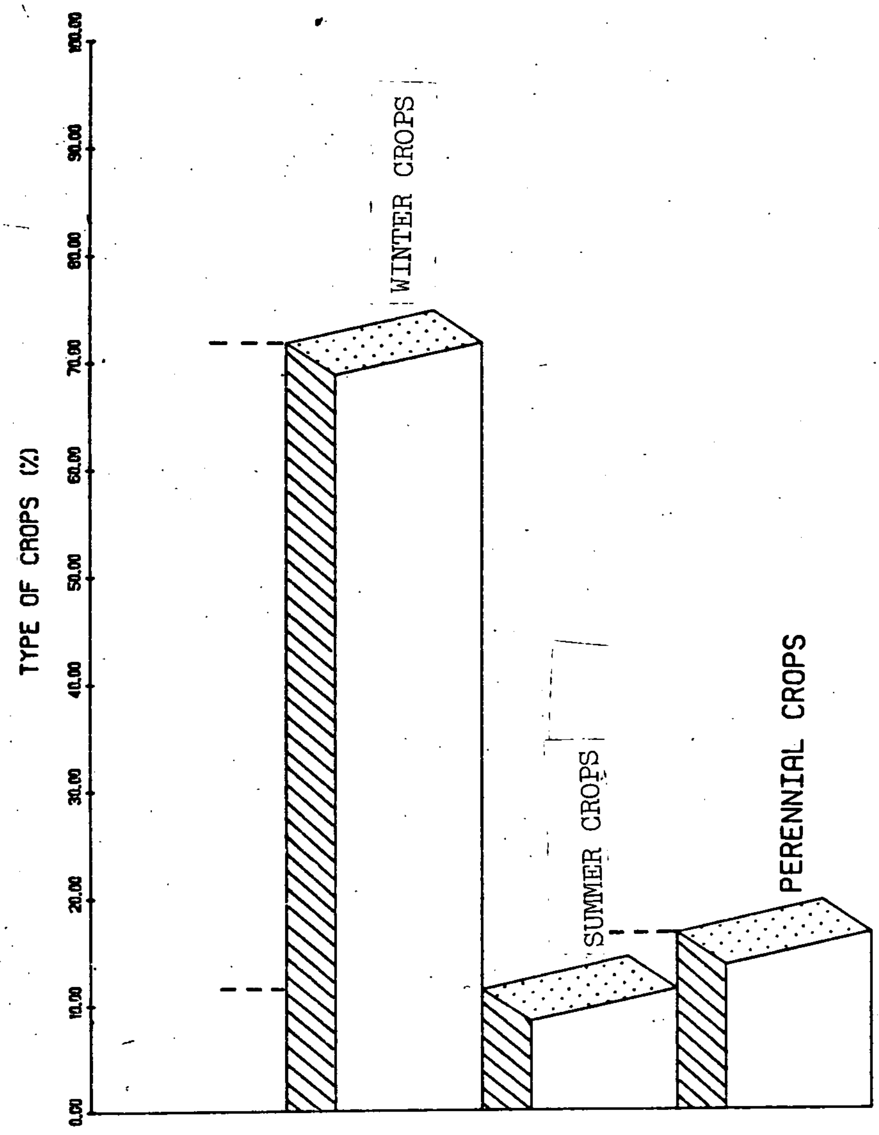
4.5.3 Perennial Crops

Perennial crops comprise : Firstly, alfalfa which is a common crop in the area. It is planted in all of the villages, and it covers 33 ha. of the cultivated land. Secondly, vines, which are planted in seven of the villages. Vineyards account for about 27.3 ha of the cultivated land. Thirdly, fruit trees which are found in seven villages. The total land under this crop was 24.7 ha, or 4.5% of the total cultivated land in the Abuzaid-Abad area. More details concerning the distribution of land under various crops in each village and in total is shown in Table 4.5 and Figure 4.9.

Table 4.5 Distribution of Gross Crop Land in the Abuzaid-Abad Area in 1978

Village \ Variable	Winter crops						Summer crops						Perennial crops						Total gross crop area ha
	Wheat		Barley		Poppy		Cotton		Onions & green vegetables		Beet		Alfalfa		Vines		Fruit trees		
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	
Fakhreh	6.3	42	5.4	36	-	-	1.8	12	0.2	1.3	0.6	4	0.7	4.6	-	-	-	-	15
Shahriary	5	50.5	4.3	49.4	-	-	0.28	2.8	-	-	0.21	2.1	0.25	2.5	-	-	-	-	9.9
Rigen	15.6	38.5	16	39.5	-	-	1.5	3.7	2.7	6.6	2	4.9	1.2	2.9	0.27	0.66	1.27	3.1	40.5
Ali-Abad	21	39.3	24	44.9	-	-	3.8	7.1	0.8	1.5	1.4	2.6	2.4	4.5	-	-	-	-	53.4
Mohamad-Abad	27.1	31.1	26.5	30.6	10	11.5	3	3.4	0.7	0.8	4.6	5.3	4.8	5.5	4.2	4.8	5.6	6.4	86.5
Abuzaid-Abad	54	31.0	50.3	28.9	15	8.6	8.3	4.7	3.5	2.0	11.4	6.5	12.7	7.3	11.5	6.6	7.3	4.1	174
Kagazi	25	40.4	17.27	27.9	-	-	-	-	1.8	2.9	2	3.2	4.1	6.6	6.6	10.6	5	8	61.8
Yazdelan	1.8	15	4.16	38.3	-	-	-	-	0.1	.83	0.4	3.3	1.7	14.1	1.1	9.1	2.28	19	12
Qasam-Abad	9.5	42.7	8.1	36.4	-	-	1.2	5.4	0.2	0.9	0.3	1.3	0.7	3.1	0.8	4	1.3	5.8	22.2
Hosain-Abad	22	46.5	11	23.2	-	-	2.5	5.2	1	2.1	2	4.2	4.5	9.5	2.3	4.8	2	4.2	47.3
Total	187.3	35.8	153.6	29.3	25	4.7	22.38	4.2	11	2.2	24.9	4.7	33	6.3	27.3	5.2	24.7	4.7	509.3
	365.9 ha 71.8%						65.2 ha 11.4%						88 ha 16.6%						

FIG 4.9 TYPE OF CROPS AND DISTRIBUTION OF AREA UNDER EACH TYPE



4.6 Amount and Distribution of Cultivated Land (Size of Holding)

The average amount of land possessed by farming families is inversely related to the population and directly related to the extent of cultivated land in each village in the area. The average size of each farm was found to be 1.5 Je[7] per individual and 8.5 Je per farming holding, but the range was from 0.6 Je to 3.9 Je per individual and 3.9 Je to 30.0 for each farming holding (household).(Table 4.6). The number of 63.2 Je refers to the Shahriary village where the qanat has dried up since 1977 and its residents have moved to the other villages or Kashan City. At the present time only 5 households are living in this village, and 65.5% of the cultivated land has necessarily been left fallow.

Traditionally, each village is divided into various units called Nasagh for the purposes of water rights and land distribution. These units are called Dang in some villages and Sarageh in others. Mohamad-Abad, Qasem-Abad and Yazdelan are divided into 120 Dangs and one Dang in these villages equals two hours allowance of village water. One Sarageh equals 9 minutes of village water allowance. All the villages in the area are divided using one or other of these two units and every farm holding has one or more such village units. Table 4.6 shows the distribution of villages on the basis of these units.

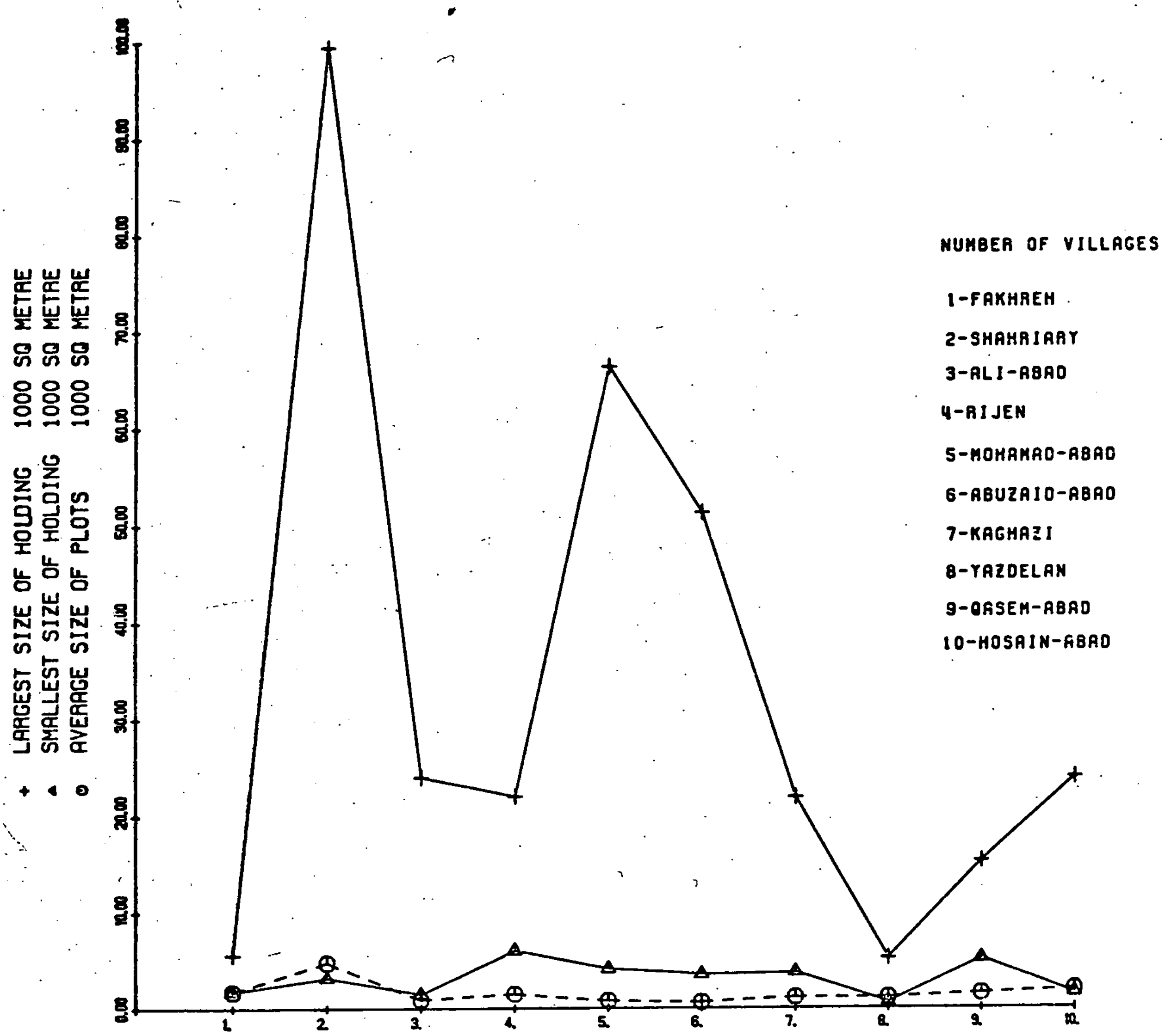
According to the field investigation the minimum and maximum ownership of village units of water allowance and size of land, and the largest and smallest holding is illustrated in Table 4.6 & Figure 4.10.

Table 4.6 Specification of cultivated Land Distribution in the Abuzaid-Abad Area 1978

	Total Cultivated area (Je)	Population	No. of Households	No. of Holdings	No. of Plots	No.of units "Dong" or "Savajeh"	Average size of cultivated land (Je) Per Person	Per House-hold	Per farm holding (Hse-hld)	Per Unit	Average size of plots (Je)	Smallest holding Je	Largest holding Je
Fakhreh	1020	257	50	34	584	1500	3.9	30	80.4	0.18	1.75	1.8	5.58
Shahriary	316	38	5	5	65	1800	8.3	63.2	63.2	0.7	4.8	3.2	99.4
Rigen	1130	338	70	69	1234	1500_S	3.3	16.4	16.8	0.75	0.9	1.5	24
Ali-Abad	1492	445	78	72	993	1500	3.4	13.9	19.1	1	1.5	6	22
Mohamad-Abad	1997	752	151	143	2615	120_D	2.6	13.2	13.9	16.6	0.8	4.1	66.4
Abuzaid-Abad	2586	3162	544	307	4659	1465_S	0.8	4.75	8.4	1.77	0.55	3.54	51.3
Kagazi	1097	789	165	152	1075	1500_S	1.4	6.6	7.2	0.73	1.02	3.65	21.9
Yazdelan	157	171	32	30	155	120_D	0.9	4.5	4.9	1.3	1.1	0.6	5.2
Qasem-Abad	612	344	69	65	415	120_D	1.7	8.8	9.4	5.1	1.5	2.5	15.3
Hosain-Abad	712	1207	210	180	406	1800_S	0.6	3.3	3.9	0.4	1.97	1.5	24

Source : Field Survey in the area (1978)

FIG 4.10 DISTRIBUTION OF CULTIVATED LAND IN THE ABUZAID-ABAD AREA 1978



4.7 Size of Farms and the Number of Plots in The Area

The cultivated land is usually divided into various parts in each village in the area. There are several reasons for the division, as follows:

(a) Quality of land

(b) Distance from village

(c) Nearness to the water resources

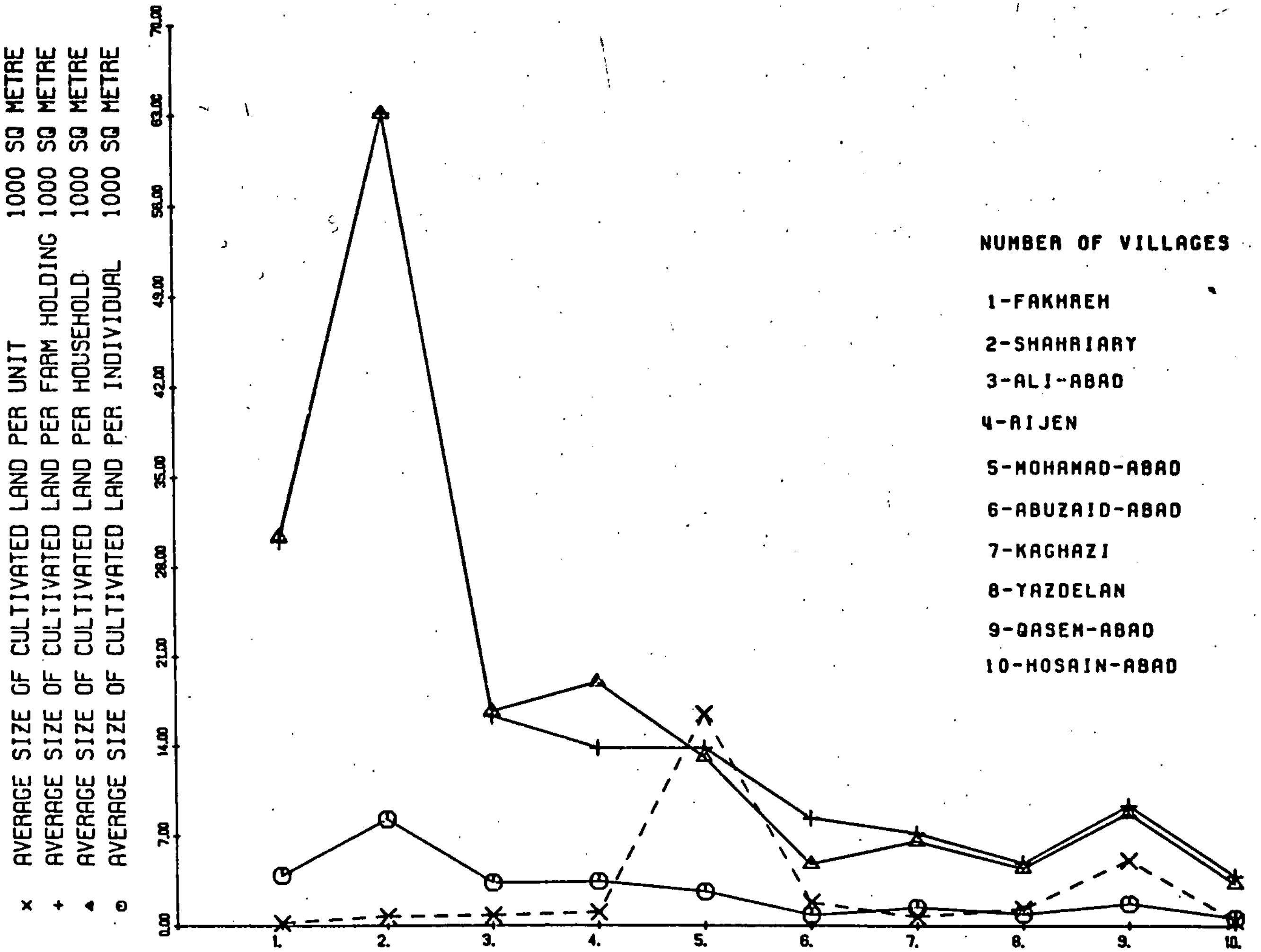
(d) Upland and low land

Although this action is fair, it divides the cultivated land into small pieces. As a result it causes some problems for agricultural activities, especially for irrigation, the use of agricultural machines, waste of human power, and as a result, the small size of the farms usually restricts agricultural activities in the area.

Usually each farmer's cultivated land is divided into a number of plots and the majority of these plots are very small. For example the smallest farm plot is 80 m^2 in Ali-Abad village. The average extent of the plots is about 1.2 Je and the range is from 0.8 to 4.9 Je.(excluding Shahriary).

Detailed information has been obtained by the author about the number of plots, number of units (Nasagh), total cultivated land, population, number of households, number of farm holdings, and about the average amount of cultivated land per person, per household, per holding and per unit. Also information has been obtained about the average size of plots, and the smallest and largest holdings in each village in the area (Table 4.6 and Figures 4.10, 4.11).

FIG 4.11 SPECIFICATION OF CULTIVATED LAND DISTRIBUTION IN THE ABUZAID-ABAD AREA 1978



The number of farm plots in Mohamad-Abad village has been investigated i.e. 98/143 of the farmers' land is divided into 10-20 plots, 29/143 into 20-30, 9/143 into 30-40 and 7/143 into 40-45 plots (Figure 4.12).

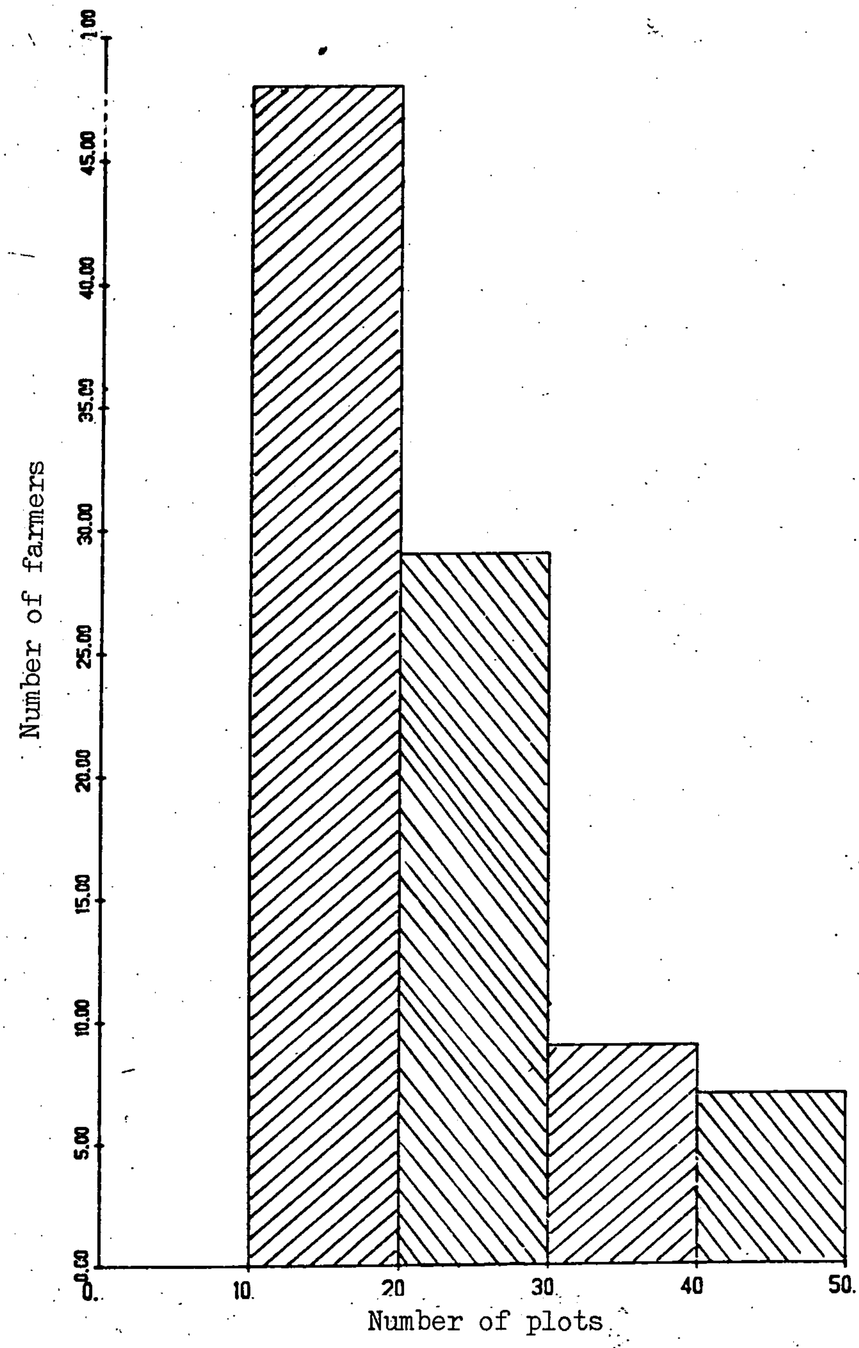
However, the average size of farm for an owner cultivator is 10.2 Je, which is normally divided into 12 plots, with each plot size normally about 0.85 Je in the adjoining villages in the Abuzaid-Abad area.

4.8 Conclusion

The land of the area can be divided according to the field survey into two major divisions; (a) cultivable land and (b) uncultivable land. Usually this division results from the impact of climate, ground water conditions and soil characteristics in the area.

The severe climatic conditions are one of the important factors that caused the different types of land. The high evaporation rate, low annual rainfall, allied to ground water, have been important factors in the development of saline land in the area. In the east of the area, in the hot arid region, the water table is found close to the surface. The close sub-surface water comes to the surface by capillary action and as a result, after evaporation, a high significant salt deposit remains on the surface, especially when the ground water content has a high concentration of minerals. This situation occurs in over 39% of the area. Many cases have been seen in the east of the Abuzaid-Abad area, where after the reduction of water resource discharge and the decrease in

FIG 4.12 DISTRIBUTION OF FARMERS PLOTS IN THE MOHAMAD-ABAD VILLAGE



irrigation water, the cultivated land has been changed to saline land. This situation has occurred in 17 hamlets in the east of the area. Also, sandy land and sand dunes which covered 27.1% of the total area resulted from the limited growth of vegetation. The very thin vegetation, caused by the severe climatic conditions cannot prevent the wind from blowing the sand from place to place.

However, in order to assess the land capability the main criteria involved are : climatic limitations, ground water quality and availability and soil properties. The severity of these factors has restricted the amount of cultivable land in the area. The available cultivable land has been divided, traditionally, into many small pieces and as a result it causes some problems for agricultural machines and a waste of human power, and furthermore it restricts agricultural activities in the area.

References

1. Edareh-e-Sābt-ē-Asnad va Amlak

2. Series K-551 Sheet No.N1 39-11 Published 1970 by The Geographical Organization of Iran, Tehran (Map)

3. Muxworthy, D.T. (1972) A User's guide to SYMAP and SYMVU, University of Edinburgh, Scientific and Social Sciences Library, Program Library Services, No. 12, pp.94.

4. See the chapter on Water Supply.

5. About 24.5 ha land has been reclaimed in the Abuzaid-Abad and Kaghazi area in 1978.

6. Bobek, H. (1959), The Great Kawir of Central Iran Arid Zone Research Center, University of Tehran. Published II. Tehran, Iran, p.42.

7. Je (Jerib) = 1000 m^2.

PART TWO

CHAPTER 5

WATER SUPPLY

5.1 Introduction

The influence of men on the water supply pertains to artificial storage, surface or underground diversion, transport and the extraction of groundwater etc. But the influence of men in the area is limited to the extraction of ground water which is operated by the qanats, shallow wells and deep wells, which are discussed as follows:

5.2 Qanats

This system of water supply is widely used for irrigation and domestic purposes in arid and semi-arid regions in some parts of the world, and in Iran, in particular, especially the Abuzaid-Abad area.

The qanat has been defined in several ways by research workers but most of them have not obtained a comprehensive definition of the qanat. Most researchers have not paid attention to the different sources of water and gradient of the tunnel and they believe that the qanats always feed off the watertable and are constructed into an alluvial fan and have gently sloping tunnels. For example, English (1968)[1] observes:

> "Qanats are gently sloping tunnels dug nearly horizontally into alluvial fan until the watertable is pierced"

Beaumont (1971) believes[2]:

> "The qanat is a method for developing and supplying ground water and consists of a gently sloping tunnel, cut through alluvial material which leads water by gravity flow from beneath the water table at its upper end to a ground surface outlet and irrigation canal at its lower end.

Ghazi (1977)[3], Walton (1969)[4], Honary (1980)[5] and Kuros (1971)[6] and others have given similar definitions. However, the author believes that although most of the qanats feed off the watertable, this is not always the case because there are many qanats that feed off springs, rivers and seepage from dams (see Fig. 5 .1). Qanats are not always constructed in the alluvial fan because the location of a qanat depends on the topographical condition of the area. Also, research workers paid little attention to the gradients of qanats, and this is an important point when considering the construction of a qanat and its study (See Appendix 3 - measuring the gradient of a qanat).

However, bearing in mind the above points, the author has tried to obtain a comprehensive definition of qanats as follows:

The qanat is a succession of vertical shafts, connected by a sloping tunnel. The slope of the tunnel depends on the length of the qanat and the different elevations between the depth of the main well and field. The qanats feed from the watertable, river or seepage from reservoirs. The water flows in the sloping tunnel from the source of water to the surface.

This system of water supply was widely used in the past and is still used at present for several reasons. First, qanats require no power source other than gravity to maintain flow. Secondly, water can be moved substantial distances in these subterranean conduits with minimal evaporation losses and little danger of pollution. Thirdly, the flow of water in the qanat is proportional to the available supply in the aquifer and, if properly maintained, these infiltration channels provide a dependable supply of water for centuries. Fourthly, a qanat is usually a sure,permanent source of water supply for settlements and irrigation in arid and semi-arid areas. Finally, the water of the qanats is usually more digestible than other water, especially in the Abuzaid-Abad area.

5.2.1 History of the Qanat in Iran

Qanats are extremely important in the history of irrigation and human settlement in the arid lands of the ancient world. A number of scholars have discussed the possibility of the existence of qanats in pre-historic times, such as Wulff (1968)(7) who said "it is still used after 3000 years". Bastani Parizy (1975)(8) demonstrated that the qanat of Joopar(9) near Kerman was dug some 3000 years ago.

Some research workers have shown the spread of qanats from Iran to other parts of the world. English (1968)(10) said "Apparently originating in pre-Achaemenid Persia, tunnel-wells spread to Egypt, the Levant and Arabia, western China and on a more limited scale in the dry region of Latin America (550-331 BC)" Honary (1980)(11) believes "...after the rising Islam, the qanat greatly spread through the world of Iran - from North Africa to Central Asia.(11)

5.3 Classification of Qanats

As previously stated, although most qanats feed off the water table, this is not always the case because there are many that feed off springs, rivers and seepage from dams (Fig.5.1).

The first category of qanats is called Qanat-e-Dashti (plain qanat). The source of water in the plain qanats comes from the water table and has gently sloping tunnels dug nearly horizontally into alluvial material until the water table is pierced. Generally when the term qanat is mentioned, it is this kind which is considered.

The second category is called Qanat-e-Motory (the engine qanat). This kind of qanat has recently been constructed in some parts of Iran. It is rather like a qanat-e-dashti, but with this difference - the water does not appear on the surface by gravity but must be pumped to the surface. This can result from incorrect digging or it may be dug to increase the water supply and reservation for a semi-deep well. This kind of qanat is found in Mazreah-e-Sarafrazieh in the Abuzaid-Abad area where the tunnel is 5 km.long and it has 110 shafts.

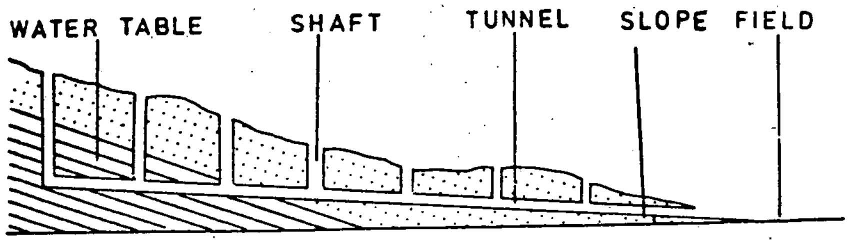
The third category is Cheshmeh-qanat (spring qanat). This kind of qanat is an extension of a natural spring and it is dug in mountainous areas. The length of the tunnel is usually short (200-1000 m) and the depth of the main well does not exceed 10-30 m. In this kind of qanat the rate of water flow is dependent on the rainfall. The qanats of Khomb and Doreh villages to the south of Kashan and Rahagh and Borz-Abad villages to the west of Kashan are Cheshmeh-qanats.

The fourth category of qanats feeds off seepage from a dam and it is called, on the south edge of the Dasht-e-Kawir, Qanat-e-Saddi (the dam qanat). This kind of qanat is fed by the water which seeps from reservoirs behind the dams. Usually the dams which feed the qanats were constructed in flood passes, and flood water collected behind the dam, and water seeps into the qanats dug beneath the dam. This kind of qanat is found in Jandaq to the south of Dasht-e-Kawir.

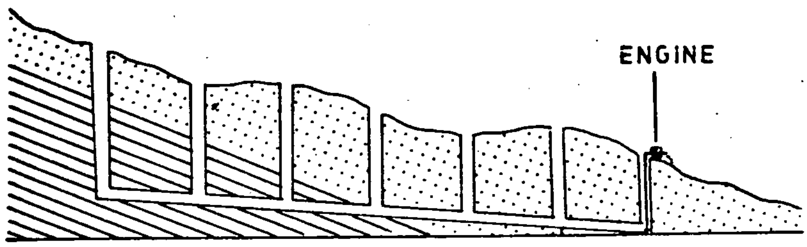
The fifth category comprise qanats that are fed by a river. This kind of qanat is named Mangol qanat, and exist in the Tehran area and Karaj[12] for example the Ab-mangol in Tehran and mangol qanats of Shams-Abad and Mohamad-Abad villages. They flow from the Gordan river to the west of Karaj. This type of qanat is a ditch which is diverted from the river, and as the depth of the ditch increases because it may pass hills or mountains, it goes underground, and when a long tunnel is to be dug underground, shafts are required to remove the soil and to provide ventilation.

The actual method for the construction of a qanat,

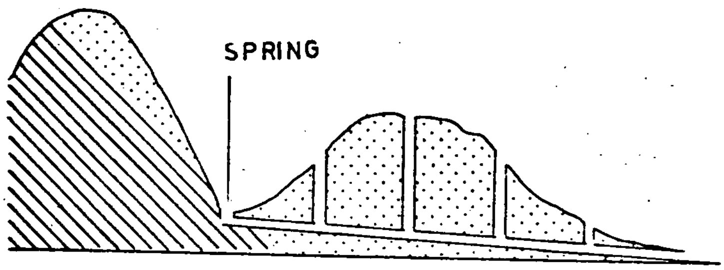
FIG 5.1 CROSS SECTION OF DIFFERENT TYPES OF QANATS



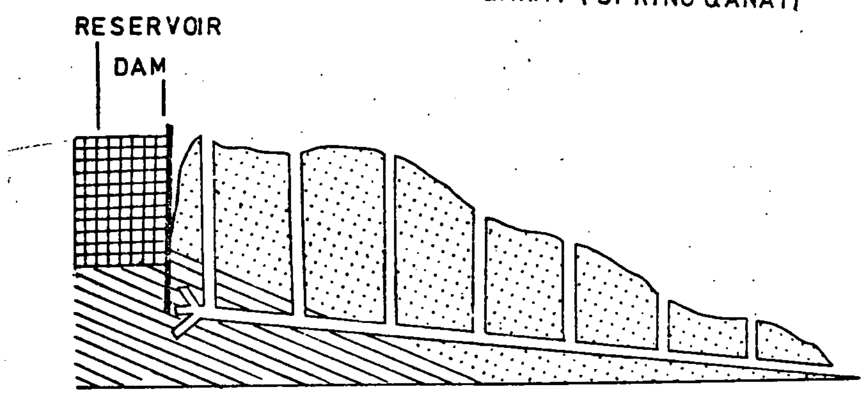
QANAT-E-DASHTI (PLAIN QANAT)



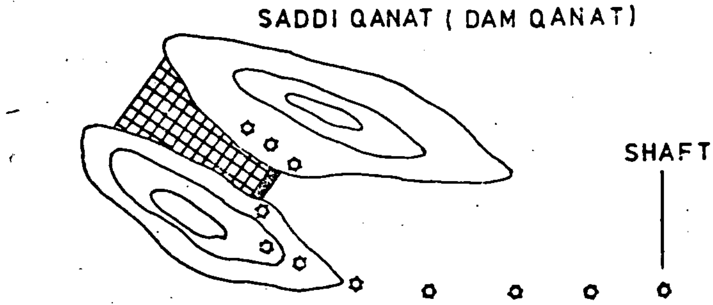
QANAT-E-MOTORY (ENGINE QANAT)



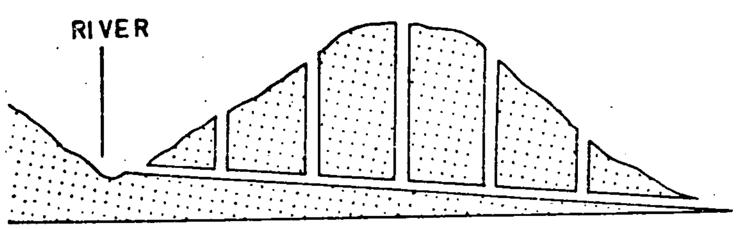
CHESHMEH QANAT (SPRING QANAT)



SADDI QANAT (DAM QANAT)



PLAN SECTION OF SADDI QANAT



MANGOL QANAT (RIVER QANAT)

mathematical methods for the estimation of the qanat gradient and the method of qanat digging have been described in the Appendix 3.

5.4 Qanats of Adjoining Villages of Abuzaid-Abad

There are ten functioning (running) qanats in the area, in addition to some old and out-of-order qanats that are not in use. Although there are plans to repair and maintain these qanats in the agricultural policy after the revolution in Iran, this policy should only be carried out as part of a scientific programme in the future.

The total length of the qanats is 64.5 km. in the adjoining villages of Abuzaid-Abad. The qanat of Hosain-Abad is the longest (12 km). There are approximately 2115 shafts connecting the 64.5 km length of tunnel.

5.4.1 Type of Qanat in the Area

Although all the qanats in the area are Dashti-qanat, the Moganis (qanat diggers) believe that they can be divided into two sorts, as follows:

(a) Pust-Ab (which means the watertable is near the surface). There is a limited layer of water relatively near the surface. The qanats using this sort of water are called pust-ab-qanat. In other words the Moganis and the farmers in the area believe if the depth of the main well is less than 30 m. then the qanat is pust-ab.[13]

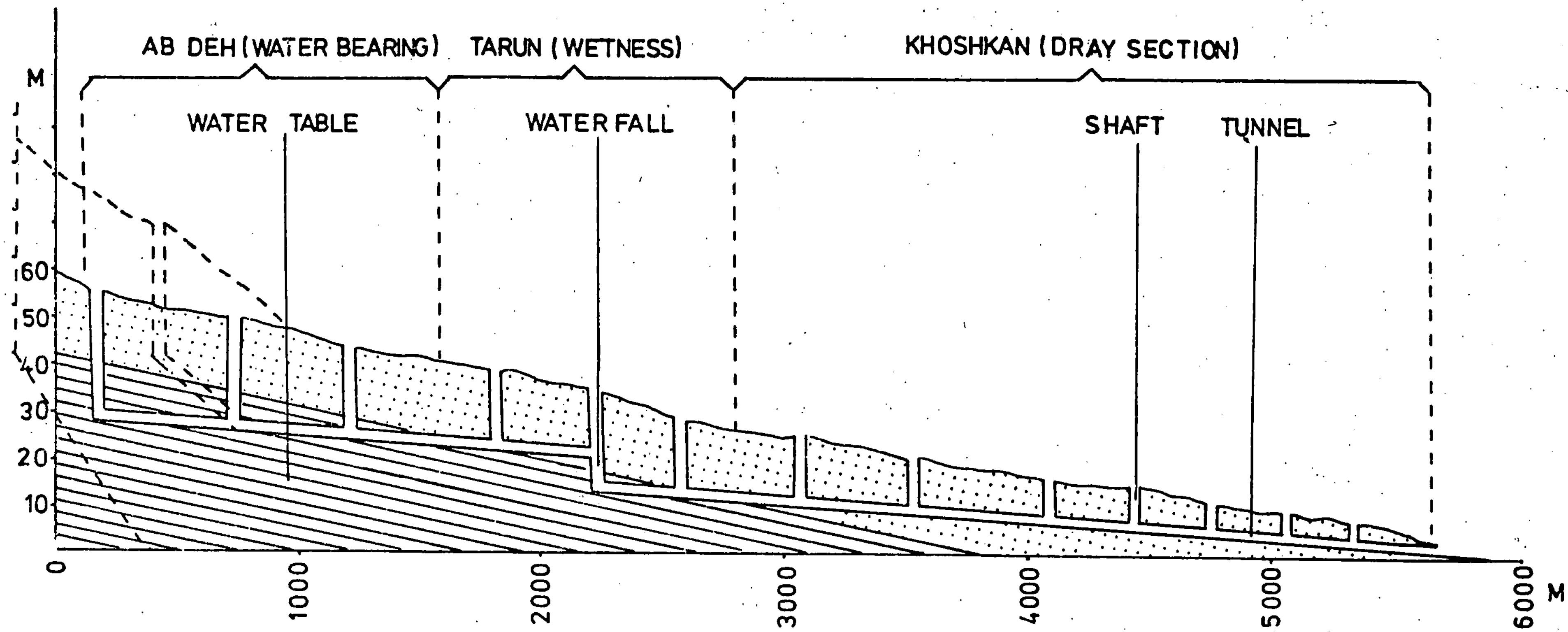
The specific water yield of pust-ab qanats change during the year. They have maximum discharge at the end of February, and minimum discharge at the end of September (see the chapter on hydrology). Moreover their total discharge directly depends on the annual rainfall. The qanats of Shahriary, Rijen, Yazdelan and Qasem-Abad villages in the area are post-ab.

(b) Qarq-ab (which is the deep rich permanent water table). If the main well is dug to more than 30 m. depth in the area, it will use the permanent water table, and the annual discharge does not completely depend on precipitation; the discharge usually does not change during the year. The qanats of Fakhreh, Ali-Abad, Mohamad-Abad, Kaghazi, Hosain-Abad and Abuzaid-Abad are qarq-ab. (Figure 6.2 shows a cross section of Mohamad-Abad qanat in detail).

5.5 Discharge of Qanats in the Area

According to a report published by the Ministry of Water and Power of Iran[14], the discharge of qanats in all the villages in the Kashan region was measured. The total discharge of qanats was 2,958,980 m^3/year in 1964 for the 11 adjoining villages of Abuzaid-Abad.

FIG 5.2 CROSS SECTION OF THE QANAT OF MOHAMAD-ABAD



Horizantal Scale 1 : 30,000
Vertical Scale 1 : 1,500

The author has estimated the discharge of qanats of the Abuzaid-Abad area in 1978. This has been calculated to be about 1,942,920 m^3/year for the area under investigation. Figure 5.3 shows the qanats discharge fluctuation in the area (1964 to 1978). According to the above estimations the total discharge of qanats has decreased to 72,575 m^3/year in the area (1964 and 1978 had been normal years from the point of view of rainfall). Inother words it has decreased by 34.3% during the last fourteen years. But, fortunately, this decrease has been conpensated for by deep and shallow wells. The total specific yield in 1978 was 222 m^3/hour. The average specific yield of a qanat in the area under investigation was 22.2 m^3/hour during the field work period. Table 6.1 shows the specification of qanats in the Abuzaid-Abad area in 1978.

The qanats supplied 24.5% of the total water (see The balance of ground water extraction Section) which was supplied from different sources in the area in 1978. It should be noted that 334,000 m^3/year of the total discharge flowed out during the winter. Of course, in wet years this amount of water is no use to agriculture, but in dry years all the water which is discharged from the qanat is used for irrigation.

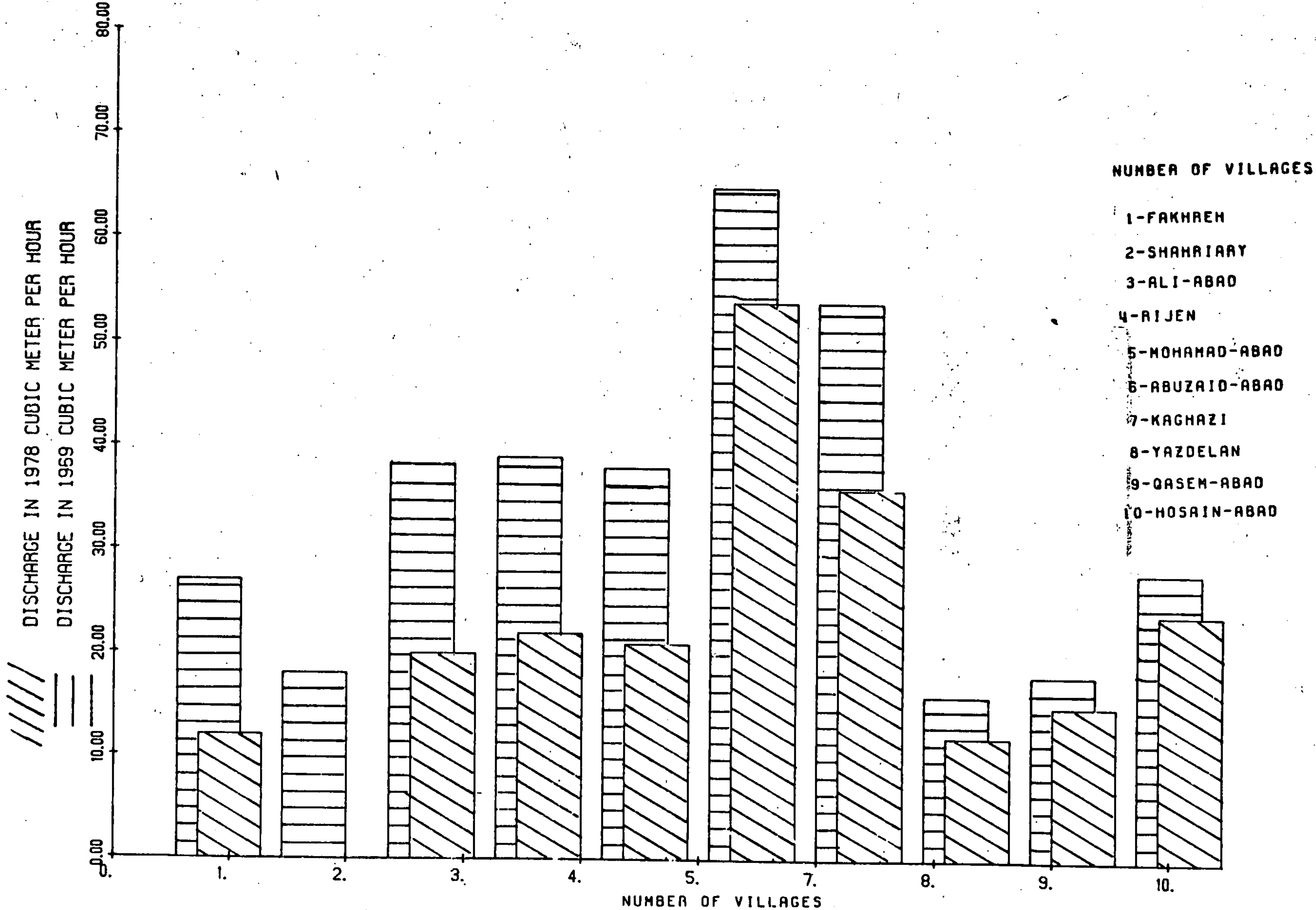
One criticism of the qanat can be made in that it wastes water during winter, or during times when cultivation does not need irrigation. On the surface this criticism appears valid, but in fact it is not exactly correct in that it is an external judgement of the qanat. Because, although a qanat is a permanent resource for water supply which

Table 5.1 Specificati on of qanats in the Abuzaid-Abad Area (1978)

No.	Villages	Length of qanat	Depth of main well	No. of shafts	Discharge m^3/year 1964	Discharge m^3/year 1978	Rate of decrease %	Specific yield m^3/hrs.
1	Fakhreh	5,140	75	123	236,520	103,080	56.4	11.7
2	Shahriary	6,245	18	155	157,680	has dried up	100	-
3	Rijen	7,250	16	238	865,760	172,800	34.9	19.7
4	Ali-Abad	8,550	41	214	341,640	162,800	52.3	18.6
5	Mohamad-Abad	5,545	28	139	332,880	182,800	45.0	20.8
6	Abuzaid-Abad	9,140	32	228	569,400	466,560	18.0	53.2
7	Yazdelan	9,480	22	238	140,160	103,980	25.8	11.8
8	Kaghazi	10,550	32	251	473,070	311,040	34.2	35.5
9	Qasem-Abad	8,950	16	224	157,680	129,600	17.8	14.8
10	Hosain-Abad	12,125	35	305	284,250	207,360	27.0	23.7
	Total	64,340		2,115	2,958,980	1,942,920	34.3	222

Source : Ministry of Water & Power (14) and Field Studies 1978.

FIG 5.3 QANAT DISCHARGE FLUCTUATION IN THE ABUZAID ABAD AREA



discharges underground water throughout the year, it must be realized that during wet years when the rainfall saturates the watertable, surplus water flows by runoff (see 'water balance' in the Chapter on Agroclimatology) and in these circumstances it is not important whether surplus water flows along a qanat or from a temporary spring. Furthermore, usually in all the villages in the arid areas of Iran qanat, water is used in the home and for animal husbandry throughout the year. Also, as stated earlier, during dry years the qanat is a source of water supply and is used for winter crop irrigation.

5.6 The Factors Causing a Reduction in the Discharge of Qanats in The Abuzaid-Abad Area

The qanat is a water supply system widely used throughout the country. Unfortunately, recently the specific yield of some qanats has decreased, especially in arid areas. There are many different causes of this decrease of qanat discharge in various regions depending on some factors relating to the geographical conditions. The most important causes in the area under investigation are as follows:

5.6.1 Drop in the water table

It is obvious that if the amount of water withdrawn from the ground water is more than the amount of water which seeps into the ground, the water table will drop. In recent years this has been the case and as a result the level of the water tables have dropped in relation to ten years ago.

Qanats are fed by the water table in the area. The Ab-Deh (water bearing) section of tunnel is dug almost horizontally into the aquifer and water seeps into the tunnel. When the water table drops, the proportion of Ab-deh decreases until the water does not perfectly seep into the tunnel. This situation has occurred in most of the qanats in the area. (Shahriary qanat dried up in 1977). Of course, sometimes extending the tunnel can be a remedy, but in some circumstances it is difficult to reach the ground water horizontally, then the floor of the tunnel can be dug downwards. This is called pay-cani. This was carried out in Kagazi village in 1977. But sometimes the water can drop too much and in this situation the water which the qanat discharges as a result of the repair may not be useful for irrigation purposes because the level of the water has dropped, but the level of the farms has not changed.

5.6.2 Wells

According to the Ministry of Water records in 1964, the total discharge of 11 qanats was 2,958,980 m^3/year and the total discharge of two shallow wells was 603,600 m^3/year at the same time. But according to estimations made by the author in 1978 the discharge of 10 of these qanats was 1,942,920 m^3/year (Shahriary qanat had dried up) and the rate of decrease is about 34.3% over fourteen years, averaging 2.45% for each year. The total discharge of wells, most of which have been dug during the last ten years, is about 6,036,000 m^3/year. The total discharge of wells at the present time is twice the discharge of the qanats fourteen years ago. On the other hand, precipitation, which is the main resource for stocking the ground water in the area has not changed during the last fourteen years (see Chapter on rainfall). There is no doubt that one of the main reasons for the drop in the water table is the over-withdrawal of ground water by wells in the area.

5.6.3 Artificial Forests

During the last 8 years the Ministry of Natural Resources has made artificial forests to control the shifting sand problem and to prevent the spread of the desert (see the chapter on Soils and Vegetation). The trees planted in these forests usually have long vertical roots (most of these are Tamarix Sp.), which extend to a depth of 8 m.[15] As there is a huge artificial forest in the area and the trees feed off the water table, this also has an effect on the yield of qanats.

5.6.4 Land Reform

Qanats need to be repaired and maintained all the time. If this is neglected, they will be destroyed within a few years. Before the Land Reform in Iran, qanat repair and maintenance was the duty of the owners who were usually keen to maintain the qanats and keep them in good condition, carrying out repairs quickly and properly. Unfortunately, since Land Reform, qanat repair has not usually been done quickly in most of the villages, because; first of all it has been difficult to get all the farmers to agree to repairs, and secondly, the collection of money from poor farmers has been another problem. Although the last government tried to provide some loans for repairs, this has not been successful because of the many official problems involved in borrowing money and so the farmers have usually been unable to take advantage of it. Nevertheless, they needed water for irrigation, and so some of them who could collect enough money, or who were rich, dug deep wells and shallow wells. This situation has resulted in two main problems: First, the rich farmers' attention has turned from qanats, which are public, to wells, which are often private. Secondly, the wells themselves are often a cause of the decrease in qanat discharge. This condition has occurred in most parts of Iran, and the Abuzaid-Abad area has suffered along with other areas.

5.6.5 Repair and Maintenance of Qanats in the Area

Several of the factors preventing the water from flowing into the tunnel or decreasing qanat yield are as follows:

(a) Collapse. Blockage of the tunnel can be caused by a broken kool (lining) or if a roof collapses, both of which prevent the water from flowing. To repair it the labourers enter the tunnel to replace the broken kool, or clean out the tunnel.

(b) Flood. Sometimes a sudden flood following a heavy rain storm washes away the raised earth ring around the opening of a shaft and water runs into the tunnel. This demolishes the shaft and the tunnel, and it then fills up with silt.

(c) Earthquakes. Sometimes a sudden earthquake makes the tunnels collapse and demolishes the qanats.

(d) Shifting sand. The movement of sand in arid areas often fills the open shafts and ditches with sand.

(e) Deposition in the tunnel. Water brings silt from the upper section of the tunnel and deposits it in the lower section of the water bearing part of the tunnel. The silt can block the tiny springs and prevent seepage of water into the tunnel.

(f) Sedimentation. In some qanats the water itself carries sediment and deposits it on the bottom of the tunnel and the rate of water flow then decreases.

In the Abuzaid-Abad area attempts were made to repair seven of the qanats by the farmers in 1977/1978 at a total expense of approximately 5,195 Rials (Table 5.2).

5.7 Shallow Wells

Shallow wells are dug in most parts of Iran especially in arid and semi-arid areas. Recently the shallow well has become one of the most common methods of supplying water, because digging of a shallow well does not require much money, the permission of the government, or the opinions of experts.

Usually from the farmers point of view, three basic factors are sufficient for the digging of a shallow well in the arid and semi-arid regions, especially in the Abuzaid-Abad area. The need of water for irrigation, land for agriculture and the relatively small expense involved. If any one farmer or a group of farmers find themselves in the above situation they usually decide to dig one or more shallow wells.

But these basic factors are often not sufficient for the digging of a shallow well because in some places either the rich water table is not near the surface, or the water is

Table 5.2 Cost of Repairing the quanats in the Abuzaid-Abad Area (1978)

No.	Village	Cost (Rials)
1	Fakhreh	257,000
2	Shahriary	-
3	Rijen	354,000
4	Ali-Abad	430,000
5	Mohamad-Abad	1,175,000
6	Abuzaid-Abad	1,254,000
7	Kaghazi	1,000,000
8	Yazdelan	-
9	Qasem-Abad	724,300
10	Hosain-Abad	-
	Total	5,194,899

Source : 1978 Field Survey

salty, especially in the area under study. As a result there are many unsuccessful shallow wells in various parts of Iran because some of them cannot supply enough water for the pump connected to them so the pump does not operate at full capacity. Also, where the water is salty it is not suitable for crops. The shallow wells of Ali-Abad and Shahriary villages are a good example of this.

5.7.1 Types of Shallow Well

Various types of shallow wells are dug in the area, the most common being as follows:

(a) Chahe-Makhzani (reservoir well) This kind of well is the most common for supplying water to individual small farms. It is dug by hand and expert advice is not necessary. It is usually constructed with a large diameter, about 4-8 metres,and to the depth of a few metres below the water table level (maximum 6 metres). There is a platform of about 2-3 square metres for installation of the engine and pump on one side of the well. This platform is usually 0.5-1 metre above the highest water table level, so the owner of the well need not worry that the water may rise and cover the engine. The platform is joined with a steeply sloping tunnel to the surface; the degree of gradient of the tunnel depends on the depth of the well as does its length. Figure 5.4 shows the position of the engine and pump. There are usually one or more tunnels for the collection of water which are usually dug in the direction of the ground water flow. These tunnels are constructed, while the yield of water filtering from the aquifer into the well is not enough for full pump capacity. When the engine stops the water collects in the tunk (well), and it rises to the level of the water table. If the rate of infiltration of water is equal to, or more than, the yield of the engine, the level of water does not change inside the well - this is the best condition and such a well can operate 24 hours a day. If the level of the water goes down until the well is empty, the rate of infiltration is less than the rate of the pump,and the engine of such a well cannot operate at full capacity 24 hours a day, so it usually works on and off throughout the day. For example the wells of Shahriary and Qasem-Abad villages are in this situation.

(b) Vertical shallow wells - are often dug in the area where the water table level is not close to the surface, and may even be 20-30 metres down. In this kind of well the pump, located at a maximum of 30 metres below the surface, draws water up to the surface from a depth of as much as 6 metres below itself.

To construct a vertical shallow well, first of all it is necessary to dig a shaft called the main shaft, with a diameter of 1.5-2 m. This shaft is dug to one metre or less above the water table level. At this level a platform is made about 2 or 3 m^2 for the installation of the engine and pump. The platform is joined with a steeply sloping tunnel to the surface. The length of the tunnel will be 125 ,or 250 m. if it leads to a platform at a depth of 25 m. at a 20% or 10% gradient respectively. The main shaft is dug to a maximum of 6 metres below the water table. Now if the penetration of water to the main shaft is satisfactory,the digging of the well is finished. If not, one or more tunnels will be dug from the bottom of the shaft. The tunnel may be dug like a qanat on one side of the main shaft, in which case it will be long, or several tunnels are dug in different directions from the bottom of the main shaft like a radial well (Fig.5.5).

(c) Qanat-e-motory (engine qanat). This is a special kind of shallow well and is not a very common method of water supply. But recently some of the old qanats even after repair are often no use because the water table level has been drawn down, or there has been some mistake in the measurement of the slope; in both these situations the water does not flow by itself to the field. The owners of these kind of qanats have to pump the water from one of the shafts to the surface. The engine and pump of a qanat motory is usually located at the surface, and the water is pumped by a suction pump. The source of water supply in Mazraeh-e-Sarafrazieh in the Abuzaid-Abad area is a qanat, but its water can not flow by itself to the field because the slope was incorrectly measured when the qanat was dug in 1961. Now the water is pumped from the last shaft.

5.8 Shallow Well Digging

Well digging is rather similar to qanat digging. The Moqani (qanat digger) usually dig the wells. Well digging is usually easier than qanat construction, although there are some special techniques in shallow well digging, and it is a skilled job. From two to five people are directly involved and the general name for a well digger is Chah-kan (well

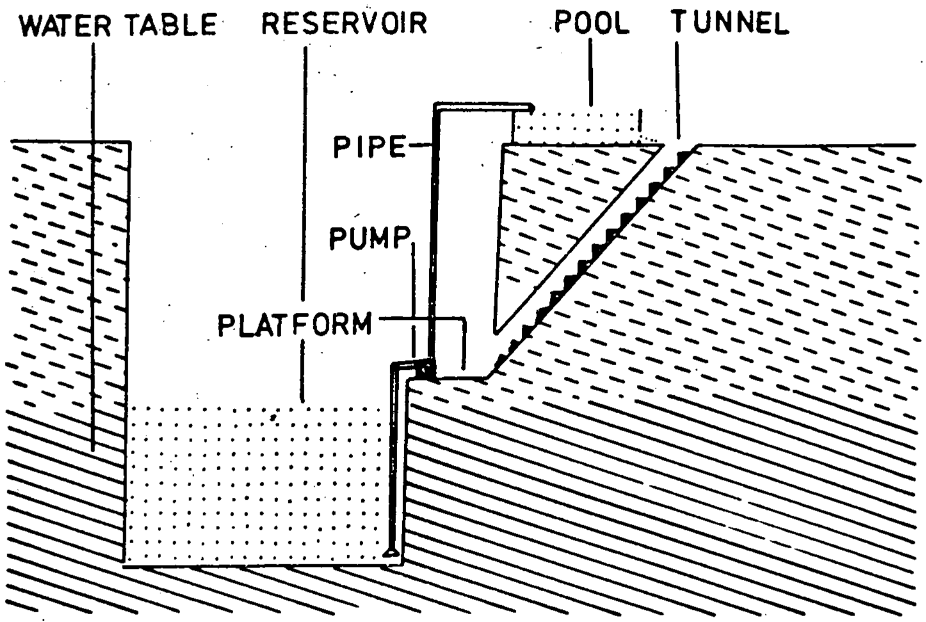


FIG 5.4 RESERVOIR SHALLOW WELL

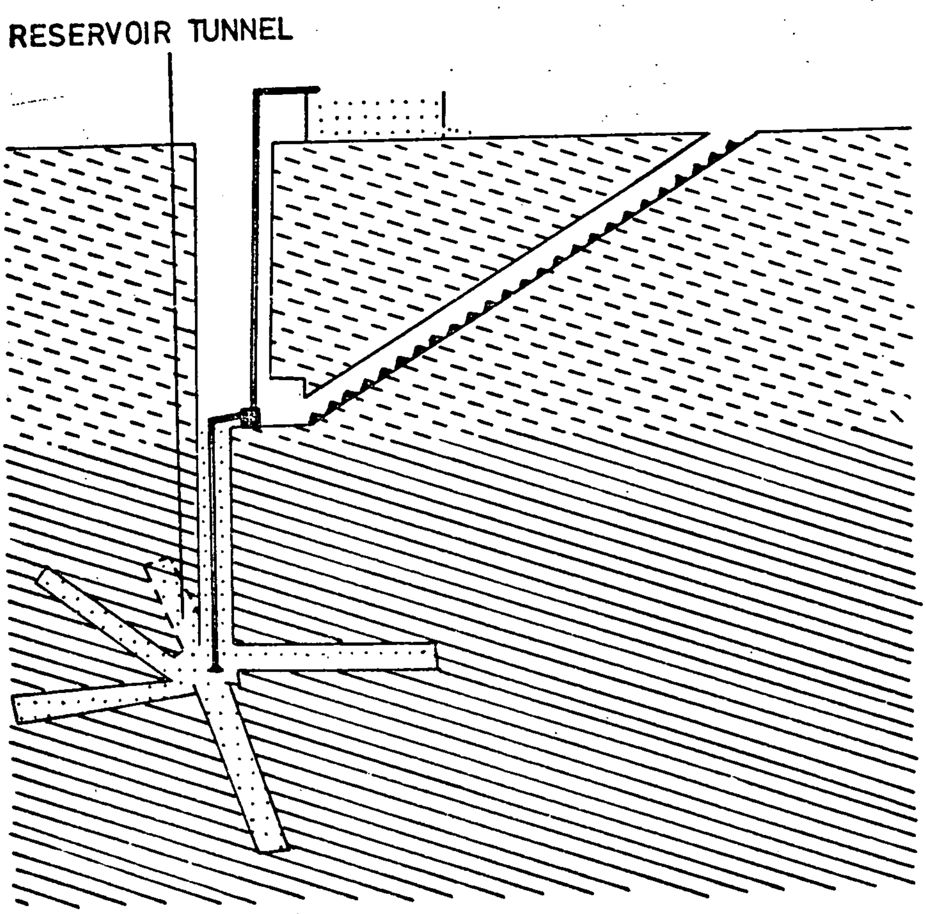


FIG 5.5 VERTICAL SHALLOW WELL

digger), the term being applied to any one of the group of labourers, although each does a different and specific job such as -

Koleng Dār (pick holder) who is actually the digger; he is an expert at digging wells and tunnels, and at measuring and surveying. Whilst he is digging a well or tunnel, he puts the soil or mud behind himself. The Koleng-dar Assistant, who is called Lashe-kash (soil puller) puts the excavated soil into a bucket and he hangs the bucket on the rope hook and it is raised out of the well by the wooden windlass which is turned by the Charkh-kash (windlass turner). He operates the windlass or Charkh with his hands and a foot. The Dalv-gir (bucket-catcher) catches the loaded bucket which has been raised up by the Chakh-kash and stacks the contents around the mouth of the well.

5.9 The Factors Causing Problems for Shallow Wells in the Area

Reservoir wells, with large diameters, are usually dangerous for workers and animals who may fall in. In order to prevent such occurrences, the owner has to build a roof over the well and this is usually expensive.

In unconsolidated soil the walls of wells collapse into the well and this is a big problem. In this type of porous soil a masonry lining is often used to support the excavation.

Carrying the engine, pump, pipe and other equipment along the narrow tunnel to the platform is also a problem in vertical shallow wells.

Reservoir wells are often dug in places where the water table level is near the surface. If the water table falls during a dry spell, a shallow dug well may easily go dry. Thus this type of well is often unreliable for agriculture, especially for orchards.

Repair or maintenance of wells must be carried out every year, and sometimes a hugh quantity of soil must be removed from the tunnel by windlass from the bottom of the well. The repair or maintenance of the engine and pump is also a problem, especially when it must be taken to a workshop because this means that it must be carried through the tunnel.

The platform where the engine and pump are established inside the well, is wet, also the space is not very large on the platform area, and the engine produces carbon monoxide and other gases that are dangerous for workers and damaging to the engine itself. Usually the damp conditions and bad weather reduce the efficiency of the engine.

5.10 Characteristics of Shallow Wells in the Area

There are six shallow wells operating in the area, which have been dug during the last 15 years (since 1963). These wells are privately owned except for the Shahriary shallow wells which belong to the entire village.

The capacity of water obtained from the wells depends on several factors, e.g. engine power, specific yield and the length of time per day when the well is operating. These factors are shown in Table 5.3. If it is assumed that

Table 5.3 Characteristics of Shallow Wells in the Area (1978)

Village	No. of Shallow wells	Specific yield m^3/hour	Operate for an average hours/day	The total of discharge m^3/9 months of 1978
Shahriary (1)	1	40	2	21,600
Shahriary (2)	1	45	3	36,450
Ali-Abad	1	60	7	113,400
Abuzaid-Abad (1)	1	100	20	540,000
Abuzaid-Abad (2)	1	80	20	432,000
Qasem-Abad	1	40	8	86,400
Total	6	365		1,229,850

Source 1978 Field Survey

the wells operate for an average of 9.5 hours per day, although the well at Abuzaid-Abad operates 20 hours per day, and the well at Shahriary operates 2 hours a day, the total specific yield of the wells should be 52.5 lit/sec. The total water yield capacity is about 189 m^3/h, and the annual (9 months of the year) discharge of all shallow wells is about 122,985 $m^3/9$ months (1978). These wells supply 15.5% of total water which also comes from other water resources. The water supplied by the shallow wells is salty, except for the Mazreah-Sarafrazihe (Abuzaid-Abad-2) which is a qanat motory.

The cost of digging a shallow well in the area depends on many factors, e.g. kind of well, type of engine, pump house, tunnel etc. But in the study of these wells, the owners were asked how much money they spent, and this is shown in Table 5.4.

Table 5.4 Cost of Shallow Wells in the Area

Village	Cost (Rials)
Shahriary (1)	200,000
Shahriary (2)	150,000
Ali-Abad	250,000
Abuzaid-Abad (1)	2,000,000
Abuzaid-Abad (2)	3,000,000
Qasem-Abad	300,000
Total	6,900,000

5.11 Deep Wells

Deep wells generally serve as devices for extracting ground water from aquifers. The selection of the design of a production well and a particular method depends upon the quantity of water required, economic factors, hydrological conditions and the farm, or the farm's' condition. The construction of many production wells can benefit from the professional assistance of ground water hydrologists, and geologic and hydrologic information gives positive guidance concerning the proper location and completion of production wells and optimum pumping rates.

Subsurface exploration is often done with small-diameter test holes from which samples of the soil and rock may be obtained and tested for permeability and specific yield. Pumping tests may also be conducted on these test wells to determine the transmissibility and storage constant for the aquifer.(16) More details of deep well construction has been described in Appendix 4.

5.11.1 Exploration of Deep Wells in the Area

The Ministry of Water & Power has dug five exploration deep wells in the Kashan region. The aim of this was to study the hydrology in the region.

Fortunately one of these wells is located in the Abuzaid-Abad area in Mohamad-Abad village. In 1976 it was sold by the Ministry of Water to the Mohamad-Abad people to supply water for irrigation. The characteristics of this well are as follows:

(a) Construction of the well. The original depth of this well was 126 m, but at 119 m it met the Palaeocene layer, and so it was filled with sand and cement to about 17 m. from the bottom - now the depth of the well is 119 m.

This well was drilled from the surface to a depth of 20 m with a 16 inch auger and from 20 m. to the bottom with a 14 inch auger. The pipes used in this well are: from the surface to a depth of 18.2 m. there is a usual 14 inch diameter pipe, from 18.24 m. to 108.38 m. there are screen pipes with a 12 inch dimater, and the rest of the well has the usual pipe.

(b) Geological and hydrological characteristics. The thickness of the quaternary alluvium is 120 m. in this area. There is a Palaeocene formation under this alluvium. Four aquifers have been recognized in the profile of this well. The first aquifer is located at a depth of 19 m; the second 29-36 m.; the third 42-57 m. and finally the fourth at 81-87 m. from the surface.

The degree of salinity of the first aquifer is 1340 m.g/lit and 1320 m.g/lit for other aquifers. The electrical conductivity is 5710 micromhos in the first aquifer and 5750 mmho/cm^2 in the others.

The maximum rate of capacity of water yield is 45 litres per second or 175 m^3 per hour. The engine planted on the well has a strength of 50 horsepower and the pump is situated at a depth of 60 m. and the diameter of the out put water pipe is 6 inches.(17)

5.12 Deep Wells in the Abuzaid-Abad Area

There are eight deep wells in the area under investigation which have been dug during the last six years (Table 5.5).

The total water yield capacity is about 920 m^3/hour[18] and the total annual discharge of all deep wells is about 4,980,000 m^3. Deep wells supply the 64.1% of total water, which also comes from other water resources (qanats, shallow and deep wells). The annual discharge of the deep well was about 2.5 times the qanat's supply in 1978.

Fortunately there are two favourable conditions for deep well development in the area. Firstly, the government plans after the revolution,in connection with agricultural development,are a main factor. Secondly, the high income to be derived from carpet production. These favourable conditions will help the deep wells' development in the future. But the salinity of water which some of the deep wells supply is a big problem for agricultural development because it is not suitable for crop irrigation. Therefore, the farmers have to raise some crops which are not sensitive to this saline water, e.g. barley and alfalfa etc. This, therefore, limits agricultural production in the area. There is also the problem that using the saline water for a long time may cause salt deposits to build up on the soil.

5.13 The Balance of Ground Water Extraction in the Abuzaid-Abad Area

Ground water in the area is extracted by shallow wells, deep wells and qanats. The total discharge of wells

Table 5.5 Characteristics of Deep Wells in The Abuzaid-Abad Area (1978)

Village	No. of well	Specific yield m^3/hour	Operate an av. of hours/ day	The total of discharge m^3/9 months	Cost of deep well (Rials)
Ali-Abad	1	120	20	648,000	4,500,000
Mohamad-Abad (1)	1	100	20	540,000	2,660,000
Mohamad-Abad (2)	1	120	20	648,000	4,220,000
Abuzaid-Abad (1)	1	120	20	648,000	1,800,000
Abuzaid-Abad (2)	1	100	20	540,000	1,600,000
Abuzaid-Abad (3)	1	120	15	486,000	4,230,000
Kaghazi	1	120	22	712,800	4,500,000
Hosain-Abad	1	100	20	540,000	4,000,000
Total	8			4,762,800	28,610,000

Source : Field Survey 1978

and qanats was measured in 1978 and found to be about 7,978,920 m^3/year.

In total, in 1978 there were ten running qanats with an annual discharge of about 1,942,920 m^3/year, with a yield of water capacity of 222 m^3/hour or 24.5% of the total discharge and 6 operating shallow wells, which annually discharge about 1,229,850 m^3/year with a yield of capacity of about 190 m^3/hour or 15.5% of the total discharge. In addition there are eight deep wells in working order which annually discharge about 4,762,800 m^3/year with a yield of capacity of 735 m^3/ hour, or 60% of the total discharge.

The total water yield capacity is 1142 m^3/hour. Table 5.6 and Figure 5.6 show the characteristics of the water supply in the adjoining villages of the Abuzaid-Abad area.

5.14 Conclusion

The influence of men in the area is limited to the extraction of ground water which is accomplished by the qanats, shallow wells and deep wells.

The qanat system for water supply purposes was widely used in the past and is still used. Recently, after the Revolution, the government has paid more attention to the development of qanats. There are ten functioning qanats in the area. The total length of the qanats is about 65 km with 2115 shafts. Unfortunately, four of them are Pust-Ab qanats because the specific water yield of them depends on the annual rainfall and climatic conditions. However, the

Table 5.6 Characteristics of Water Resources in the Abuzaid-Abad Area (1978)

Variables / Villages	Qanat				Shallow well				Deep well				Total discharge m^3/year
	No. of qan.	Annual dis. m^3/year	Specific yield m^3/hr.	Percent of tot.dis	No. of wells	Total dis. m^3/9 mth	Specific yield m^3/hour	Percent of tot.dis	No.of wells	Tot.dis m^3/9 mth	Specific yield m^3/hour	Percent of tot.dis	
Fakhreh	1	1,030,080	11.9	100	-	-	-	-	-	-	-	-	103,080
Shahriary	1	-	-	-	2	58,150	8.9	100	-	-	-	-	58,150
Rijen	1	172,800	20	100	2	-	-	-	-	-	-	-	172,800
Ali-Abad	1	162,800	18.5	17.7	1	113,400	17.5	12.2	1	648,000	100	70.1	924.200
Mohamad-Abad	1	182,800	21	13.4	-	-	-	-	2	1,188,000	183	86.6	1,370,800
Abuzaid-Abad	1	466,560	53.2	15.0	2	972,000	150	31.3	3	1,664,000	256	53.6	3,102,560
Kaghazi	1	311,040	35.5	30.4	-	-	-	-	1	712,800	110	69.6	1,023,840
Yazdelan	1	103,980	12	100	-	-	-	-	-	-	-	-	103,980
Qasem-Abad	1	129,600	15	60.0	1	86,400	13.3	40.0	-	-	-	-	216,000
Hosain-Abad	1	207,360	24	27.8	-	-	-	-	1	540,000	84	72.7	747,360
Total	10	1,942,920	222	24.5	6	1,229,850	190	15.5	8	4,762,800	735	60.0	7,935,570

Source : 1978 Field investigation and calculated from Tables 6.1, 6.3 and 6.5.

FIG 5.6 GROUNDWATER PRODUCTION IN THE ABUZAID ABAD AREA IN 1978

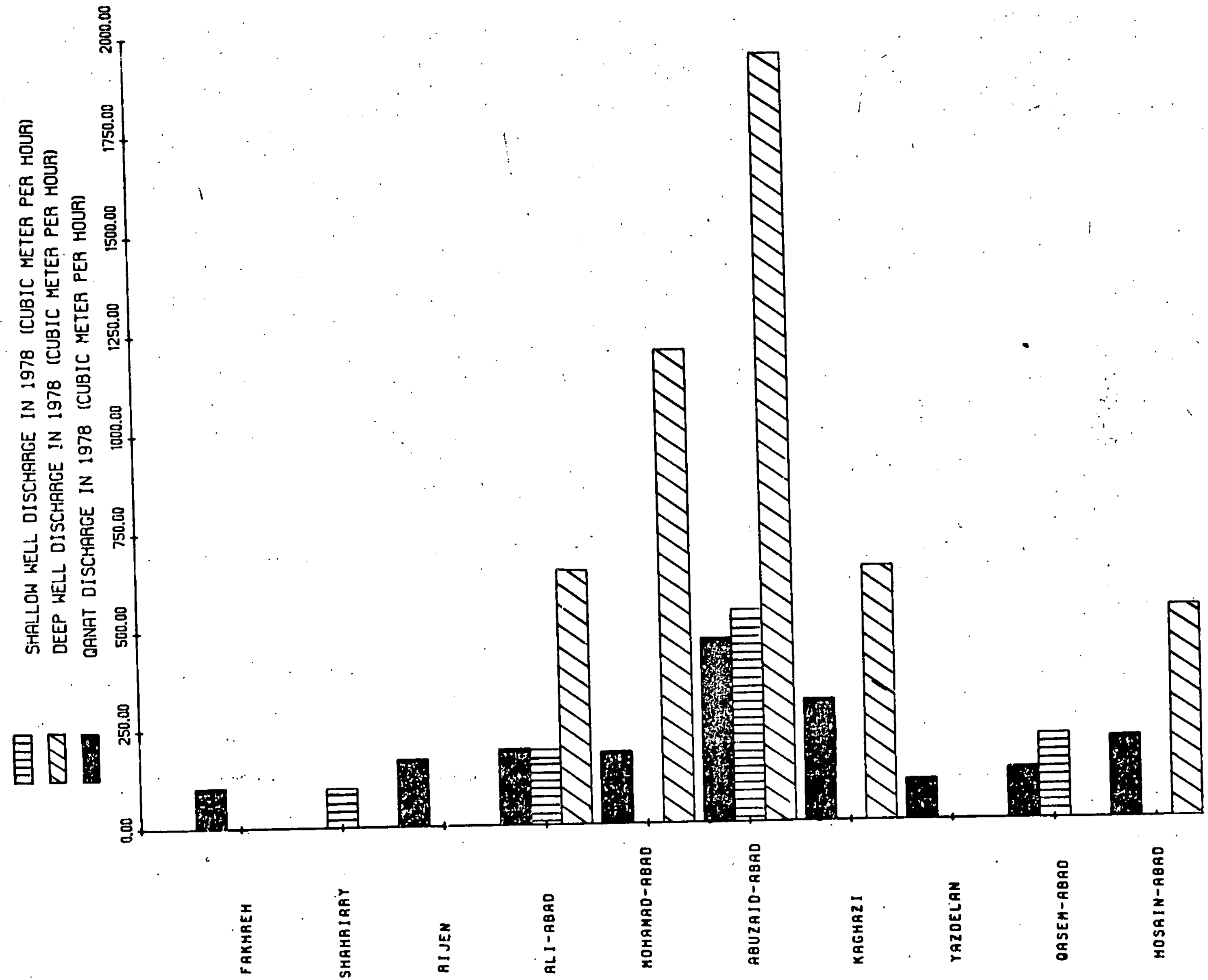
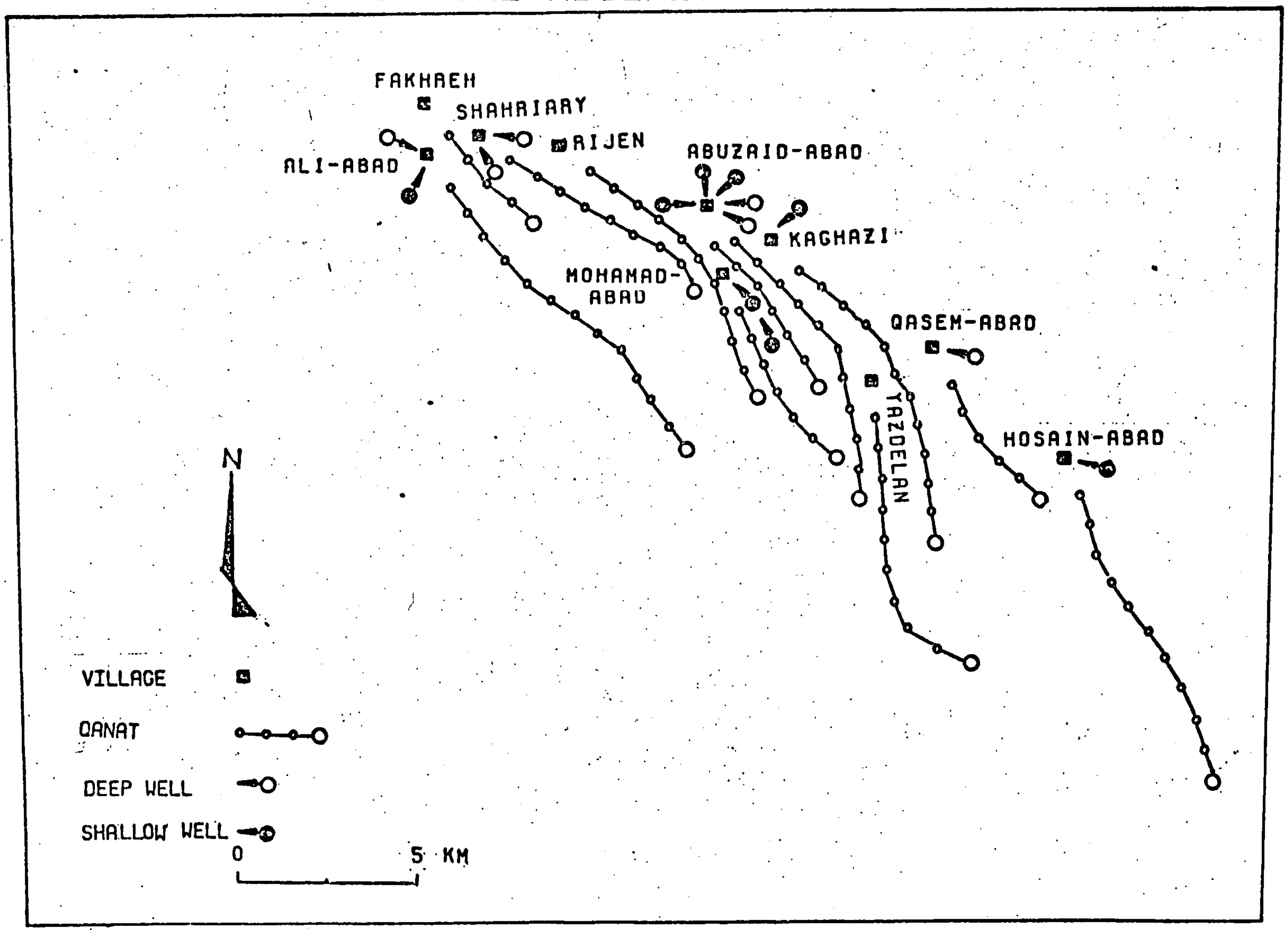


FIG 5.7 DISTRIBUTION OF WATER RESOURCES IN THE ABUZAID-ABAD AREA 1978



total discharge of the qanats was about 1,942,920 m^3 in 1978. It has decreased by 34.3% during the last fourteen years. There are many factors causing a reduction in the discharge of qanats in the area, and it is very difficult to say which is most important. To prevent qanat discharge reduction in the margin of Dasht-e-Kawir, attention should be paid to the individual qanat's problems in each village. The problems of the qanats vary from village to village. To understand the problem it is vital to use the opinions of experts and hydrologists, geologists and Moqanis. However, a general response like the repair and maintenance of qanats in all cases is not recommended by the author. There are many qanats which do not need repairing as their discharge has been affected by the construction of wells etc.

One of the less suitable methods of water supply in the Abuzaid-Abad area is the shallow well for the following reasons:

(a) The first water table which provides the source for the shallow well is inadequate since the rate of infiltration is often less than the rate of output. Therefore the engines of the wells cannot operate at full capacity for 24 hours a day, and are thus not economical to run.

(b) The first water table is often brackish and the discharge is not suitable for crops. Moreover the saline water eventually damages the soil and changes it to a saline condition.

(c) The shallow wells are usually dug by inexperienced people in unsuitable conditions. This has been noted in a few cases in which workers have been injured by the collapse of engines and the wells' walls, etc.

After the qanat, the deep well system is the best method for water supply in the area because the quality of water is much better than that of the shallow well, and the engines of deep wells often operate to full capacity. This method will be a useful aid to agricultural development.

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12. Karaj is a city in the west of Tehran, Iran (30 km. from Tehran).

13. Personal interview with Moqanis and farmers.

14. Ministry of Water & Power. The General Office of Ground Water (1979) List of Qanats and wells of Kashan Region (in Persian) No.3 p.123-139.

15. The roots of these trees have been seen by the author at 8 m depth of a well in the Rijen qanat in 1978.

16. Linsley, R.K., (1972) Water Resources Engineering pp.101-105.

17. Ministry of Water & Power, The General Office of Ground Water (1972) op.cit., pp.35-37.

18. Mahdavi, M. (1978) Research on the Water and Irrigation of Desert Areas East of Kashan. University of Tehran, Iran, Desert Research Center, No.5 p.41.

CHAPTER 6

IRRIGATION

6.1 Introduction

Irrigation is defined as the application of water to soil for the purpose of supplying the moisture essential for plant growth. Water to supply moisture essential for plant growth may come from other sources, e.g. precipitation, atmospheric water other than precipitation and ground water.

6.2 Precipitation

Although the amount of precipitation is not sufficient to replace moisture depleted from the root zone, and the frequency is not enough to replenish the soil moisture before plants suffer from lack of moisture, the low intensity of rainfall can be absorbed by the soil and has great benefit for production. Precipitation, with suitable frequency, during plant growth,considerably increases the yield of production and decreases the amount of irrigation needed in the area.

The precipitation characteristics have been mentioned in the agroclimatology chapter (Chapter 1). The amount of annual rainfall in this area, as we have seen before, is about 140 mm. Now only about 60% is confined to the period of plant growth (November 12.2 mm, December 15.2 mm. March 23.8 mm. April 18.3 and May 15.5 mm). This quantity of rainfall is not enough for agriculture, since temperatures are high and, as a result, evapotranspiration is also high.

It is obvious that the date of the end of the rainfall season, as well as the amount of rainfall, and its variability, are factors of extreme importance to agricultural possibilities for winter crops in the area. The area can not be classified as one of dry land farming, because successful agriculture without irrigation requires at least 240 mm. annual rainfall, and an interannual variability of 37%.[1] Wallen (1963)[2] believes "as suggested method allows a theoretical assessment of the rainfall limit within which regular dry-land farming is possible, and this limit is found to lie between 200 and 300 mm. of annual rainfall"

6.3 Atmospheric Water other than Precipitation

Atmospheric conditions which generally prevail to make this source of water significant are : considerable dew formation, fog, clouds and high humidity. These conditions reduce the plant's water needs by reducing the forces causing water to transpire from the plant. Dew occurs in the early spring or at the end of autumn in the area, but the amount is not considerable. The low value of humidity results in the limited value of this resource. Fog occurs early in winter and it has little affect on the crops because that time does not correspond with plant growth. As a result the atmospheric water, other than precipitation, is not considerable in the Abuzaid-Abad area.

6.4 Ground water

Upward movement of ground water by capillary action from the water table into the root zone, can be a major source of water for plant growth where the water table is near the surface. The water table level has been shown in the

Fig. 2.3 in the hydrology chapter. According to this figure the depth of water table in the Abuzaid-Abad area is more than 5 metres below the surface. It is not suitable for shallow rooted crops or for cultivation where the seed has to germinate in the upper soil layer, for example, cereals. However, orchards and other trees can usually make use of it. The tamarix trees have been planted by the Ministry of Natural Resources, as discussed earlier, and have made an artificial forest. These trees have long vertical roots which extend to a depth of 8 m. There is now a huge artifical forest in the Abuzaid-Abad area because the trees feed on the subsurface ground water. Of course, when the trees were young, they were irrigated by a mobile tank, but today it is not necessary.

On the north west of the area on the Band-e-Rig (sand dunes), where the water table is near the surface (about 2-3 m), the dry farm water melon has been planted,without irrigation since,1977. Production of this crop was considerable, about 150 tons in 1976, but recently it was stopped because the farmers believe that the level of the water table has gone down. Unfortunately, in some places in the area, where the water table is near the surface, and crops can use it, the soil is salty which results, via capillarity, in the rising of the ground water table to the soil surface, causing a heavy salt concentration in the upper soil.

6.5 Irrigation Methods

Actual irrigation methods vary with respect to topography, soils, crops, available water supplies and the prevailing cultural pattern within a region. Surface, subsurface, and sprinkler irrigation are three basic methods by which water can be added to the soil.

In the arid parts of Iran the surface system of irrigation is common. This is a traditional method which has been applied in the plateau of Iran for a long time, and even though the system of water supply has changed in some parts of the area, it still remains the traditional system.

Surface irrigation is usually used in different ways, of which, border, basin and corrugation irrigation, are common in the Abuzaid-Abad area. These methods have proved to be the best with respect to the quantity of water, type of crops, climate, soil, topography conditions and available technology.

(a) Border irrigation

Border irrigation is widely used in the area and in this method the land is divided into parallel borders. The border is called Marz and the land surface between two Marz is named Kart, or border strip. The width of the Karts is not usually over 2 to 3 metres and the length 5 to 20 metres. The length of the Karts mostly depends upon the size of the farm, the average size being 1,200 m^2 as was discussed in the Chapter on 'Land Use'.

In this method, water is supplied into each strip from the head ditch along which it flows slowly towards the lower end. The surface is essentially level between borders. The advancing sheet of water covers the surface of the basin, the slope being uniform within each level, and downslope of the border strip, according to the field survey which was carried out by the author in the area, usually lay between 2-4 per thousand. The height of the border is not more than 20-30 cm. The size of the stream flowing into a single border is usually chosen according to the kind of soil, the size of border, and the nature of the crop in the developed irrigation area. But the limitation of water does not allow complete freedom of supply, and the stream flow is cut off, usually when three quarters of the Kart length is covered by water. This system is used for cereals in the Abuzaid-Abad area. According to the author's field study, about 360.9 ha. or 66.0% of the total cultivated land is under this system of irrigation (Table 6.1).

The amount of stream flow in this method varies from village to village, depending on the available water resources, i.e. the streams which flow directly from qanats, wells and water reservations. The water reservation(3) is usually a large natural pool which can be used as a good scale for measuring the qanats or wells discharge.

In general, the low capacity of water flow from qanats is not suitable for direct irrigation in some of the villages because this low speed causes excessive infiltration and evaporation and therefore much of the water is lost before it reaches the field. Therefore, this low capacity water is usually stored for 6-24 hours in the reservation pool and when the pool is full of water, the waterway is opened and the water flows with a greater intensity and movement.

(b) Basin irrigation

This method is used extensively to irrigate orchards, and some of the summer crops and alfalfa in the Abuzaid-Abad area are also irrigated in this way.

This irrigation method consists of levelled field units, which are surrounded by borders to form a basin. In this method the levees are stronger than the borders in the border irrigation . The size of basin is usually chosen according to the capacity of water flow. The shape of the border is usually rectangular. In general, the infiltration rate of the soil and the available flow rate should be influential factors in the size of the basins. The width and length of basins do not exceed 5 and 10 m. respectively in the Abuzaid-Abad area. In this method the water is held in the basin at the desired depth (usually 10 cm) for the required time. In the supply ditch the water is conveyed to the basin either by it flowing through one basin and into another, or preferably by small constructed ditches in which the water may be turned directly from the ditch into each basin.

About 112 ha.,of summer crops and perennial crops, or 21% of the total cultivated land was irrigated by this method in the area in 1978 (Fig. 6.1).

(c) Corrugation Irrigation

Irrigation water can be applied very efficiently to widely spaced plants using this method, by which adequate water can be placed in the root zone without wetting the soil surface; almost the entire land surface receives water by other forms of irrigation.

Table 6.1 Distribution of Irrigation Methods in the Abuzaid-Abad Area in 1978

		Border Irrigation		Basin Irrigation		Corrugation Irrigation		Total
		ha	%	ha	%	ha	%	ha
1	Fakhreh	11.7	78	3.1	20.8	0.2	1.2	15
2	Shahriary	9.3	92.7	0.75	7.3	-	-	10.2
3	Rijen	31.6	78	7.4	18.2	1.04	3.8	40.5
4	Ali-Abad	45	84.2	7.9	14.8	0.5	0.9	53.4
5	Mohamad-Abad	53.6	62.7	22.8	26.3	10	11	86.4
6	Abuzaid-Abad	104.3	60	47	27	22.7	13	174
7	Kaghazi	42.3	68.3	7.5	12.1	12	19.4	61.8
8	Yazdelan	6.4	53.3	2.2	18.4	3.4	28.3	12
9	Qasem-Abad	17.6	79.3	2.4	10.8	2.2	9.9	22.2
10	Hosain-Abad	33	69.7	10	21.4	4.3	9	47.3
	Total	366.9	66.0	111.05	21.2	56.8	10.8	522.8

Source : Field Survey in 1978.

Using the corrugation for irrigation necessitates the wetting of only a part of the top surface of the soil ($\frac{1}{3}$ to $\frac{1}{4}$) and is suitable for crops which are sensitive to going below the water.

By this method of irrigation, water flows down the slopes very gently in V or U shaped furrows, which are called Baneh (rill). The depth of the Baneh depends on the kind of crops, for example, for cucumber, pumpkin, melon and water melon, the depth is about 30-50 cm; for vines it is about 80-120 cm. The length of rills varies from 10 to 25 metres for vines and 5 to 10 metres for the summer crops. The gradient of slope in this method does not exceed 4 per thousand.

Usually a set of rills, which are formed by 4 to 10 rills, is supplied with water vertically from a ditch. This ditch supplies water from the head ditch. This set of rills is named Takhteh. The water turns from the head ditch into the smaller ditches and the flow continues until the rills fill with water.

Another kind of corrugation irrigation common in the area is called Qolam Gardeshi (slave movement). In this method the rills are connected together as a spring and the head of the first rill supplies water from the head ditch. This kind of irrigation usually occurs on a level farm. However, about 56.8 ha. of summer crops and perennial crops (for example, vine), or 10.8% of total cultivated land was irrigated by this method in the Abuzaid-Abad area in 1978.

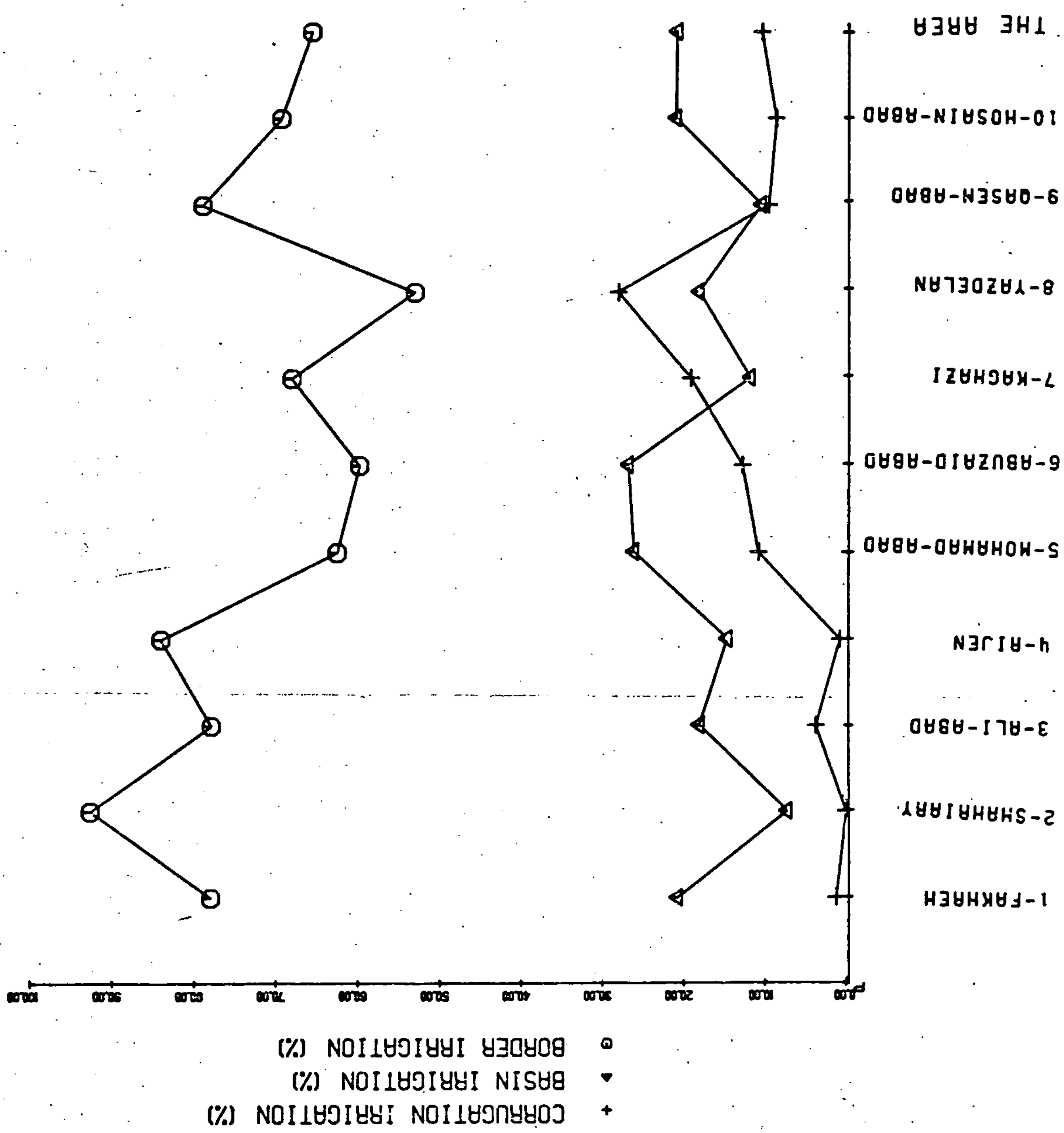


FIG 6.1 DISTRIBUTION OF IRRIGATION METHODS IN THE ABUZAID-ABAD AREA

6.6 Water Requirement

The quantity of water, regardless of its source, required by a crop, in a given period of time, for its normal growth under field conditions, is known as its water requirement. It includes surface evaporation and other economically unavoidable wastage.[4] When the consumptive [5] use of the crops is known, the water use can be calculated. The consumptive use has been estimated by one of the several methods in this study, with respect to the lack of some climatological factors, e.g. solar radiation, wind velocity, saturation vapour pressure etc., in the area. Thus the Blaney and Criddle method has been recognized, as suitable.

Blaney and Criddle [6] developed a simplified formula using temperature during daytime hours, and the consumptive use coefficient for various crops. By multiplying the mean temperature (t) in F^{o} by the monthly percentage of daytime hours of the year (p), by the crop consumptive use coefficient (k)[7] and by 25.4[8] constant figure, a consumtive use of crop in mm for a given time is obtained. Expressed mathematically it is -

$$U = 25.4\ k\ \Sigma \frac{tp}{100}$$

where U is total consumptive use for a particular crop during the growing season.

Table 6.2 has been prepared to assist in the interpretation and use of the above equation for computing consumptive use. In this table the average monthly water requirement for a group of crops, e.g. forage crops (alfalfa), small grain crops (cereal), cotton, orchard vine and fruit trees and summer crops has been calculated.(Figs.6.2-6.6).

Table 6.2 **Estimation of Monthly Crops' Water Requirement in the Abuzaid-Abad Area**

Months	Average Monthly Temperature F°	Average day time hour % of the Year P	Alfalfa			Cereal			Cotton			Orchard			Summer crops		
			K	U m.m	U/ha m^3	K	U m.m	U/ha m^3	K	U m.m	U/ha m^3	K	U m.m	U/ha m^3	K	U m.m	U/ha m^3
March	55.58	8.36	0.65	76.7	767	0.64	75.2	752	0.29	34.1	341	0.57	66.8	668	0.70	82.3	823
April	65.5	8.80	0.70	102.4	1024	1.26	184.4	1844	0.22	32.2	322	0.60	87.8	878	0.73	106.8	1068
May	75.7	9.92	0.80	152.6	1526	0.87	165.9	1659	0.61	116.4	1164	0.60	114.4	1144	0.78	148.7	1487
June	85.5	9.70	0.90	189.6	1896	-	-	-	0.55	115.8	1158	0.64	134.8	1348	0.82	172.7	1727
July	89.6	9.88	1.10	247.0	2470	-	-	-	0.50	112.0	1120	0.64	143.9	1439	0.87	195.6	1956
August	87.3	9.33	1.00	206.8	2068	-	-	-	0.45	93.0	930	0.68	140.6	1406	0.75	155.2	1552
September	80.6	8.36	0.85	145.4	1454	-	-	-	-	-	-	0.68	116.0	1160	-	-	-
October	68.3	7.90	0.80	109.8	1098	-	-	-	-	-	-	0.65	89.0	890	-	-	-
November	52.9	7.02	0.70	66.0	660	0.64	60.3	603	-	-	-	0.62	58.5	585	-	-	-
Total				1293.6	12936		485.8	4858		503.5	5035		951.8	9518		861.3	8613

F° = The mean monthly temperature   P = The monthly percentage of daytime hours of the year (see Chapter on Agroclimatology)

K = The consumptive use coefficient U = The consumptive-use mm.

U/ha = The total monthly consumptive-use per hectare m^3

FIG 6.2 TOTAL MONTHLY CONSUMPTIVE USE OF ALFALFA $(M^3)/ha$

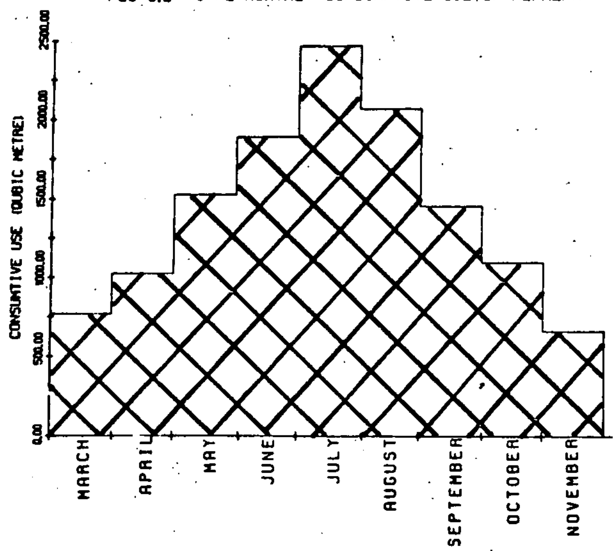


FIG 6.3 TOTAL MONTHLY CONSUMPTIVE USE OF CEREAL $(M^3)/ha$

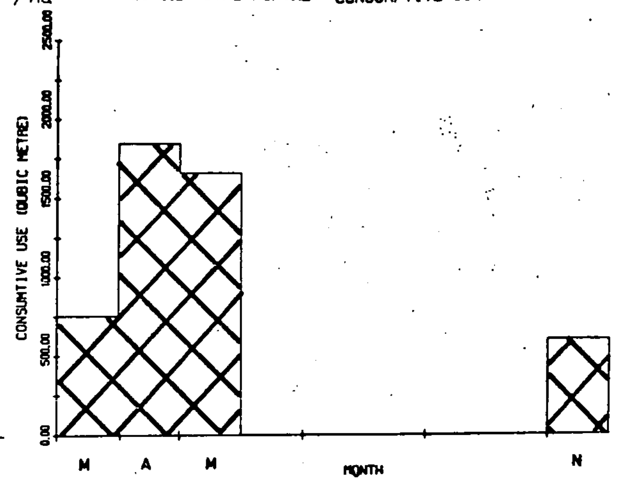


FIG 6.4 TOTAL MONTHLY CONSUMPTIVE USE OF COTTON $(M^3)/ha$

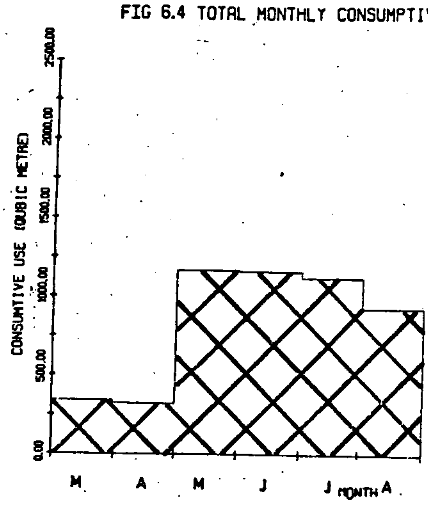


FIG 6.5 TOTAL MONTHLY CONSUMPTIVE USE OF ORCHARD $(M^3)/ha$

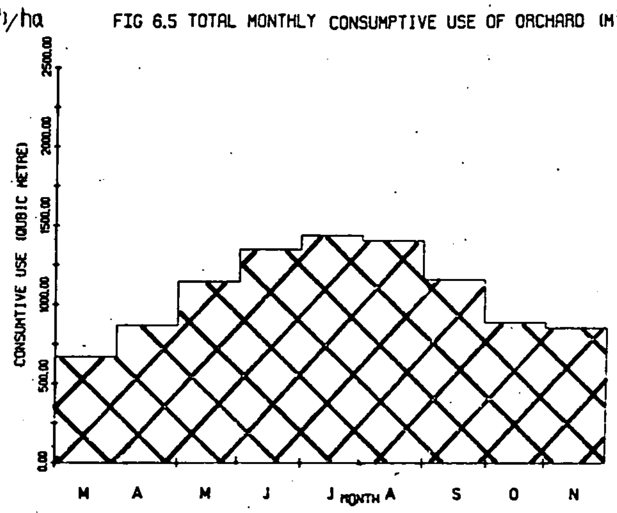
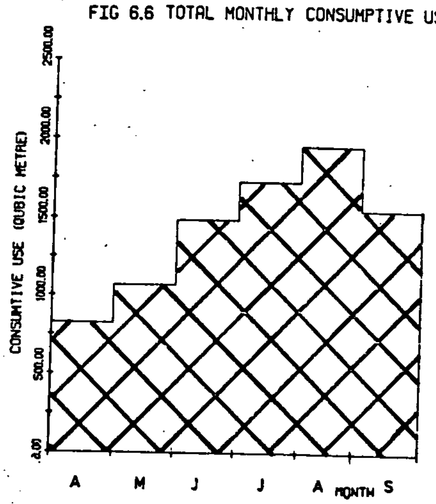


FIG 6.6 TOTAL MONTHLY CONSUMPTIVE USE OF SUMMER CROPS $(M^3)/ha$



6.7 Effective Rainfall

Water supply for consumptive use by crops consists of the effective rainfall on the irrigated area and the water brought in by conveyances.[9] Effective rainfall is the total rainfall falling during the growing season. Only about 85 mm. of annual rainfall occurs during the plant growth period in the Abuzaid-Abad area.

Table 6.3 shows the distribution of total effective rainfall during the crop growing season in the Abuzaid-Abad area.

6.8 Water Losses

Losses of water occur in various ways in the area, e.g. domestic and animal consumption, canal or ditch seepage, storage losses and other losses due to accidents or other uncontrolled losses.

The water supplied in the area is used for domestic consumption and irrigation purposes, although apparently, domestic consumption is only small. The accumulation of all forms of consumption is considerable. According to an estimate which was carried out by this author, about 10% of the qanats' discharge was consumed by the residents of the area and its animals. The residents often use the qanat discharge for domestic purposes because the qanats are near their dwellings and the water of qanats is more digestible than the well's discharge. Also water loss due to seepage from ditches, and storage loss caused by evaporation and seepages is considerable.

Table 6.3 Distribution of the Total Effective Rainfall During the Plant Growing Season

	Monthly Av.rain fall mm	Alfalfa (33 ha) m^3	Cereal (341 ha) m^3	Cotton (22.5 ha) m^3	Orchard (52.0 ha) m^3	Summer crops (61.0ha) m^3	Total m^3
March	23.8	7,854	81,158	5,355	12,376	14,518	121,261
April	18.3	6,039	62,403	4,117	9,516	11,163	93,238
May	15.5	5,115	52,855	3,487	8,060	9,455	78,972
June	2.7	891	-	607	1,404	1,647	4,549
July	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-
October	4.4	1,452	15,004	-	-	-	16,456
November	12.2	-	41.602	-	-	-	41,602
Total	76.9	21,351	253,022	13,566	31,356	36,783	356,078

Source : Meteorological Organization and Field Studies 1978.

According to measurements which were carried out by the author in the qanats of Ali-Abad and Abuzaid-Abad villages, in the points of source and head ditches of irrigated fields, the average amount of water had been reduced by about 35% from the source points to the field because of domestic consumption and water losses in the ditches and storage. This situation has been similarly observed in the other villages by the author. Now, we can say, about 25% of the qanat's discharge is lost in the canal or ditches, or by storages, seepage and evaporation. In other words, about 680,022 m^3 of the total qanat's discharge is lost due to the above factors. Rohwer (1948)(10) believes, "the average seepage rate from irrigation canal in the sand and sandy loam, loam and fine sandy loam and adobe is about 3.3 - 3.8 ft^3/ft^2 - (11)

According to other measurements which were carried out in the Ali-Abad deep well and Abuzaid-Abad shallow well (Sarafraziah), the average seepage rate from irrigation canals and evaporation is about 15% or 158,400 m^3 and 747,000 m^3 from shallow wells and deep wells respectively.

However, according to Table 6.4 the result of an estimate of domestic consumption, ditches and storage water losses, the total water loss was 1,585,422 m^3, and the total available irrigation water at the head ditches of the fields were 6,393,493 m^3, in the Abuzaid-Abad area in 1978.

Table 6.4 **Distribution of irrigated water and water losses in the Abuzaid-Abad Area in 1978 (cubic meter)**

Village	Qanat			Shallow well			Deep Well			Total		
	Discharge	Water loss	Irrigation water	Discharge	Water loss	Irrigation water	Discharge	Water loss	Irrigation water	Discharge	Water loss	Irrigation water
Fakhreh	103,080	36,078	67,002	-	-	-	-	-	-	103,080	36,078	67,002
Shah-riary	-	-	-	100,000	15,000	85,000	-	-	-	100,000	15,000	85,000
Rijen	172,800	60,480	112,320	-	-	-	-	-	-	172,800	60,480	112,320
Ali-Abad	192,800	67,480	125,320	200,000	30,000	170,000	648,000	97,200	550,800	1,020,800	174,680	846,120
Mohamad-Abad	182,800	63,980	118,820	-	-	-	1,200,000	180,000	1,020,000	1,372,800	233,980	1,138,820
Abuzaid-	466,560	163,296	303,264	540,000	81,000	459,000	1,944,000	291,600	1,652,400	2,950,560	535,896	2,414,664
Kaghazi	311,040	108,864	202,176	-	-	-	648,000	97,200	550,800	959,040	206,064	752,976
Yazdelan	103,080	36,078	67,002	-	-	-	-	-	-	103,080	36,078	67,002
Qasem-Abad	129,600	45,360	84,240	216,000	32,400	183,600	-	-	-	345,600	77,760	267.840
Hosain-Abad	207,360	72,576	134,784	-	-	-	54,000	81,000	959,000	747,360	153,576	593,784
Total	1,942,920	680,022	1,262,898	1,056,000	158,400	897,600	4,980,000	747,000	4,233,000	7,978,920	1,585,422	6,393,508

Source : Field Survey.

6.9 When to Irrigate, and how much water to apply

Normally the time of irrigation depends on the cycle of water rotation (see the section on apportionment of water in this Chapter) and availability of water with which to irrigate, so the farmers cannot always apply water when the crop is most in need.

The frequency of irrigation for the crops usually depends on the frequency of water rotation in each village during the growing season. For example, the frequency of water which ~~is~~ applied to alfalfa is 14 times, cereal 7 times, cotton & orchard 10 times and summer crops 9 times during the growing season. Another factor affecting frequency of irrigation, is that rainfall occurs usually in the early spring and late autumn. According to Table 6.3 the total amount of effective rainfall does not exceed 356,078 m^3 for 522.8 ha., crops in the area.

However, according to field survey, the total amount of water which was applied to 522.8 ha., crops, with respect to the irrigation frequency, and its depth, was about 6,393,508 m^3. On the other hand the total consumptive use was about 3,217,029 m^3., in the same time in the area. It should be noted that not all water which is put into the irrigation system is efficiently used by the plants because of wrongful placement of the water, etc.

It is necessary to apply more water than will be needed by the plants. In the Abuzaid-Abad area, according to the calculation resulting from Table 6.5 the total amount of water which was applied for irrigation was 50.3% more than the water which was used by the plants. This case is supported by Hansen (1980)[12] and is illustrated in his book: "Thus it was assumed, that the average efficiency for application of water would be 70 per cent for sprinkling and 50 per cent for surface irrigation". More details of the irrigation frequency and amount of water to be applied and amount of water requirement for the crops, in the Abuzaid-Abad area in 1978 have been illustrated in Table 6.5.

6.10 Cost of Irrigation Water

The cost of irrigation water in the Abuzaid-Abad area can be defined as the total available water in the head ditch of the field, divided by the total annual depreciation of initial investment, plus annual interest on cost and annual expenditure.

As we have seen before, there are two sources of water supply in the area, wells and qanats. The initial investment and expenditure on each, are quite different, so in this investigation they have been studied separately as follows:

Firstly, wells - the initial investment on wells in the area, which have been constructed since 1963, include the price of well drilling, cost of engine, the cost of reservoirs, canal construction price, field buildings and land levelling. The specification of the above process has been illustrated in Table 6.6. As shown in Table 6.6 the total annual cost of irrigation water from the wells is 3,696,550 Rials. Moreover, the total expenditure which consists of fuel, maintenance of engine and motormen's wages (see the Chapter on Rural Economy), all together, was

Table 6.5 The Irrigation Frequency and Amount of Water to be Applied and Amount of Water Requirement for Crops in the Abuzaid-Abad Area in 1978

Crops	Hectarage ha	Effective Rainfall m^3	No. of irrigations	Depth of irrigation mm/year	Total of irrigation Water m^3/ha	Total of water applied for irr.purposes m^3	Consumptive use mm	Total Consumptive use m^3/ha	Total Crop Consumptive use m^3
Alfalfa	33	21,351	14	2,100	21,000	714,351	1293.6	12,936	426,880
Cereal	341	253,022	7	1,050	10,500	3,636,452	485.8	4,858	1,656,578
Cotton	22.5	13,566	10	1,500	15,000	351,066	503.3	5,033	113,242.5
Orchard	52.0	31,356	10	1,500	15,000	811,356	951.8	9,513	494,936
Summer Crops	61	36,783	9	1,360	13,500	860,283	861.3	8,613	525,393
Total	5,095	356,078	-	-		6, 393508	-	-	3,217,029.5

Source : Tables 7.3 and 7.2 and Field Studies, 1978.

Table 6.6 Initial Investment (wells) and cost of Surface Irrigation water in the Abuzaid-Abad Area in 1978

Item	Cost (Rials)	Useful life (years)	Depreciation		Interest on cost/year		Cost/year
			%	(Rials)	%	(Rials)	Rials
Deep well drilling	16,000,000	50	2	320,000	6	480,000	800,000
Shallow well digging	1,870,000	30	3.3	623 00	8	74,800	137,100
Engine & pump	17,790,000	12	8.3	1,482,500	6	533,700	2,016,200
Reservoir	3,150,000	20	5	15,750	8	13,600	28,350
Field canals	250,000	20	5	12,500	8	10,000	22,500
Field buildings	260,000	30	3.3	8,700	8	10,400	19,100
Land levelling	1,000,000	30	3.4	33,300	8	40,000	73,300
Annual expenditure	-	-	-	-	-	-	3,703,600
Total	33,170,000			2,495,750		1,162,500	7,361,850

Source : Field Studies, 1978.

3,703,600 Rials in the currency price in 1978.

Therefore, the average cost of a cubic metre of well discharge was 1.3 Rials at the head ditches of the field (excluding the irrigator's wages).

Secondly qanats - the price of water discharge by qanats, according to the field investigation which has been carried out by this author, illustrated in Table 6.8, is 207% and 119% cheaper than shallow wells' and deep wells' discharge respectively. The main reason for this, is that the initial investment for qanat construction, constructed many years ago has been paid completely, and the expenditure of the qanat is usually limited to the maintenance of the qanat. Not all of the qanats are maintained every year in the Abuzaid-Abad area, but at least every two or three years it is necessary to undertake repairs (see the Chapter on Water Supply) in the area.

During the period of this study in the area (1976-1978), all of the qanats were repaired at least once, and some of them have been maintained every year. However, the total maintenance cost paid by the farmers during 1976-1978, was 4,940,000 Rials.

Also the total discharge of qanats with respect to the qanat discharge reduction rate of about 3.7% (see the Chapter on Water Supply), was 5,825,150 m^3 at the Mazhar (where the water comes to the surface). Therefore, according to these calculations, the average cost of one cubic metre of qanat water was 0.84 Rials at the point of sources, and 1.3 Rials at the head of the ditches. It should be noted that the water losses of qanat discharge were about 35% (see the Section on Water Losses). According to these calculations, the cost of one cubic metre of water (at the point of source) supplied from the qanats, shallow wells and deep wells were 0.84, 1.74 and 1.0 Rials respectively, and the average price of one cubic metre of available water at the point of resources was about 1.05 Rials in the Abuzaid-Abad area in 1978.

In Tables 6.7 and 6.8 the distribution of water price in the villages has been illustrated. The water prices which were supplied from the shallow wells lay between 3.5 and 1.6 Rials according to these tables. The average price of one cubic metre of irrigation water from shallow wells was 2 Rials. The price of deep well discharge lay between 1.0 and 1.7 Rials and the average price per cubic metre of deep well was about 1.3 Rials. The price of qanat discharge at the field lay between 0.58 and 2.6 Rials and the average price was 1.3 Rials/m^3 in 1978 in the Abuzaid-Abad area.

However, the average price of one cubic metre of irrigation water at the head ditches was about 1.53 Rials in the Abuzaid-Abad area in 1978.

6.11 Distribution and Apportionment of Water for Irrigation

Water apportionment in Iran is based on four sources e.g. Islamic laws, Customs, the civil code and other water agreements subsequent to the civil code.[13]

The water distribution has been carried out according to customary regulations in the Abuzaid-Abad area because the water has been supplied by collective work and cooperatives of residents. The method of water apportionment has been one of

Table 6.7 The price of wells discharge in the Abuzaid-Abad Area in 1978

	Shallow well						Deep well					
	Initial invt-ment dep Rials/ year	Expen-diture Rials/ year	Total Cost Rials/ year	Total dis-charge m^3/year	Price at the point of sources Rials/ m^3	Price at the Field Rials/ m^3	Initial invt-ment dep Rials/ year	Expen-diture Rials/ year	Total Cost Rials/ year	Total dis-charge m^3/year	Price at the point of sources Rials/ m^3	Price at the Field Rials/ m^3
Fakhreh	-	-	-	-	-	-	-	-	-	-	-	-
Shahriary	70,220	230,055	300,275	100,000	3.00	3.5	-	-	-	-	-	-
Al-Abad	89,240	351,500	440,740	200,000	2.2	2.6	158,750	423,680	582,430	648.000	0.9	1.00
Rijen	-	-	-	-	-	-	-	-	-	-	-	-
Mohamad-Abad	-	-	-	-	-	-	317,510	847,370	1,164,880	1,200,000	0.97	1.1
Abuzaid-Abad	216,360	513,180	729,540	540,000	1.35	1.6	476,270	1,271.050	1,747,320	1,944,000	0.9	1.05
Ka ghazi	-	-	-	-	-	-	169,750	516,550	686,300	648,000	1.05	1.2
Yazdelan	-	-	-	-	-	-	-	-	-	-	-	-
Qasem-Abad	72,120	302,170	324,290	216,000	1.7	2.0	-	-	-	-	-	-
Hosain-Abad	-	-	-	-	-	-	158,760	613,660	772,420	540,900	1.4	1.7
Total	449,840	1,396,910	1,846,750	1,056,000	1.74	2.0*	1,281,059	3,672,340	4,953,400	4,980,000	1.0	1.2

* Average price per m^3 of irrigation water

Source: Field Studies, 1978.

TABLE 6.8 The Distribution of qanat Water Price in the Abuzaid-Abad Area

Variables / Villages	Cost of qanats maintenance (1976-1978) 1976 Rials	1977 Rials	1978 Rials	Total cost Rials	Total qanats discharge (1976-1978) m^3	Price of water at the point of sources Rials/m^3	Price of water at the field Rials/m^3
Fakhreh	-	-	200,000	200,000	320,823	0.62	0.95
Shahriary	-	-	-	-	-	-	-
Ali-Abad		200,000	100,000	300,000	600,064	0.49	0.77
Rijen	150,000	-	250,000	400,000	537,816	0.74	1.14
Mohamad-Abad	270,000	300,000	250,000	820,000	568,941	1.44	2.2
Abuzaid-Abad	400,000	-	750,000	1,150,000	1,452,200	0.79	1.1
Kaghazi	-	1,000,000	-	1,000,000	968,070	1.0	1.6
Yazdelan	120,000	-	-	120,000	320,822	0.37	0.57
Qasem-Abad	300,000	-	400,000	700,000	403,362	1.7	2.6
Hosain-Abad	250,000	-	-	250,000	653,052	0.38	0.58
Total	1,420,000	1,500,000	1,950,000	4,940,000	5,825,150	0.84	1.3*

* Average price per m^3

Source: Field Studies, 1978.

the most important of customary regulations in the Iranian rural areas for many years.

6.11.1 Nasagh

The agreement, which has been arranged for land and water distrubiton in Iranian villages, is called Nasagh (agricultural pattern).

For management purposes the land, or water of a village, is broken down according to the number of holders, or sometimes it is broken down according to the number of available oxen in that village (14) (in the past). So, the land and water contribution of each peasant is identified by his Nasagh.

The type of Nasagh usually varies from region to region. This differentiation usually arises from restriction of water and land. In some of the regions which have experienced limitation of cultivation land (mountainous area), the pattern has been arranged according to land distribution, and the unit of the Nasagh is one of land measurement units, e.g. Joft (amount of land which is managed by a man and an oxen) Gav (½ Joft = ox), Pa ($\frac{1}{4}$ ox), Jerib (1000 m^2) Tanab (324 m^2) etc.. Also in the regions in which there are water limitations, the unit of Nasagh has been chosen according to water right units, e.g. time, Stakhr (pool), Salkh (reservoir), Pialeh (goblet), Fenjan (cup), Tasht (bowl), Tagh (12 hours a day), Shabaneh Rooz(24 hours), Sarajeh (equals 9.5 minutes of a villages' water).

In the Abuzaid-Abad area, the base of Nasagh is the water units, because of water limitation. The unit of Nasagh or water apportionment is the Sarajeh in all of the villages (excluding Mohamad-Abad). The Sarajeh is measured by a water clock. The tool for measuring time is a simple form of water clock. The equipment is a copper bowl of constant shape which is called a Sarajeh. It has a hole in the bottom. In order to measure time, the Sarajeh is placed in a full pan. The water goes up through the hole into the Sarajeh. It takes exactly 9.6 minutes for it to fill. A Mirab (water controller) lifts and empties it, and places it in the filled pan again.

There are other units called Taqh (12 hours) or 75 Sarajehs, Shabaneh Roos (24 hours) or 150 Sarajehs.

6.11.2 Water Rotation

The system of water cycle is based on the Madar, which is a cycle of water distribution. The Madar changes from village to village. The cycles of water right are 10 or 12 days in the villages. Therefore there are 30.6 and 28 complete cycles of rotation in a year in the villages. The specification of units has been illustrated in Table 6.9. Each cycle starts from sunrise and goes on until the sunrise in 10 or 12 days time. Each cycle equals 1,500 or 1,800 Sarajehs. The Mohamad-Abad villages Nasagh has been distributed to 120 Dong, and the cycle of water rotation is 10 days, so each Dong equals 2 hours of village's water. Table 6.10 shows the distribution of units of water right in the Abuzaid-Abad area.

Table 6.9 Specification of Water Apportionment in the Abuzaid-Abad Area

No.	Explanation
1	9.6 minutes = one Sarajeh
2	one hour = 6.25 Sarajeh
3	one Tagh = 75 Sarajeh
4	½ Tagh = 37.5 Sarajeh
5	Shabaneh Roos = 150 Sarajeh
6	One cycle of water rotation (12 days) = 1,800 Sarajeh
7	One cycle of water rotation (10 days) = 1,500 Sarajeh
8	One year = 28 complete Madar (12 days)
9	One year = 30.6 complete Madar (10 days)

Source : Field Survey, 1978.

Table 6.10 Distribution of Units of Water Right in the Abuzaid-Abad Area

	Village	Water Cycles (Mader) day	Number of units	Number of Holding	Average Units/ holding	Smallest holding Sarageh or Dong	Largest holding Sarageh or Dong
1	Fakhreh	10	1500 S	34	44 S	10 S	31 S
2	Shahriary	12	1800 S	5	360 S	4.5 S	142 S
3	Rijen	10	1500 S	710	21.4 S	2 S	32 S
4	Ali-Abad	10	1500 S	78	19.2 S	6 S	22 S
5	Mohamad-Abad	10	120 D	143	0.85 D	0.25D	4 D
6	Abuzaid-Abad	10	1465 S	307	4.8 S	2 S	29 S
7	Kaghazi	10	1500 S	152	9.8 S	5 S	30 S
8	Yazdelan	10	120 D	30	4 D	0.5 D	8 D
9	Qasem-Abad	10	120 D	65	1.8 D	0.5 D	3 D
10	Hosain-Abad	12	1800 S	210	8.6 S	13 S	60 S

S = Sarageh

D = Dong

Source : Field Studies, 1978.

6.12 Irrigation Management

The Mirab who has the responsibility of water apportionment has a list of shareholders, and uses it to inform them about their time of irrigation.

Although the unit of water distribution is the Sarajeh in the area, today the water clock is not used as a base of water distribution. The Mirab uses an ordinary watch which he times at twelve o'clock at sunrise. At sunrise on the first day of a cycle the Mirab informs the first share holder to turn the water onto his land. Shortly before the first farmer's time of irrigation is finished, the Mirab tells the next one to go and direct water onto his land, and so on.

The system of irrigation has not changed for many years, but the holders themselves change the irrigation time from day to night in each cycle of water rotation. By rotating the time of irrigation, therefore, a fair system of distribution of water among the farmers is achieved.

6.13 Conclusion

Irrigation is used in this area to add water to the soil to supply the moisture essential for plant growth. It may wash out or dilute salts in the soil.

The rainfall, atmospheric water other than precipitation and ground water make little contribution to crop growth in the area. Crop growth mostly depends upon irrigation. As we have seen, dry farming is limited to a few hectares of water melons on the slope of Band-e-Rig,where the water table,is close to the surface. The high evapotranspiration and light sandy soil make the farmer wary of taking land under cultivation. Often the size of area cultivated is chosen exactly to correspond to the available irrigation water. So, according to calculations and field observations, the crops do not suffer from water limitation and therefore the rate of crops' output, in general, is not usually less than other parts of Iran, but the total output, because of water limitation, is not considerable.

The system of water rotation is worked, according to local regulation, which has been used for many years, according to the climate, and soil condition, and the crops' water requirement in a distinctive interval of time. Therefore the water cycle system is based on the Madar which is chosen according to crops' water requirements, and it changes from village to village. Any modification in the water management is by consultation with the farmers.

Therefore, there is a fair and regular system of water distribution and water rotation, ensuring the crops against the high evapotranspiration in the area.

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CHAPTER 7

AGRICULTURE

7.1 Cultivation

Cultivation in the Abuzaid-Abad area is approximately similar to that in most other arid areas of Iran. Water shortage, traditional methods of cultivation, saline soil and severe climatic conditions are the obvious characteristics of the area.

Crops in the Abuzaid-Abad area comprise annual crops and perennial crops.

7.1.1 Annual Crops

The annual crops are divided locally into Shatvi (winter crops) and Safi (summer crops). They are designated Shatvi and Safi depending upon when they are sown, but the same crops may be grown as Safi or Shatvi, i.e. wheat, barley, poppy etc.

7.1.1.1 Winter Crops

Shatvi crops are sown in the autumn and harvested in the following spring, summer or early autumn, e.g. wheat, barley, cotton etc. For cultivating winter crops, usually, two days before sowing the land is made moist by irrigation, and in most small plots and gardens the soil is turned over by hand. Unlike other parts of Iran, the Iranian traditional iron-shod nail-plough is not usually employed in the Abuzaid-Abad area. In a few large plots the soil is ploughed by tractor, which is usually hired. The prepared seed bed may be left for some days before sowing, or it may be ploughed and sown the same day (usually on the small plots). The sowing of cereals in the Abuzaid-Abad area is quite different from that in other parts of Iran, because cereals are sown in rows with a hand hoe, a few seeds at a time. These seeds have been left to soak in water for 1 or 2 days before sowing.

The boundary banks and the irrigation ditches are made by hand and no special implement is used. This contrasts with other parts of Iran where a tool called a <u>Pash</u> is used.

Wheat, barley, cotton and poppy are probably the most important winter crops.

a) <u>Wheat</u>

Wheat is the principal winter crop in the Abuzaid-Abad area, and is grown in the area on about 187.3 ha., of land. Sowing is usually done in late October or November. The crop is normally irrigated twice before the winter rain, which starts about two to three weeks after sowing. The fields are irrigated again after the end of the spring rains. Winter wheat is harvested in late June or July, whereas spring-sown wheat is harvested later.

Harvesting is done with sickles. Threshing is normally powered by tractor. After threshing the crushed straw and chaff are winnowed with a fork and the chaff is blown away. The straw is used for animal feed, and the grain is cleaned again. The yield is said to be about 15 to 19 grains per stalk in the area. The quantity depends on various factors, e.g. fertilizer, irrigation, rain, the farmer's skill , type of plough and seed. In the one instance where the weight of seed and harvest were compared, the yield was about 10 to 15 because usually a few per cent of seeds do not germinate, and some of them were eaten by birds and insects. Also a few per cent of the crops output is wasted during the harvest.

However, the yield of 10 to 15 fold was equivalent to about 2,000 to 2,400 kg. of grain/ha. The wheat growing season lasts approximately 200 to 220 days. The phase from November to December usually includes the period from sowing to the emergence of the crop. The growth period usually lasts from December to May, a period which includes germination, vegetation and the reproductive stages. The period May to July is usually the ripening stage of the wheat (Figure 7.1).

b) Barley

The crop is sub-divided locally into sweet Jow-e-Shirin and sour Jow-e-Tursh types of barley. The Jow-e-Tursh as a spring crop is sown early in March and harvested late in July. This kind of barley is sown only in Hosaid-Abad village. Ordinary barley or Jow Shirin is sown from October onwards. The method of cultivation is similar to the cultivation of wheat. The rate of seeding is said to be about 125 kg/ha. The yield varies widely, but on average it is about 2,500 kg/ha.

Barley sowing usually occurs before wheat sowing. The phase from October - November usually includes the period from sowing to emergence (Fig. 7.2). Germination takes approximately 5 days, and the crop is irrigated every 10 to 15 days. Barley is harvested in June.

Figure 7.I Typical Growth Stages of the Wheat Crop

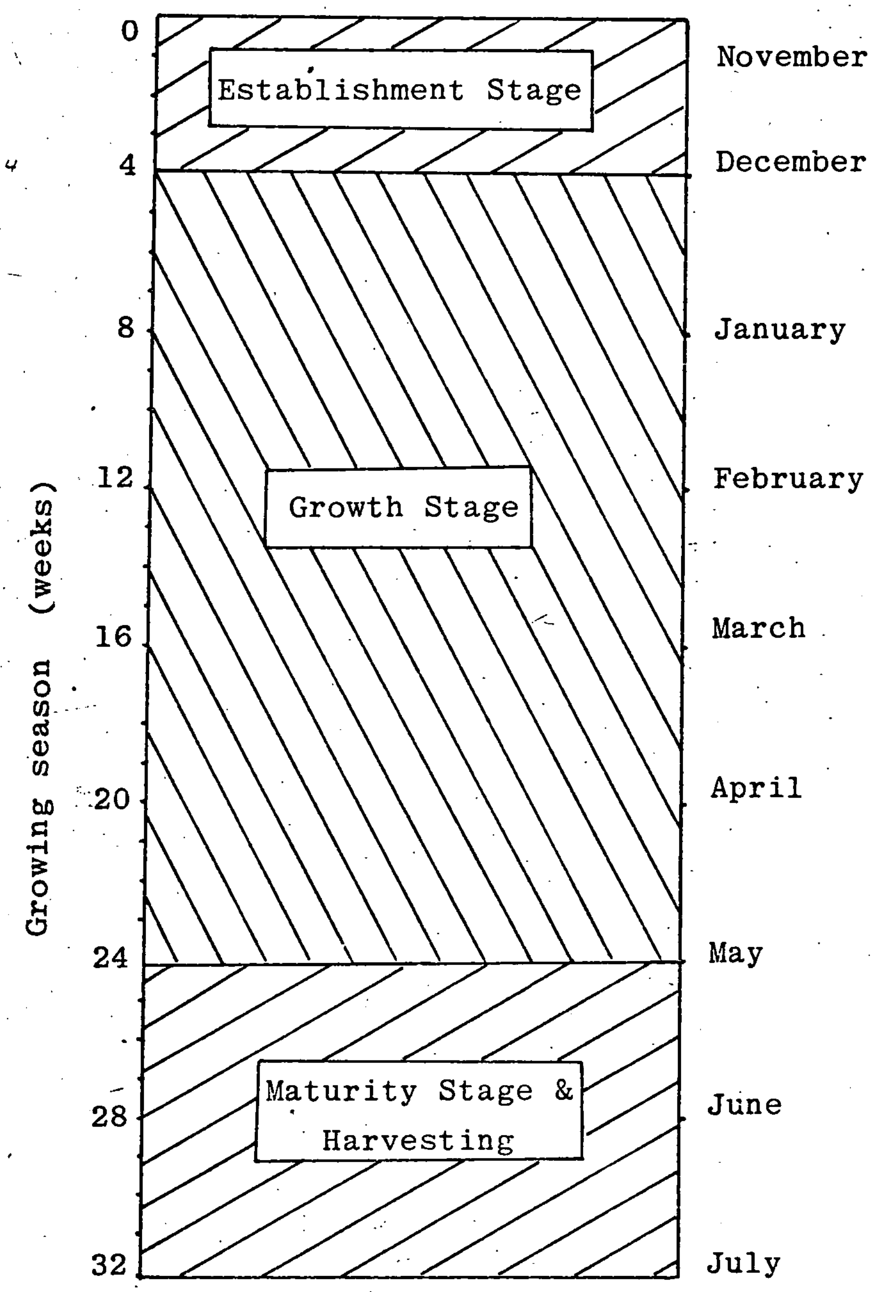
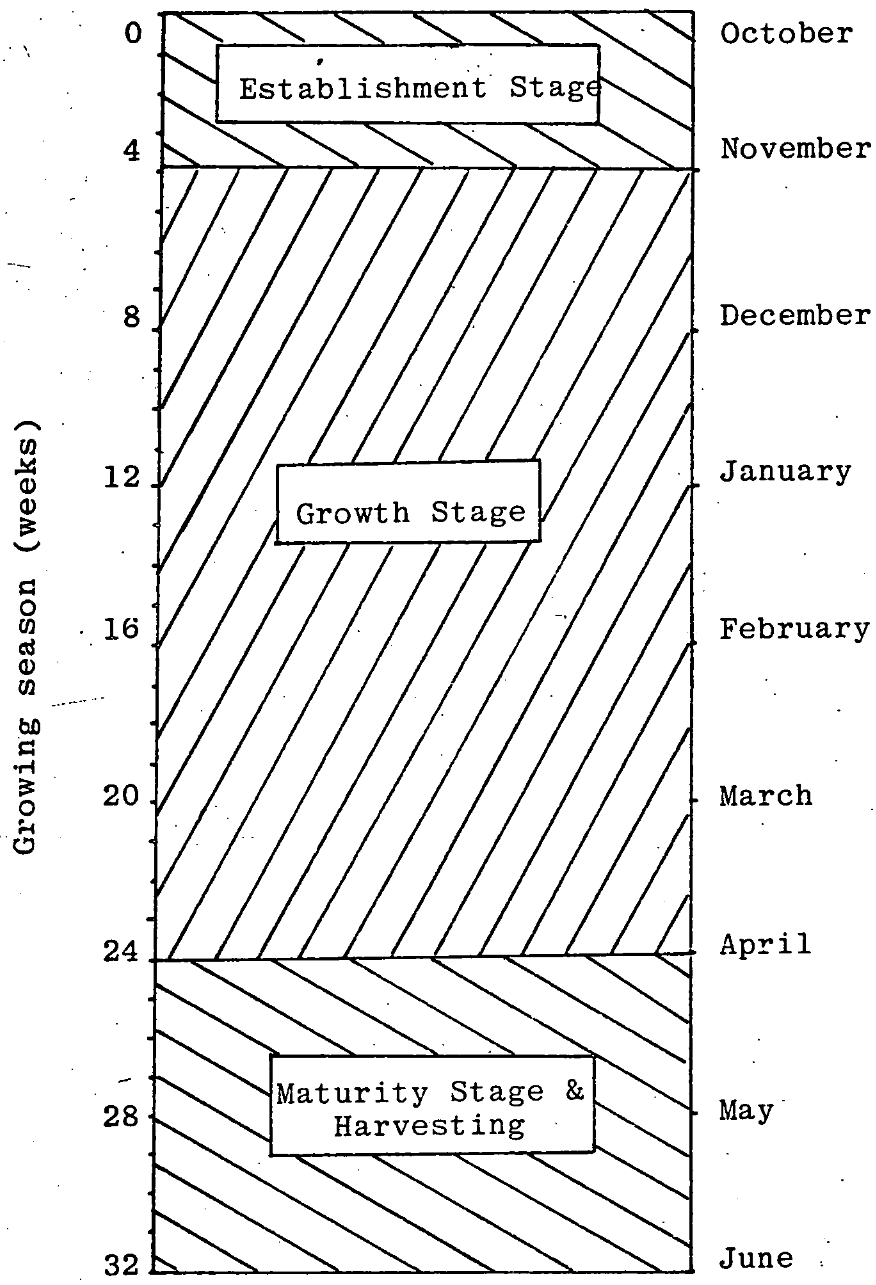


Figure 7.2 Typical Growth Stages of the Barley Crop



c) Poppy

The opium poppy is a crop of high value for small bulk, and has a lower water requirement than most crops. It is therefore a very suitable cash crop in arid areas. From November to December the seed is broadcast on a carefully cultivated and manured seed bed. The plants are thinned out to 25 cm.,apart and the fields are regularly weeded. Irrigation begins during March or April, depending upon the spring rains, and continues until harvest at intervals of 15 days. The opium is harvested during May and June, just before petals fall. Three small gashes are made on each pod during the afternoon, and the congealed latex collected the following morning. The yield in 1978 averaged about 3 kg/ha.,in Mohamad-Abad and Abuzaid-Abad villages, and this was sold to the government.

3.1.1.2 Spring Crops

Onion and beet are the common Safie crops in the area. Although some green vegetables are grown, the total area of field does not exceed 11 hectares in the area. These kinds of vegetable are usually grown in private gardens or backyards and are usually irrigated from nearby wells.

a) Onions are sown in the early spring. The seed bed is prepared and onion seeds are scattered carefully, and are usually covered by one to two centimetres of manure, after the first irrigation. The seedlings are thinned to 10 cm apart. The fields are weeded two or three times after each irrigation, which occurs at least every 10 days. The onions are harvested at the end of October.

b) Beet

Beet, like onions, is sown mostly during March. The seed is broadcast on cultivated land, and chemical fertilizer is usually scattered after sowing on the already irrigated field. Beet fields are irrigated every 12 to 15 days (water rotation). While the beet is growing some leaves are removed for cattle feeding. The beet is harvested during November and is used to feed both the family and the cattle during the winter.

c) Alfalfa

Alfalfa is the principal forage crop in the area, and is sown in the spring or autumn in a carefully prepared seed bed. The period of alfalfa productivity ranges between 5-7 years. Harvesting is a hand operation which usually occurs in the middle of April, June, August and at the end of October, thus alfalfa is usually harvested four times in a year in the area. Alfalfa fields are irrigated using the normal water rotation system (every 10-12 days) and are manured every year with poultry residual, animal waste and chemical fertilizer.

Table 7.1 shows the distribution of seeds for various crops in Abuzaid-Abad area in 1978.

7.2 Tree Crops

The area with abundant sunshine, and a long growing season and with the limitation of soil and water is suitable for a special kind of fruit tree, e.g. vine, pomegranates, apricots and fig etc. The fruit trees in the area are grown in small plots, mainly in backyard gardens. The tree crops are planted in kart (basin) and irrigated usually in the water rotation.

Table 7.1 Distribution of Seeds for Various Crops in The Abuzaid-Abad Area. Kilogram/ha

Variables / Villages	Wheat	Barley	Cotton	Alfalfa	Onions	Beet
Fakhreh	123	120	62	37	29	27
Shahriary	125	125	62	39	29	28
Rijen	125	125	70	37	28	29
Ali-Abad	123	120	62	37	27.5	29
Mohamad-Abad	125	123	62	39	28	27
Abuzaid-Abad	125	120	62	39	29	28
Kaghazi	125	127	62	39	28	27
Yazdelan	130	125	-	42	30	29
Qasam-Abad	130	125	65	41	30	29
Hosain-Abad	135	130	62	40	31	29
Average	126.5	124	63	40.4	29.1	29.3

Source : Field Investigation, 1978.

7.3 Use of Fertilizer

Fertilization in the Abuzaid-Abad area is very common, and often it is applied to the crops. The following fertilizers are applied:

5.2.1 Animal manure

In the area, as everywhere else in Iran, the application of organic manure, derived from animal and human waste, is the widely accepted traditional method of improving soil fertility and productivity in the area.

It is difficult to calculate the average amount of manure needed per hectare of crops in the area, but following field observation, an average calculated by the author was applied for each crop in the area (1978).

The sources of organic manure are twofold; firstly, the village dwellings and secondly, residual poultry waste.

Most of the households in the area keep one or two cows, or a few goats and sheep for milking etc. The animal waste is collected periodically from the stalls where the animals are kept permanently. In the area some farmers use human waste as a manure, but its application is not very common in the area under study.

The residual poultry waste is brought by the farmers from the poultry houses of Kashan, Qom and Tehran, and is brought by lorry to the area.

The total organic manure used in 1978 in the area was about 4595.5 tons, or an average of 11.63 tons per hectare, and the usual price per ton of organic manure was 500 Rials

(£4).[1] In addition, about 1,259 tons of residual poultry waste was bought, which was used at a rate of 2.9 tons per hectare. The usual price per ton of residual poultry waste was about 2000 Rials (£16).

The amount of organic manure applied depends on various factors -

(a) the kind of crops. The average amount of manure which is applied to perennial crops and summer crops is higher than the average amount used for cereals and cotton, because the summer crops and perennial crops need more fertilizer.

(b) The farmers' financial situation. Some of the time, finances do not allow the purchase of more manure, especially residual poultry waste.

(c) the availability of manure. There is not always enough manure in the area for application as a fertilizer, because animal waste is also used as a fuel for cooking and heating in most households.

7.3.2 <u>Chemical Fertilizer</u>

Four types of chemical fertilizers have been introduced to the area : nitrogen, phosphate, potash and urea. Unfortunately, the Government Agricultural Research Department has not investigated the soil fertility of this area, and also has not recommended any particular type of chemical fertilizer.

A mixture of nitrogen, phosphate and potash appears to be the most popular fertilizer. This fertilizer is known as 15/15/15 compound and is applied at the rate of 80 kg/ha for wheat and barley(Table 7.2). This mixture is recommended for general use by the merchants or rural cooperative staffs, who sell it in Kashan or cooperative shops in the area.

As a result the farmers are usually satisfied by this mixture. It can be said that the majority of farmers have no idea at all about which, and how much fertilizer to give to which crop. Table 7.2 shows the application of manure, poultry waste and chemical fertilizer for various crops in the area, including the total and average consumption of each kg/ha in the various villages in the Abuzaid-Abad area. These figures have been calculated by the author during a field survey in 1978 (Fig.5.3).

7.4 Crop Rotation

The rotation of crops is a vital element, which has a considerable impact on the agricultural production in the area. Two systems of rotation are used in the Abuzaid-Abad area (a) biennial system or two-year cycle and (b) triennial system or three year cycle.

The choice of system depends upon the situation of the field, the availability of irrigation water and the kind of crops etc. The system of rotation is usually selected by consultation with the farmers in each village.

The biennial rotation system is applied as follows:

Year	O	N	D	J	F	M	A	M	J	J	A	S
1	Wheat									Fallow		
2	Barley									Fallow		

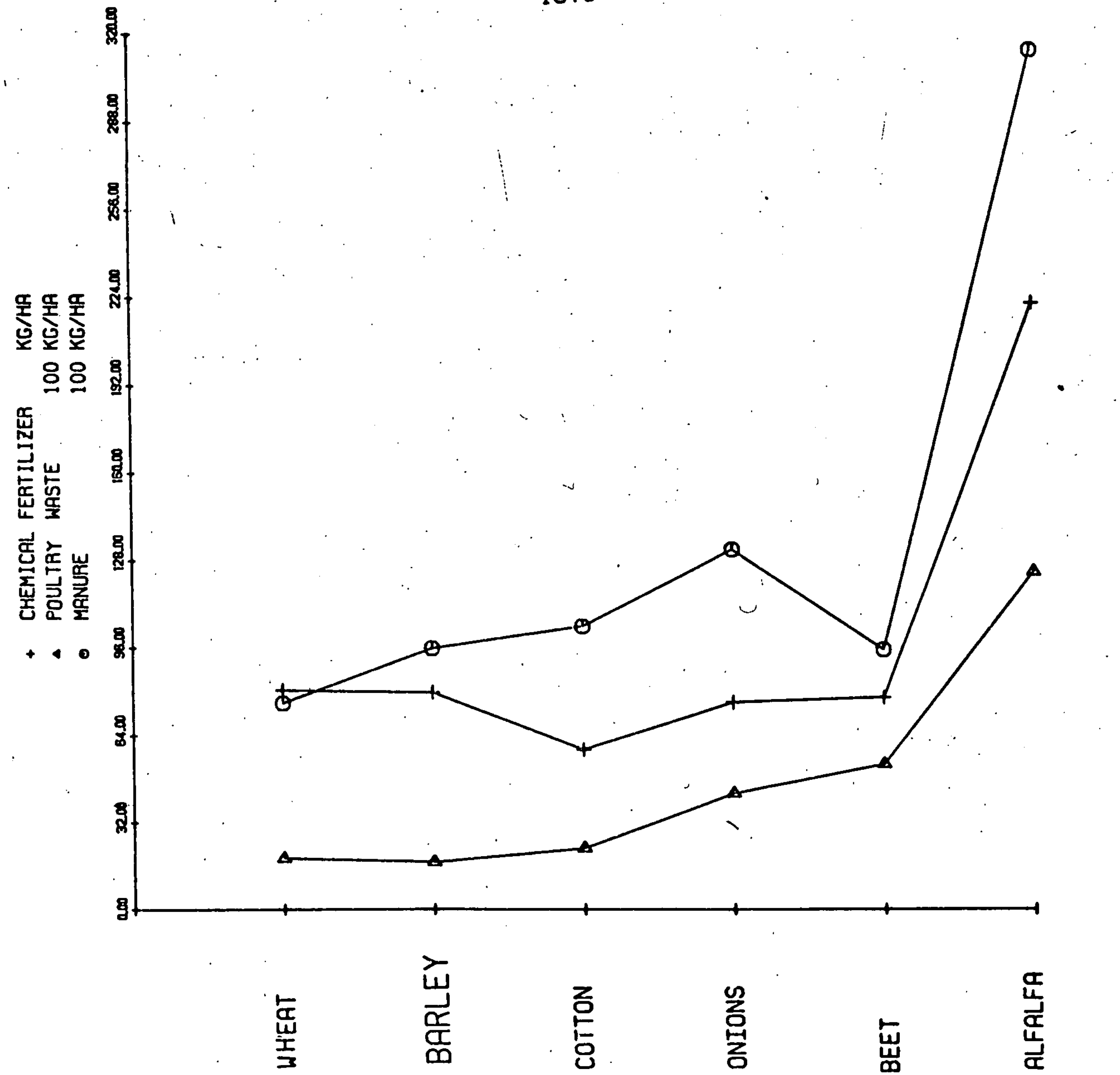
Table 7.2 Application of Manure, Poultry Waste and Chemical Fertilizer for Various Crops in the Abuzaid-Abad Area (1978)

(kg/ha)

Village \ Variable	Wheat			Barley			Cotton			Onion			Beet			Alfalfa		
	manure	poultry waste	chemical fert.	m.	p.w.	c.f.	m.	p.w.	c.f.	m.	p.w.	c.f	m.	p.w.	c.f.	m.	p.w.	c.f.
Fakhreh	7687	1545	73	7687	1548	56	5814	2250	53	11000	2887	40	12636	2478	62	22289	3125	120
Shahriary	2880	2880	72	2512	2232	64	3857	3857	107	-	-	-	2714	3857	119	37142	7714	321
Rijen	4323	-	105	4230	-	98	4137	1689	60	1739	5272	72	5122	1750	65	9043	2500	109
Ali-Abad	7596	1092	81	7598	1097	69	5720	1610	52	2000	8000	45	1500	9957	19	31987	1717	160
Mohamad-Abad	9468	1707	190	9944	1707	93	8333	1993	67	14461	2512	44	6854	1951	125	14033	1810	165
Abuzaid-Abad	9160	1730	75	9160	1730	34	8346	2282	66	10374	2343	104	8675	2212	48	14934	2921	147
Kaghazi	5333	1500	100	5333	1200	100	7432	1750	70	12359	2500	100	8975	2439	80	27432	9500	540
Yazdelan	15776	1309	-	13776	833	-	-	-	-	23731	-	-	-	18850	-	39800	1786	-
Qasan-Abad	10821	3246	31	12000	3600	30	8544	2563	55	15000	6292	130	14673	4408	103	37495	10438	215
Hosain-Abad	2901	-	-	29201	-	-	40647	-	-	28123	-	-	24497	-	-	79923	-	-
Total	75945	15009	727	95941	13947	644	93474	17994	530	118787	29805	535	85676	47902	621	314078		1777
Average	7594	1876	80.7	9594	1743	80	10386	2249	58.8	13198	4257	76	9516	5332	778	31407	12390	222.1

Source : Field investigation in 1978.

FIG 7.3 APPLICATION OF FERTILIZER FOR VARIOUS CROPS IN THE ABUZAID-ABAD AREA
1978



This system is used in the farms around the villages or near the water resources. Usually the land is manured every year, both by animal manure and chemical fertilizer. The fallow period in this system is very short and does not exceed 3-4 months. By this system of rotation the land remains under annual cultivation.

The triennual crop rotation is a traditional rotation system in the area, which was practised more in the past than at the present time. Recently much remote land, which was under the three year cycle rotation, has been placed under well irrigation. The system involves the division of the field into three plots and the rotation is as follows

		O N D J F M A M J J A S	
First Year	First plot	Cereals	Fallow
	Second plot	Fallow	
	Third plot	Fallow	Fallow(Plough)
Second Year	First plot	Fallow	
	Second plot	Fallow	Fallow (Plough)
	Third plot	Cereal	Fallow
Third Year	First plot	Fallow	Fallow (Plough)
	Second plot	Cereal	Fallow
	Third plot	Fallow	

In this system of rotation the field is usually fertilized allowing it to lie fallow, although these fields are manured occasionally. This system is usually used in the remote fields in the area, but during the last few years, in some of the villages i.e. Mohamad-Abad, Abuzaid-Abad and Kaghazi, with the construction of wells, this system has lapsed somewhat. It was, however, carried out regularly before the construction of deep wells in the area. Since the construction of deep wells (1975), 137 ha., of land, which was previously under the triennial rotation system is now under well irrigation, and they have changed to the two-year cycle rotation, because in some cases there is also land limitation. The farmers believe that the land under well irrigation must be near the well as the water capacity decreases as a result of infiltration in the sandy land and evaporation (hot weather) as it travels to the remoter fields. Therefore they prefer to use the land near the well under biennial rotation.

However, while this field investigation was being carried out, it was very difficult to determine how much of the area is under each rotation system, because after the construction of the wells in the area there is no clear, general pattern of rotation systems. Table 7.3 and Figure 7.4 show the distribution of fallow land in the area. 630 ha., out of 1,165 of cultivated land are left fallow (54% of the total cultivated area). The total amount of fallow land under qanat irrigation was 465 ha and the total amount of fallow land under well irrigation was 139 ha., in 1978.

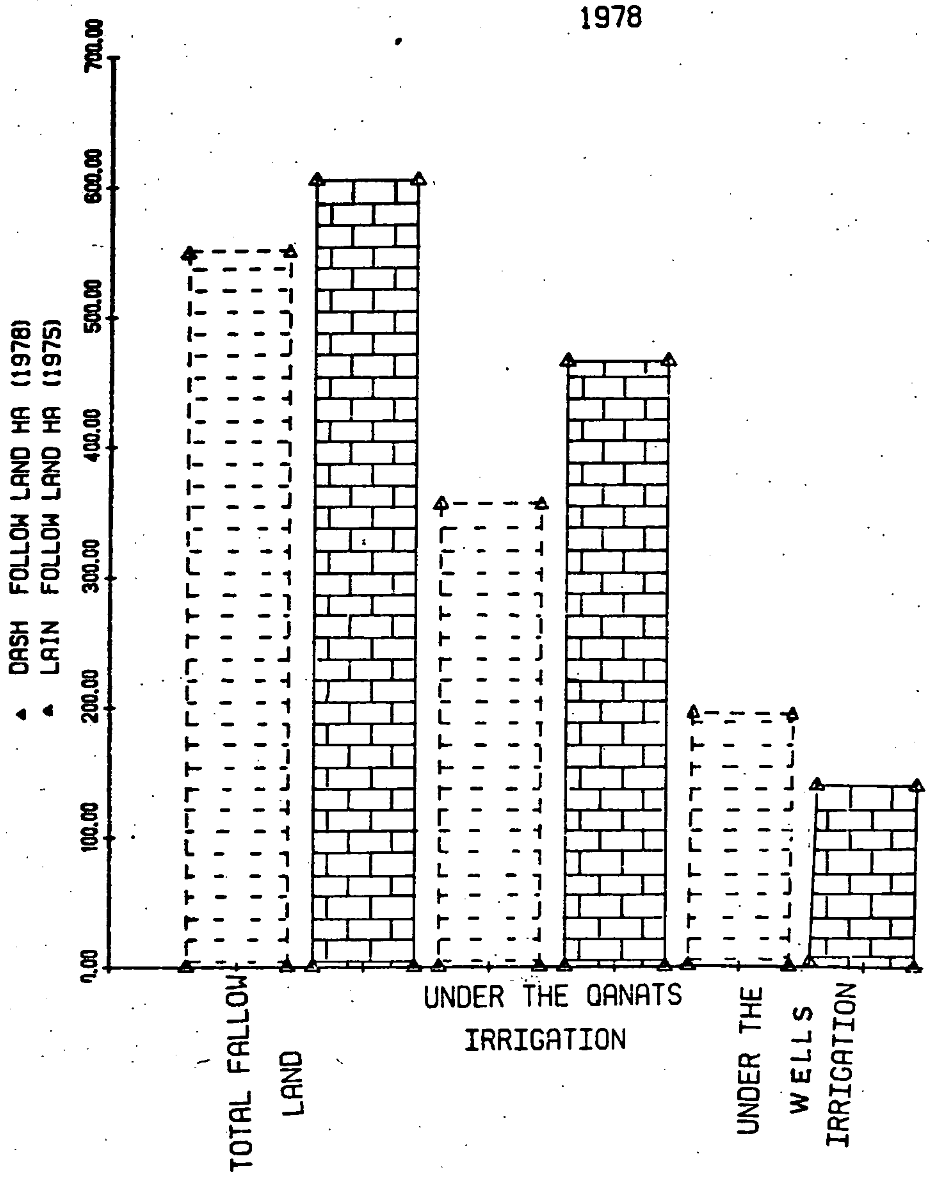
Table 7.3 Distribution of Fallow Land in the Abuzaid-Abad Area (1975 & 1978)

Variables / Village	Land under cultivation (ha)		Fallow land ha.		Fallow land %		Fallow land under quanat irrigation (ha)		Fallow land under well irrigation (ha)	
	1975	1978	1975	1978	1975	1978	1975	1978	1975	1978
Fakhreh	102	102	69.6	84.8	68.2	82.1	69.6	83.8	-	-
Shahriary	107.5	31.6	92.5	21	86.0	66.4	45	-	47.5	21
Rijen	113	113	70.9	78.5	62.7	69.4	70.9	78.5	-	-
Ali-Abad	149.2	149.2	101.9	86.7	68.2	58.1	101.9	66.7	-	20
Mohamad-Abad	199.7	199.7	67.8	122.54*	33.9	61.3	26.5	72.5	41.3	50
Abuzaid-Abad	258.6	258.6	69.8	83.8	26.7	32.4	22.2	51.8	47.6	32
Kaghazi	138.5	109.7	47.2	62.05	34	56.5	47.2	52	-	10
Yazdelan	15.7	15.7	4.0	4.2	27	27	4.0	4.2	-	-
Qas m-Abad	70.75	61.2	27.4	38.4	38.7	62.7	14	32	13.4	6.4
Hosain-Abad	86	71.2	-	23.8	-	33.4	-	23.8	-	-
Total	1195	1165.2	551.1	604.7	46.0	51.7	356.3	465.3	194.8	139.4

* Artificial forest has been planted on 49.4 ha. of Mohamad-Abad fallow land.

Source : Farm surveyed.

FIG 7.4 DISTRIBUTION OF FALLOW LAND IN THE ABUZAID-ABAD AREA 1978



7.5 Crop Production

For the purposes of investigation, crop production in the Abuzaid-Abad area has been divided into two sections. Firstly, the annual crops, which are planted and harvested within one year : wheat, barley, cotton,beet, onions etc., are considered. Secondly, perennial crops, which are planted one year and harvested every year for a few years e.g. alfalfa, vines and fruit trees, are discussed.

The volume of crop production in relation to the area cropped is one of the most important indicators of the level of development of farming in any given region. For this purpose basic decimal data have been used by the author to calculate the yielding capacity per hectare, the total crop production, and the land under the various crops etc.

5.4.1 Annual Crop Production

As we have seen, annual crops can be divided into two types :

I. Winter Crops (Shatvi)

(a) Wheat

Wheat is the most important single crop and is grown over an area of 187.3 ha. As a result of the author's 1978 investigation in the field, the estimated average annual output of wheat per hectare was calculated to be 2140 kg., which accounts for a gross output of 400.9 metric tons.(2) Table 7.4 shows the specification of crops production in the area. However, wheat is grown over 32.4% of the winter crop area. The most common local varieties of wheat are Omid and Shahpasand.

(b) Barley

Barley is grown over 154 ha., or 41.9% of the total winter field crop area, with a total production of 381 metric tons. The estimated average yield of barley per hectare was calculated to be some 2480 kg., in 1978. The barley is used for animal feeding, especially for fattening sheep, because the majority of households fatten a few sheep for sale or for home consumption.

(c) Poppy

Poppy was sown on 25 ha., or 6.8% of the total winter field crop area. The total output of poppy was 75 kg., of opium with an average yield of 3 kg., per hectare. The poppy has been sown in the Mohamad-Abad and Abuzaid-Abad villages since 1979.

II. Summer Crops (Safi)

The more important summer field crops in the area consist of cotton, onions and beet, although there are other summer crops which are planted in the area such as vegetables, water melons etc., but their production is very small.

(a) Cotton

Cotton is grown over 4.8% of the total cultivated land or over 30.2% of the summer field crop land. The land under cotton cultivation was 22.4 ha., in 1978. The average yield of uncleaned (including the seed) cotton is about 2436 kg/ha and the total output was 54.5 tons in 1978.(3) The variety of cotton grown is local and called wash. The fibres of wash are short and so it is not popular in the Iranian markets.

Table 7.4 Specification of Crops Production in the Abuzaid-Abad Area in 1978

Village	Wheat			Barley			Cotton			Onions		
	Cult. land/ha	Yield kg/ha	Prod. kg.	Cult. land/ha	Yield kg/ha	Prod. kg.	Cult. land/ha	Yield kg/ha	Prod. kg.	Cult. land/ha	Yield kg/ha	Prod. kg.
Fakhreh	6.3	2126	13436	5.4	2345	12569	1.8	2050	3608	0.2	18020	3604
Shahriary	5	2350	11750	4.3	2460	10578	0.25	2895	811	-	-	-
Rigen	15.6	2295	35802	10	2423	24230	1.5	2092	3096	2.7	14164	39093
Al-Abad	21	2232	46872	24	2296	55104	3.8	2039	7585	0.8	17980	15103
Mohamad-Abad	27.1	2164	58655	26.5	2274	60276	3	3053	9160	0.7	17702	12392
Abuzaid-Abad	54	2345	126630	50.3	2474	124937	8.3	2674	22194	3.5	16697	38439
Kaghazi	25	2374	39369	17.27	2253	38305	-	-	-	1.8	22980	31364
Yazdelan	1.8	2170	3612	4.6	2253	9024	-	-	-	0.1	17600	2112
Qasem-Abad	9.5	2143	20362	8.1	2673	21653	1.2	2586	3103	0.2	12025	2405
Hosain-Abad	22	2020	44440	11	2274	23814	2.5	1988	4970	1	17348	17348
Total & Average	187.3	2140	400,928	153.6	2480	380,490	22.38	2436	54,527	11	14,717	161,890

Source : Field Survey 1978.

Table 7.4 (Cont.)

Village	Beet			Alfalfa			Opium		
	Cult. land/ha	Yield kg/ha	Prod. kg.	Cult. land/ha	Yield kg/ha	Prod. kg.	Cult. land/ha	Yield kg/ha	Prod. kg.
Fakhreh	0.6	29861	12722	0.7	94825	68274	-	-	-
Shahriary	0.21	24000	5040	0.25	88696	22174	-	-	-
Rigen	2	30298	60595	1.2	95506	10967	-	-	-
Al-Abad	1.4	2968	44173	2.4	75834	182001	-	-	-
Mohamad-Abad	4.6	29089	133812	4.8	103089	494828	10	3.2	32
Abuzaid-Abad	11.4	29080	331512	12.7	103505	1230060	15	2.9	43
Kaghazi	2	25708	51417	7.1	125819	515859	-	-	-
Yazdelan	0.4	28000	10080	1.7	101786	171000	-	-	-
Qasem-Abad	0.3	25000	7500	0.7	96144	67301	-	-	-
Hosain-Abad	2	28266	56532	4.5	127463	573584	-	-	-
Total & Average	24.9	28649	713383	33.0	94166	3293050	25	3	75

(b) Onions

Onions are an important summer crop in the area. The average yield has been estimated at about 14 metric tons per hectare. The total output of onions in 1978 was 161 tons, of which about 50 tons were sent to market and the rest were consumed by the residents of the area or sown to supply onion seed. The total land under onion cultivation in 1978 was 11 hectare or over 15% of the summer field crop.

(c) Beet

Beet is the other important summer crop. The beet is sown for both human consumption and animal feeding. It plays an important role in animal feeding, especially for cattle. The total production of beet in 1978 was 713 tons, and the yield of beet averaged 28 tons per hectare. Beet occupied about 25 hectares of land or over 33% of the total summer field crop area. Beet is not sent to market, since it is produced for domestic consumption and animal feeding.

7.5.2 Perennial Crop Production

Perennial crops occupy 18.8% of the total cultivated area. Alfalfa, vine and fruit tees are included in this group of crops.

Perennial crops (excluding alfala) are limited to seven villages, Mohamad-Abad, Abuzaid-Abad, Kaghazi, Rigen, Yazdelan, Qasem-Abad and Hosain-Abad.

(a) Alfalfa

Alfalfa is usually sown in all of the villages and it is the crop that provides the highest income for the farmers in the area. Alfalfa is the principal forage crop in the area, and it occupies 33 ha.,of cultivation land. Crop yield per hectare is estimated to average 94 tons ranging between 75 and 125 tons. Production could undoubtedly be increased considerably through fertilization, additional water, and proper measures against plant disease.

A small percentage of alfalfa is used while still fresh green for animal feeding, but a large percentage is dried as it is used by families who own livestock, and they store it for winter consumption.

7.5.3 Tree Crop Production

In every village the farmers usually have approximately equal units of land distributed for annual crops, but the ownership of an orchard or of land for perennial crops (excluding alfalfa) does not depend on the same units of distribution. Therefore in most villages in the area, the gardens, yards or orchards usually belong to a group of villagers who are particularly skilled in the raising and maintaining of fruit trees. According to field work investigation, fruit trees occupied 51.8 ha.,of cultivated land or 4.5% of the total cultivated land. In other words fruit trees occupied 10.7% of the total irrigated land under cultivation (excluding fallow land).

The number of fruit trees in the Abuzaid-Abad area according to the questionnaire administered in 1978 was 164,2000 of which 137,700 were productive. 26,500 fruit trees were planted during the 3 years of this investigation, increasing the number of fruit trees by about 19.2%. This increase is due to the construction of wells in the area.

The total fruit production of 1978 was about 1,753 tons, comprising grapes, pomegranates, apricots, figs etc. Table 7.5 shows the specification of tree crops in the area in 1978.

(a) Vines

Grapes are grown for local consumption in the area, or to be sold. Fresh vines are grown in six villages. The grapes from Kaghazi village are the best quality and most sought after and are famous in the Kashan region. In fact grapes are considered to be one of the most profitable of the traditional cash crops.

The number of vines in the area in 1978 was 106,060 of which 83,470 (78.7%) were productive. The average yield per productive vine in 1978 was 9.7 kg. The total production of grapes was 797 tons at the time of this investigation.

(b) Pomegranates

Pomegranates rank second among fruit trees for production and play an important part in agriculture. They are grown mainly on the irrigated farms in the traditional horticultural areas, and backyard gardens in the villages.

The pomegranate matures in the early autumn and so usually some families store them for the winter because the price of pomegranates in the autumn is usually low.

The best type of pomegranate is called Soltani and it is late maturing. It is produced on a larger scale in Kaghazi and Abuzaid-Abad villages than in the other villages.

The number of pomegranate trees in 1978 was 45,720, of which 41,058 (89.8%) were productive. The average yield per productive tree in 1978 was 17.8 kg. The total production of

Table 7.5 Specification of Tree crops in the Abuzaid-Abad area in 1978

Variables / Villages	Grapes			Pomegranates			Apricots			Other fruits		
	No.of trees	Prod. kg.	Yield kg/ tree	No.of trees	Prod. kg.	Yield kg/ tree	No.of trees	Prod. kg.	Yield kg/ tree	No.of trees	Prod. kg.	Yield kg/ tree
Fakhreh	-	-	-	-	-	-	-	-	-	-	-	-
Shahriary	-	-	-	-	-	-	-	-	-	-	-	-
Rijen	-	-	-	5,035	99,261	19.7	-	-	-	-	-	-
Ali-Abad	-	-	-	-	-	-	-	-	-	-	-	-
Mohamad-Abad	20,532	211,632	10.3	5,191	93,964	18.1	462	8,910	19.2	735	6,151	8.3
Abuzaid-Abad	38,709	337,449	8.7	17,084	309,592	18.1	1,502	37,667	25	3,465	72,136	20.8
Kaghazi	11,416	124,663	11.2	7,415	150,110	20.2	788	7,896	10.0	1,810	28,132	15.5
Yazdelan	3,069	29,276	9.5	1,500	26,000	17.3	420	7,200	17.0	418	1,770	4.2
Qasem-Abad	2,371	29,443	12.0	1,536	20,720	13.4	281	2,616	7.3	133	1,090	8.1
Hosain-Abad	7,377	88,756	12.3	2,297	33,898	14.7	1,325	18,525	14.0	1,828	30,624	16.7
Total	83,474	796,788	10.6	41,058	733,596	17.8	4,778	82,814	18.3	8,389	139,903	17.6

Source : Field survey, 1978.

1978 was 733 tons, about 62.5% of which came from Kaghazi and Abuzaid-Abad villages.

(c) Other Fruit Production

The main tree crops in the area are grapes and pomegranates which account for about 87.5% of tree crop production. Other fruits amount altogether to 223 tons, or about 12.5% of total production.

The number of other fruit trees was about 12,420 of which 8,390 (67.5%) were productive. The average yield per productive tree in 1978 was about 17 kg. The common types of these fruits are apricots, figs and apples. These fruits are usually not sent to market, because after domestic consumption there is very little surplus left for sale.

7.6 Farm Labour

According to a questionnaire survey which was carried out by the author in the area in 1978, 49.5% of the total male adult population (over 15 years old), or 1,057 persons were classified as permanent full time farmers. In other words 14% of total population were owner cultivators. Also according to the above survey 7.2% of the total population or 542 persons (male adult) were landless farmers involved in agriculture. They were hired labourers and were paid by the day. About 55 of them were hired in 1978 by Karaj city landlords, and they were contracted to work in the market gardens of Karaj. 9.8% of the population, or 744 persons, (male adults) were landless workers, the majority of whom were involved in non-agricultural activities; a group of them went and worked for part of the year in Kashan, Tehran and other cities.

171 persons (male adult), or 2.2% of the total population, were employed in the villages for social services, or they had private jobs in the area, i.e. shopkeeper, driver, barber, bathkeeper, mogani, watchman, head man etc.

According to an estimate which has been made, the average work per owner cultivator (male adult) at the farm per annum, was 455 man-hours/year or 59 man-days per year (average 8 hours work/day), or about 1.3 hours/day during the year.

Table 7.6 shows the distribution of farm labour in the different stages of cultivation in the Abuzaid-Abad area. (Fig. 7.5) According to the Table 7.6 the maximum number of days worked per owner cultivator (male adult) per annum in Shahriary village was about 149 days during the year.[4]

However, the total possible labour force was 4,563,700 (m-h)/yr.[5], in the area. In fact only 390,401(m-h)/yr, or 8.6% of the total labour force, was spent on the cultivation in 1978 in the Abuzaid-Abad area.[6]

According to an estimate which was made from Table 5.6 and field observation, the seasonality of farming labour has been calculated and the result of this calculation is shown in Table 7.7. Figure 7.6 shows that the highest number employed occurs in the summer season - about 33%, and in winter 14%.

Table 7.3 Specification of the Labour Force in cultivation in the Abuzaid-Abad Area (1978)

Variables \ Village	Fakhreh	Shah-riary	Rijen	Ali-Abad	Mohamad-Abad	Abuzaid-Abad	Kaghazi	Yazdelan	Qasem-Abad	Hosain-Abad	Total
Ploughing and boundary ditch construction (M-H)/year	3,360	1,552	5,744	10,016	12,368	24,960	8,800	2,064	3,360	8,098	80,312
Weeding (M-H)/year	1,720	776	2,872	5,008	6,184	12,480	4,400	1,032	1,680	4,048	40,201
Irrigation (M-H)/year	1,548	698	2,584	4,507	5,545	11,232	3,960	928	1,512	3,643	36,177
Qanat maintenance and ditch clearing (M-H)/year	2,580	-	5,744	15,024	18,552	37,440	13,200	1,548	1,680	10,120	112,888
Horticulture working (M-H)/year	1,536	-	540	2,640	1,920	6,960	4,560	412	672	1,608	20,628
Harvesting (M-H)/year	5,080	2,328	8,616	15,024	18,552	37,440	13,200	3,096	5,040	12,144	130,520
Total annual man-hours worked in each village	15,824	5,946	26,101	52,373	63,141	130,513	48,120	9,080	13,944	39,659	404,699
Number of cultivators involved in agriculture	34	5	69	78	143	307	152	30	65	180	1,057
Work per farmer (male adult) (M-H)/year	455	1,191	378	722	442	425	317	302	214	220	-
Work per farmer (male adult) (M-Day)/year	58	149	47	91	55	53	39	38	27	275	-
Work per farmer (male adult) (M-H)/day	1.3	3.3	1	2	1.3	1.2	0.8	0.8	0.6	0.6	-

Source : Field Survey (1978).

FIG 7.5 DISTRIBUTION OF LABOUR FORCES IN THE CULTIVATION ACTIVITIES IN THE AREA 1978

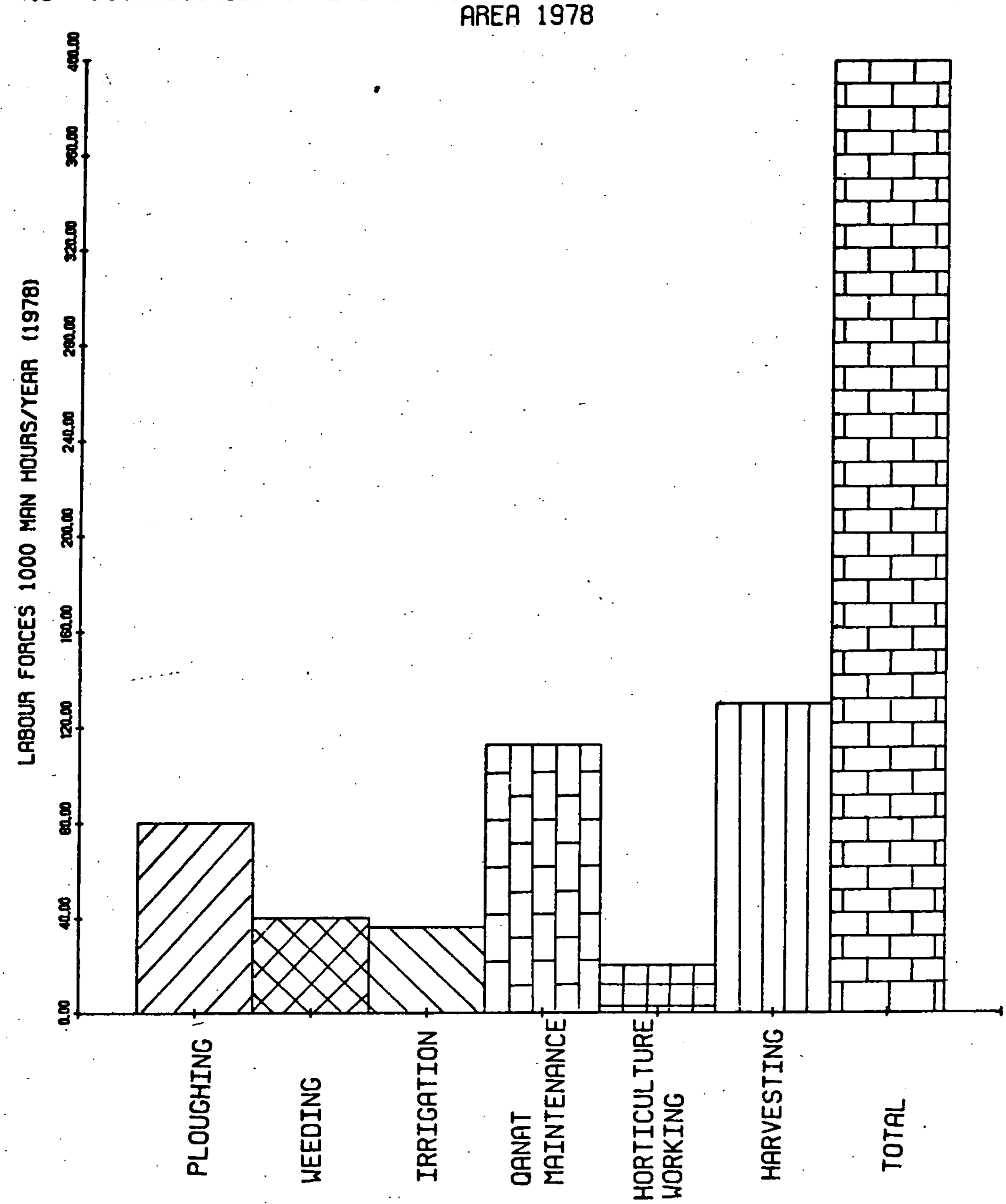
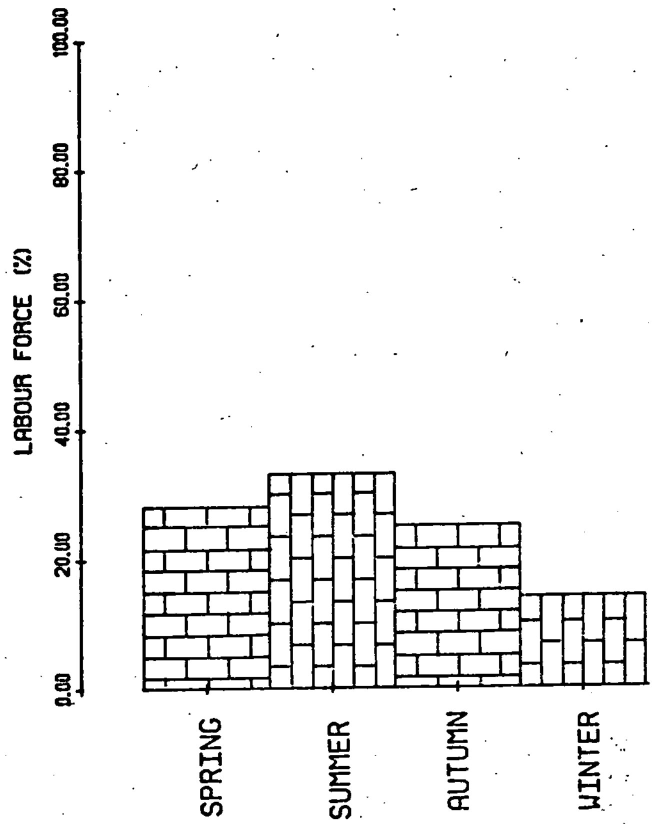


Table 7.7 **Seasonal Fluctuations of Labour Force in Farming in the Abuzaid-Abad Area in 1978**

Variables / Seasons	Spring			Summer			Autumn			Winter		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Seasonal rainfall throughout the year	Rain			Dry					Rain			
Farming	weeding & patch clearing			Harvesting				Ploughing, sowing & ditch cleaning				
Percentage of Farmers work during the season	28%			33%			25%			14%		

FIG 7.6 SEASONAL FLUCTUATION OF LABOUR FORCE IN THE ABUZAID-ABAD AREA



7.7 Animal Power

The use of animal power in traditional agriculture is common in Iran. Horses, oxen and donkeys are usually employed for ploughing, threshing and transport. The use of animals has decreased during the last few years because machines have replaced animals in agriculture in most parts of Iran. Although machines are not yet widely used in the area, the use of animals has almost been forgotten, due mainly to the high cost of feeding animals. This is because there is not enough pasture for the animals, and the farmers have to keep them in the stable during much of the year.

According to the field investigation, there were only 6 oxen which were frequently used for ploughing, and also there were 667 donkeys which were used for ploughing and transporting goods and manure. However, the total oxen power in the area equals 4.5 horse power (1 ox power = 0.75 horse power)[7] and the total donkey power equals 233.5 horse power (1 donkey power = 0.35 horse power). Altogether the total animal power in the Abuzaid-Abad area is 238 horse power. Although there are 367 head of camels in the area, they are not used for agricultural activities (Table 7.7).

7.8 Farm machinery

Mechanization is not well developed in the area under consideration and it has been introduced only recently. In the ten villages surveyed, only two tractors were found. The total value of the two tractors, which were bought by farmers from the Agriculture Ministry[8] was 871,000 Rials (£ 7,528), paid in instalments. The use of tractors is not very common

Table 7.7.1 Specification of Animal Power in the Abuzaid-Abad Area (1978)

	Oxen	Equals in horse power	Donkey	Equals in horse power	Total
Fakhreh	-	-	8	2.8	2.8
Shahriary	-	-	2	0.70	0.70
Rijen	-	-	88	30.8	30.8
Ali-Abad	-	-	40	14	14
Mohamad-Abad	3	2.25	83	29	31
Abuzaid-Abad	3	2.35	211	73.8	76.03
Kaghazi	-	-	58	20.3	20.3
Yazdelan	-	-	12	4.2	4.2
Qasem-Abad	-	-	34	11.9	11.9
Hosain-Abad	-	-	131	45.8	45.8
Total	6	4.5	667	233.5	238

Source : Field investigation (1978)

in the area, because the cultivated plots are too small to be operated by machinery.

However, apart from these two tractors, which are used for ploughing there are no other agricultural machines, e.g. harvesters, threshers, seed drills etc.

The two tractors, are hired out for ploughing and sometimes for threshing at 1,000 Rials (£6.6) per hour.

In the ten villages surveyed in 1978, there were 14 water pumps (more details about the cost of well construction have been given in the section on water supply) for which the farmers have paid altogether 5,540,000 Rials (£36,933).

The total investment in mechanization in the area was 6,411,000 Rials (£42,740) in 1978, of which about 86.5% was accounted for by the machines involved in the water supply.

7.9 Livestock

Animal husbandry in the area is practised by settled peasant farmers. In the villages of the Abuzaid-Abad area animal husbandry plays a substantial role. Even in the three villages of Hosain-Abad, Qasam-Abad and Yazdalan more than 50% of the income from agriculture comes from livestock.

Animal husbandry has always been the most important source of income in the past, but today it is considerably less important, because most of the grazing land has been protected by the government to control the sand dunes and desert expansion.

The predominant animals in the Abuzaid-Abad area are goats, sheep, cattle, donkeys and camels. Poultry are very widespread and are found in almost every household. Goats and camels predominate in the eastern part along the margin of the desert, and sheep, goats and cattle in the middle and western parts of the area. Donkeys are used everywhere for agricultural purposes (transport, ploughing and threshing). Animal migration inside the area occurs according to the conditions of the pasture in the region. In the dry season - summer and autumn - sheep and goats move west and southward to the mountains. In winter they are kept in stables, fed with dry alfalfa, barley and chaff, and in the spring and late winter they graze, usually around the villages. Camels are herded in the eastern part of the area (Yazdalan, Qasam-Abad and Hosain-Abad). The camels are free, and walk long distances without water, to graze in the margin of Dasht-e-Kawir.

The number of animals and their products depends entirely on the pasture condition, and stable services. However, the total number of animals in the area, according to the field investigation was 21,092 head in 1978, of which 74,5% were goats, 17.5% sheep, 3% cattle, 3% donkeys and about 2% camels. In their interviews with the author the local residents expressed the view that the number of animals has decreased by more than 75% in the last 15 years, especially camels and goats. On the other hand cattle have increased in relation to a few years ago. The main reasons for the reduction in animal numbers are (a) the increased price of animal feed (b) more than 70% of the grazing land has been changed to protected land or has been used for artificial forest, and (c) shepherds' wages are too high, and moreover few people will accept this job in the area.

7.9.1 Animal Distribution

(a) Goats

They are the most important animals in the arid area of Iran in general, and in the Abuzaid-Abad area in particular. Although goats produce more milk and sometimes more meat than sheep, they are unfortunately, harmful to the vegetation - grazing land. This is because when goats are grazing, they do not bite the branches off the plants, but rather they pull the plants out roots and all, especially in the soft, sandy grazing land in the area, and this action is harmful to the vegetation. So before the Revolution the government made a plan to limit goat raising in the arid area, but this plan has now been cancelled.

It is estimated that in good years each 100 nanny goats produce about 70 to 80 kids. The goats usually produce young once every normal year. Twin kids are very rare. The lactation season starts at the beginning of spring (the end of March). The length of the lactation season and the milk produced, however, depends entirely on the availability and the duration of the pasture (annual rainfall). The normal nanny goat produces about $\frac{1}{2}$ litre (about 1 pint) of milk per day during the whole season, and gives between $\frac{1}{2}$ to $\frac{3}{4}$ kg., of purified butter monthly as well. Goat hair is used mainly for making rugs. The shearing period usually started at the beginning of summer, and the average yield per goat is about $\frac{3}{4}$ kg., per year.

The number of goats was 15,701 head (according to field investigation) or 75% of all animals, with an average per household of about 11 goats.

(b) Sheep

Sheep are also very useful animals giving in addition to meat, milk, skins and manure. Sheep are similar to goats in their characteristics, but in arid areas sheep are not harmful to the vegetation because sheep usually bite the branches of the plants which allows the plant to grow again.

The number of sheep varies from village to village according to the vegetation density and interest of the people. The number of sheep was 3,695 head in 1978. This figure usually fluctuates from year to year, even from season to season, because especially in late autumn and winter, the majority of households fatten a few sheep for sale or for home consumption. In drought years sheep have to be kept in stables and they have to be fed on alfalfa or grass. In this situation keeping sheep results in financial loss, and so the farmers usually reduce the number of sheep in the area.

(c) Cattle

The cattle are raised in stables in the Abuzaid-Abad area and they are kept mainly for breeding and milk production. Unlike other parts of Iran the use of cows for work is not very common. The native breed of cattle are well adapted to the local environment and have a strong resistance to disease. The most common variety of cattle in the area is a local black or brown coloured, cow, short horned and small in size.

Normally a cow drops a calf once every year and lactation continues the year round and stops only two or three months before delivery. Milk production per cow is, in general, about 2-4 litres per day. In 1978 cattle comprised about 3% of the total number of animals; the number being 629 head, all of which were fed at the stall.

(d) Donkeys

They are the most important working animals in Iran, in general, and in the Abuzaid-Abad area in particular. It carries on its back loads exceeding 100 kg., and often they are engaged in most of the farm work. Without these hardy and patient and economical animals, the cultivation of scattered small plots in desert areas would be impossible. Although donkeys are not commonly used for ploughing, this does sometimes occur in the eastern villages (Qasem-Abad, Yazdelan, and Hosain-Abad) where they are used for cereal ploughing. Donkeys are found in all of the villages and their number is about 624 head, or 3% of the total animal population.

(e) Camels

The number of camels according to the field investigation in 1978 was 372 head. The camel is bred in the eastern part of the area, usually for meat at the present time, but it was used in the past for transport purposes.

The female camel produces one baby every two years. Camel milk is not used in the area. The camel also yields about 2 kg., of hair per year. Camels are bought for meat by buyers who come to the area especially for this purpose.

(f) Poultry

Poultry-keeping in rural areas is the least developed agricultural activity. The chickens are mostly of a small black and white native breed. This type of chicken yields a very small egg. They are left to feed in the fields and are only rarely fed on grain. It was difficult to estimate the number of poultry in the area because it was necessary to question the women. The men usually did not know anything about them. However, about 7,000 chickens were estimated by this author to be in the area in 1978. The number fluctuates frequently because disease may kill many chickens in only a few days.

Table 7.8 shows the distribution of livestock in the Abuzaid-Abad area.

7.10 Conclusion

The severe climatic conditions , water shortage, saline soil, small plots of cultivated land and traditional methods of agriculture have restricted the agricultural activities in the margin of Dasht-e-Kawir in general and in the Abuzaid-Abad in particular.

In the Abuzaid-Abad area, cultivation is limited to a few principal crops which have been found to be suited to regional conditions. The main crops are usually cultivated for local consumption, but in many cases the production of some crops such as wheat, barley, alfalfa etc. is not enough for resident consumption. For example, in 1978 the wheat production was only one third of the resident's annual consumption in the area, and shortfalls in barley and alfalfa

Table 7.8 Distribution of Livestock in the Abuzaid-Abad Area (1978)

	Goats	Sheep	Cattle	Donkeys	Camels	Poultry
Fakhreh	170	120	22	8	-	236
Shahriary	52	20	2	2	-	15
Rijen	316	36	15	40	-	188
Ali-Abad	260	45	60	45	-	390
Mohamad-Abad	1,752	223	136	83	-	1,600
Abuzaid-Abad	5,398	1,805	210	211	71	2,237
Kaghazi	739	135	70	58	-	879
Yazdelan	902	340	18	12	22	170
Qasem-Abad	952	-	36	34	138	189
Hosain-Abad	4,660	1,218	160	131	141	1,335
Total	15,701	3,695	729	624	372	7,058
Per cent	74.4	17.5	3.5	3.0	1.7	

Source : Field investigation (1978)

production have limited the number of animals raised locally.

Some methods for agricultural development in the arid area are suggested, but the Abuzaid-Abad area, as in other regions, has individual problems. For example,the limitation of ground water does not allow the extraction of more water, because when this investigation was being carried out there were nine operating qanats, six shallow wells and 8 deep wells in the area. The wells and four of the qanats were using local underground water, but it is well known that excessive extraction of underground water affects the discharge of the other water supply sources. As has been discussed the construction of wells is one of the main reasons for the decrease in qanat discharge in the area.

The small plots of land make the use of agricultural machinery difficult. Also the unsuitable soils restrict the chances of using more land for cultivation.

According to this author's opinion,the best ways for agricultural development in the area are :

a) to take care of the qanats.

b) To construct deep wells in the Fakhreh and Rijen areas, and prohibit well digging in the central areas (Mohamad-Abad, Abuzaid-abad and Kaghazi).

c) To reclaim lands that are covered by shifting sand in the northern part of Kaghazi and western part of Rijen and Abuzaid-Abad.

d) To give permission for the use of pretected land and destruction of about 25 ha of artificial forest which is located in the Kaghazi and Zahraieh deep wells area.

e) To chose the biennial rotation system if there is available water for irrigation, because in this method of rotation, the salt does not have the opportunity to surface by capillary action, which results from high evaporation rates.

f) To use chemical fertilizer according to advice from specialists, bearing in mind soil analysis.

g) To improve seeds, pest and disease control.

References

1. In 1978 one pound was equal to 120 Rials.

2. According to the author's estimation in the area in 1978 the wheat production was only one third of the annual area residents' consumption.

3. The cotton is sold non-ginned to purchasers who come to the area especially to buy it.

4. We must note that the population of this village was only 38 persons, of whom only 5 persons were involved in cultivation.

5. 8 hours/day, 6 days/week and 10 days holiday.

6. More details in the chapter of population, employment section.

7. Hopfon, H. (1969) Farm Implements for arid and Tropical Regions. FAO, Rome, p.10.

8. Adareh-e-Tosoah Mashinhie Keshavarzi (The office of Development, The Agricultural machinery).

CHAPTER 8

POPULATION AND SETTLEMENT

8.1 Introduction

Until 1956 there was no accurate information about the population of the Abuzaid-Abad area. In 1956, 1966 and 1976 national censuses were carried out by the government, providing the basic data on Iran's urban and rural populations. In this study some information has come from these national censuses and some from a field survey, which was carried out by the author in the Abuzaid-Abad area in 1978.

The population of the area consists predominantly of non-tribal peasants, who speak Persian, with a distinctive accent, similar to the Kashan accent. The religion of the people is Islam, and the true sect is the Jafarey (recognizing twelve Imams as the religious head).

8.2 Population characteristics of the Abuzaid-Abad Area

According to the Ministry of the Interior of Iran's definition, an area with less than 5,000 people is called a village (1) as is shown in Table 8.1. There is a similar disparity in the population of rural areas in Iran as a whole in terms of village size distribution. This table shows that the percentage of the middle size population (groups 250-499 and 500-999) in the area is higher than the other groups.

Approximately 20% of the villages in the area have populations of less than 250, 40% between 250-500, and

Table 8.1 Distribution of Villages in Iran (1966) and the Abuzaid-Abad Area 1966-1978

Population Range	Iran 1966 (a)			The Abuzaid-Abad Area 1966 (b)			The Abuzaid-Abad Area 1978 (c)		
	No.of places	% of places	% of Population	No. of places	% of places	% of Population	No. of places	% of places	% of Population
Below 50	20,850	31.3	2.9	5	36.7	1.3	1	10	0.5
50-100	10,528	15.8	5	-	-	-	-	-	-
100-249	16,936	25.4	18.1	4	28.5	16	1	10	2.2
250-499	10,415	15.6	23.9	3	21.4	25.5	4	40	18.8
500-999	5,314	7.9	23.7	1	7.1	12.7	2	20	20.4
1000-2499	2,087	3.1	19.7	1	7.1	44.1	1	10	15.9
2500-4999	308	0.5	6.7	-	-	-	1	10	41.9
Total	66.638	100	100	14	100	100	10	100	100

Sources: (a) - Vadiie(1973)[1]

(b) - National Census 1966

(c) - Field Survey 1978

40% populations between 500 and 5,000.

Village population size in 1978 varied from a minimum of 32 (Shahriary) to a maximum of 3,162 (Abuzaid-Abad), the mean being 754. In 1956 [2] the average population was 254, in 1966 [3] it was 337 and in 1976 [4] it was 719.

The average household size in 1966 was 4.5 and in 1978 it was 5.5 persons, in the Abuzaid-Abad adjoining villages. Four of the hamlets, Gazo, Bejah, Sadeq-Abad and Garshahy which were habitable in 1966, with a total of 6 households, in 1978, were uninhabitable because their qanats had dried up, and the residents had to migrate to the other villages or cities. However, the mean household size in 1966 was 4.5, increasing by 1978 to 5.5, as shown in detail in Table 8.2. The increase was due to a rapid increase in natural growth with high fertility rates and, more recently, to relatively low mortality rates.

8.3 Population Density

The total extent of the Abuzaid-Abad area is about 703 km^2, of which the cultivable area is estimated to be about 22,898 ha. One-ninth is under cultivation, the rest being utilized as a grazing area, protected land and artificial forest. About 45,610 ha. is arid desert and uncultivable land (for more detail see the Chapter on land use). The population is settled in the ten villages in the south west of the area. The total population was about 7,536 in 1978 according to the field investigation made by the author. The range of population of these villages lay between 38 and 3,162 in Shahriary and Abuzaid-Abad villages respectively.

Table 8.2 Distribution of villages population in the Abuzaid-Abad Area on the Basis of their Average Household Size

No.	Name of Village	Population 1966			Population 1978		
		Popul-ation	Number of House-holds	Size of House-hold	Popul-ation	Number of House-holds	Size of House-hold
1	Fakhreh	167	33	5	257	5	4.7
2	Shahriary	38	7	5.4	38	6	7
3	Rijen	239	61	4	378	70	5.4
4	Al-Abad	281	72	3.9	445	94	4.7
5	Mohamad-Abad	453	97	4.6	752	150	5
6	Abuzaid-Abad	2,085	452	4.6	3,162	524	6
7	Kaghazi	474	107	4.4	789	156	5
8	Yazdelan	147	26	5.6	171	32	5.3
9	Qasem-Abad	208	45	4.6	344	69	4.9
10	Hosain-Abad	601	135	4.4	1,200	210	5.7
11	Gazo *	3	1	3	-	-	-
12	Bejeh *	9	2	4.4	-	-	-
13	Sadeq -Abad *	7	1	7	-	-	-
14	Gaz-Shahy *	7	2	3.7	-	-	-
	Total & Average	4,719	1,039	4.5	7,536	1,365	5.5

Source: National Census 1966, Field Survey 1978.
* These villages were uninhabited in 1978 (field survey)

The general population density in the Abuzaid-Abad area was about 11 persons per km^2 in comparison with the Iran general density, which was about 21 persons per km^2 in 1976[5], increasing by probably one person per km^2 in 1978 (according to the population growth rate). So the general population density of Iran was about twice that of the area.

It has been mentioned that water and cultivable land are the controlling factors in population distribution in the agricultural area in Iran in general, and in the arid area, in particular. Thus there were a few villages in the area where the population declined after the water resources decreased. For example, in the hamlets of Gazo, Beseh, Sadeq-Abad and Garshahy the qanats dried up (1969-1975) and the population emigrated to other villages or the cities.

The population densities with respect to two main factors; lānd and water, were calculated by the author for the area as follows :

To obtain the density of the population per unit of arable area, the total population was divided by the cultivable land and by the land under cultivation in all the villages in the area. The density per unit of cultivable land and the land under cultivation were 0.15 and 0.07 ha/person respectively in 1978 (Table 8.3).

In Iran as a whole the density of the agricultural population in 1976 was 0.83 ha/person[6] (rural population), so the density of agricultural population is very low in the area because of the limited arable land. In other words the limitation of water and rainfall has limited the development of

Table 8.3 Agricultural Population Density in the Abuzaid-Abad Area in 1978

No.	Variables / Village	Population	Total cultivable land (ha.)	Density of population/ ha. of cult land	Total cultivated land (ha.)	Density of population/ ha. of cult land	Total water discharge (m^3)	Density of population/ 1000 m^3 water discharge
1	Fakhreh	257	99.7	2.6	15.05	17	103,080	2.5
2	Shahriary	38	30.7	1.2	9.7	4	58,150	3.0
3	Rijen	378	113	3.4	34.07	11	172,800	2.9
4	Ali-Abad	445	152	2.9	53.1	8.4	924,200	0.48
5	Mohamad-Abad	752	204	3.7	81.8	9.1	1,370,800	0.5
6	Abuzaid-Abad	3,162	258	12.2	184.8	17.1	3,102,560	1.0
7	Kaghazi	789	128	6.1	66	12	1,023,840	0.77
8	Yazdelan	171	15	11.4	11.5	15	103,980	1.6
9	Qasem-Abad	344	60	5.7	21.3	16.1	216,000	1.7
10	Hosain-Abad	1,200	71	16.9	47.4	25.3	747,360	1.6
	Total	7,536	1,135	6.3	506.1	14.9	6,935,570	1.08.

Source : Land Use & Water Supply Chapter.

irrigated land and dry farming in the area.

Secondly, the density of population per cubic metre of irrigation water was calculated. The total water discharge in 1978 was 7,935,570 m^3 in the area, the density volume of water per person was 1,053 m^3 compared to Iran for which an average 20,428 x $10^6 m^3$ water was supplied from the springs, qanats and wells in 1976.(7) The total rural population was 16,484,000 in 1976 in Iran.(8) So the irrigation water per person was 1,239 m^3.

We must bear in mind that a high percentage of the Iranian rural population is engaged in the dry farming system. Figure 8.1 shows the density of agricultural population in the area in 1978.

8.4 Population Distribution

The population was concentrated in the south west in a small area. The distribution of population in the villages shows the capacity of villages. About 42% of the total area population were living in Abuzaid-Abad village. The population of this village was about 3,162 in 1978. Shahriary village, with 38 persons, had only 0.5% of the total population. In other words about 78% of the total population were concentrated in the four villages in the area.

The pattern of population distribution can be examined in Figure 8.2. The population is irregularly scattered over the region's territory and its distribution is affected by the varying fertility of the soil and availability of water. 42% of the population live in Abuzaid-Abad village, 35% live in the three other big villages of Hosain-Abad (15-16%),

FIG 8.1 DENSITY OF POPULATION IN THE ABUZAID-ABAD AREA IN 1978

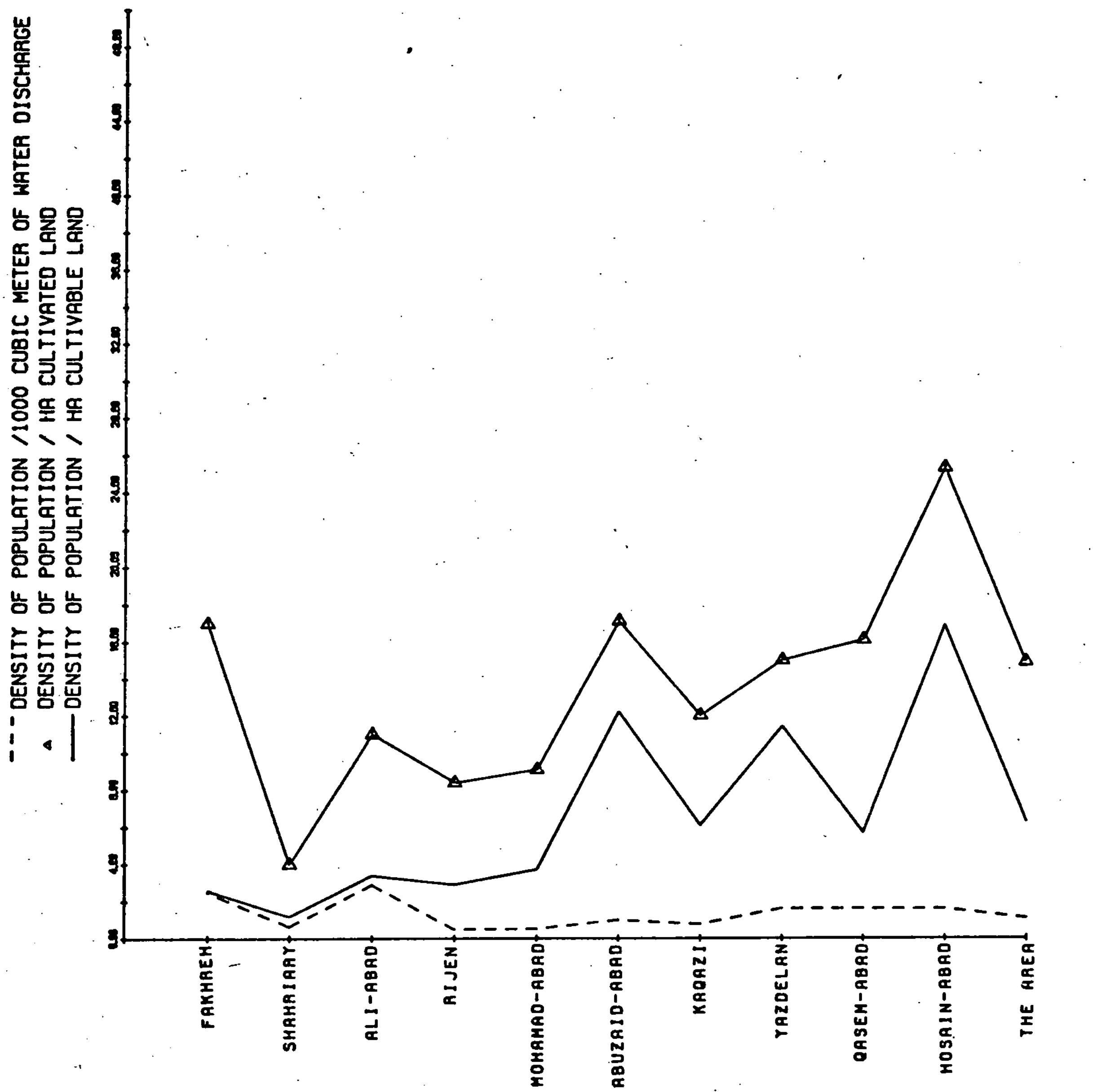
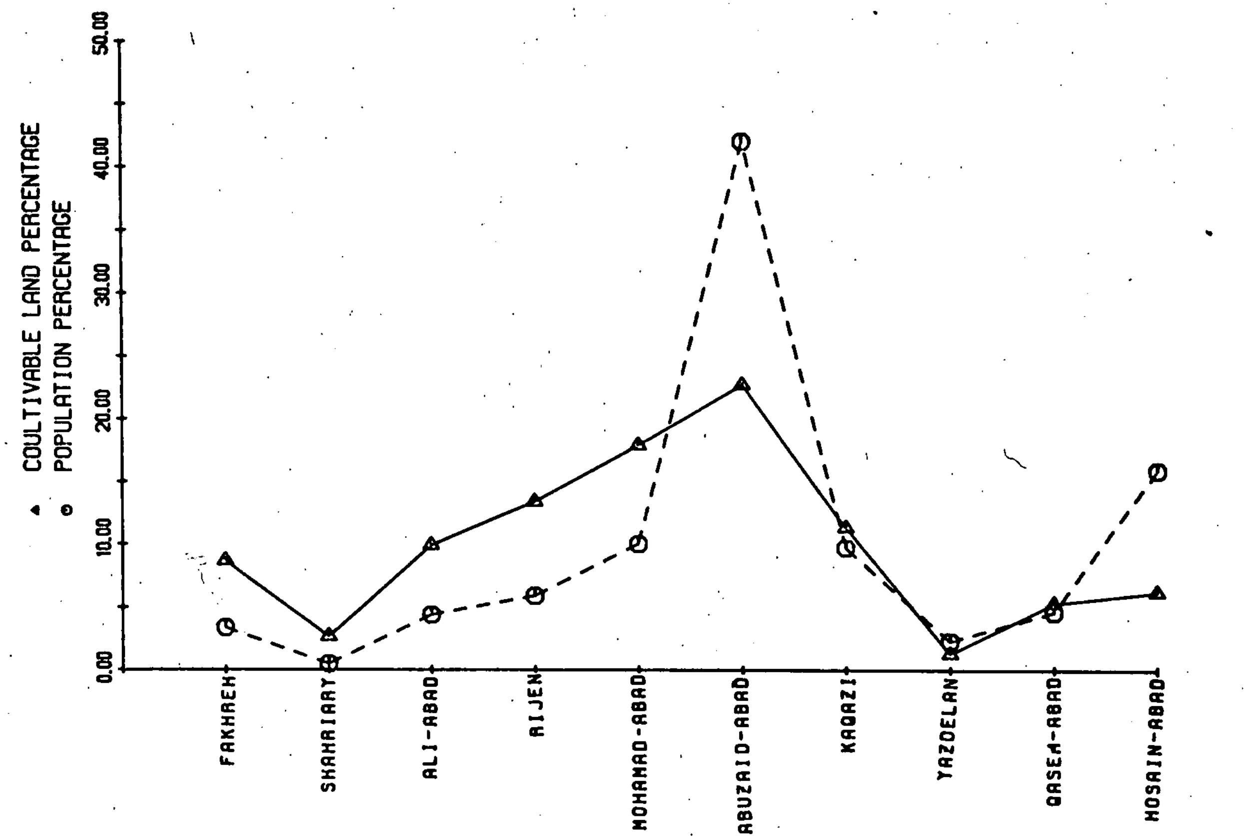


FIG 8.2 DISTRIBUTION OF POPULATION & AREA IN THE ABUZAID-ABAD AREA IN 1978



Mohamad-Abad (9-10%) and Kaghazi (9-10%), and 23% is distributed among the other villages, (Fakhreh 3.4%, Shahriary 0.5%, Rijen 4.4%, Ali-Abad 5.9%, Yazdelan 2.3% and Qasem-Abad 4.6%). Figure 8.3 shows the cumulative curve of the population concentration in the area.

8.5 Population Growth in the Abuzaid-Abad Area

According to the national census of Iran in the periods 1956-1966, 1966-1976 and field investigation in 1978, the Abuzaid-Abad area's population has increased at a rate of 3.5% per annum since 1956. The increase in the period 1956-1966 was by 1163 or 32.7%, in the period 1966-1976 there was a high increase of 2469 or 52.3%, and in the period 1976-1978, the increase was 348, or 4.8% (for two years).

The annual rate of the population growth was 2.9% between 1976-1978 in the area under investigation.(9) Table 8.4 shows the population growth of the Abuzaid-Abad area during 1956-1978 (Fig.8.4).

In comparing the population growth during 1956-1966, of the whole of Iran with that of the area, the rate of population growth in the area has been equal to the rate of Iranian population growth, but during 1966-1976 the rate of population growth in the area has been higher than that in Iran as a whole.

The high increase shown in the last census resulted from high natural fertility, declining mortality rates and little migration to the cities. The latter case was because during this period (1966-1976), carpet weaving developed greatly in the area, and the income from carpet-making increased considerably, so this was a good reason to stop

F I G 8.3 CUMULATIVE CURVE OF THE POPULATION CONCENTRATION IN THE ABUZAID-ABAD AREA 1978 (Cultivated land)

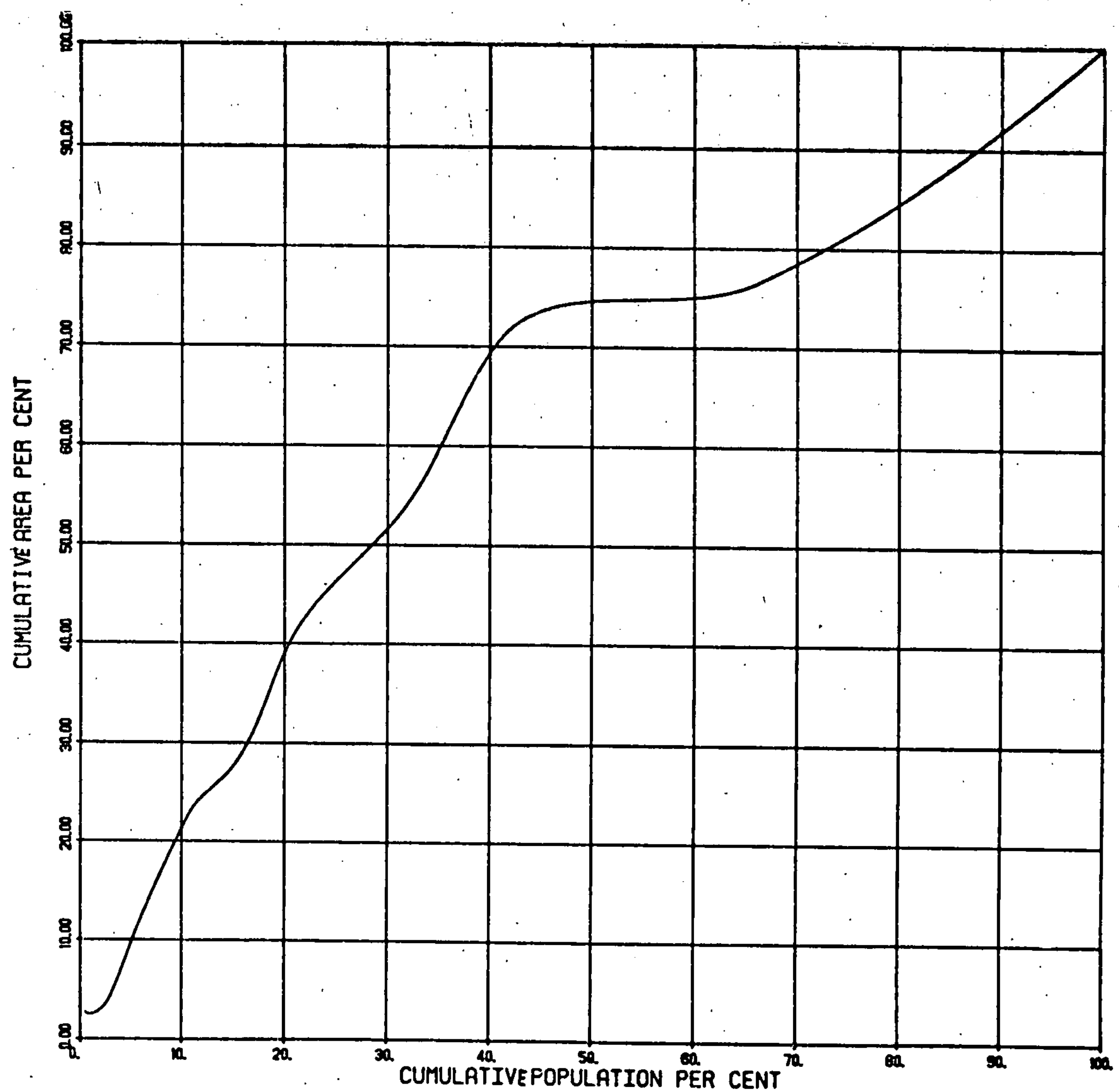
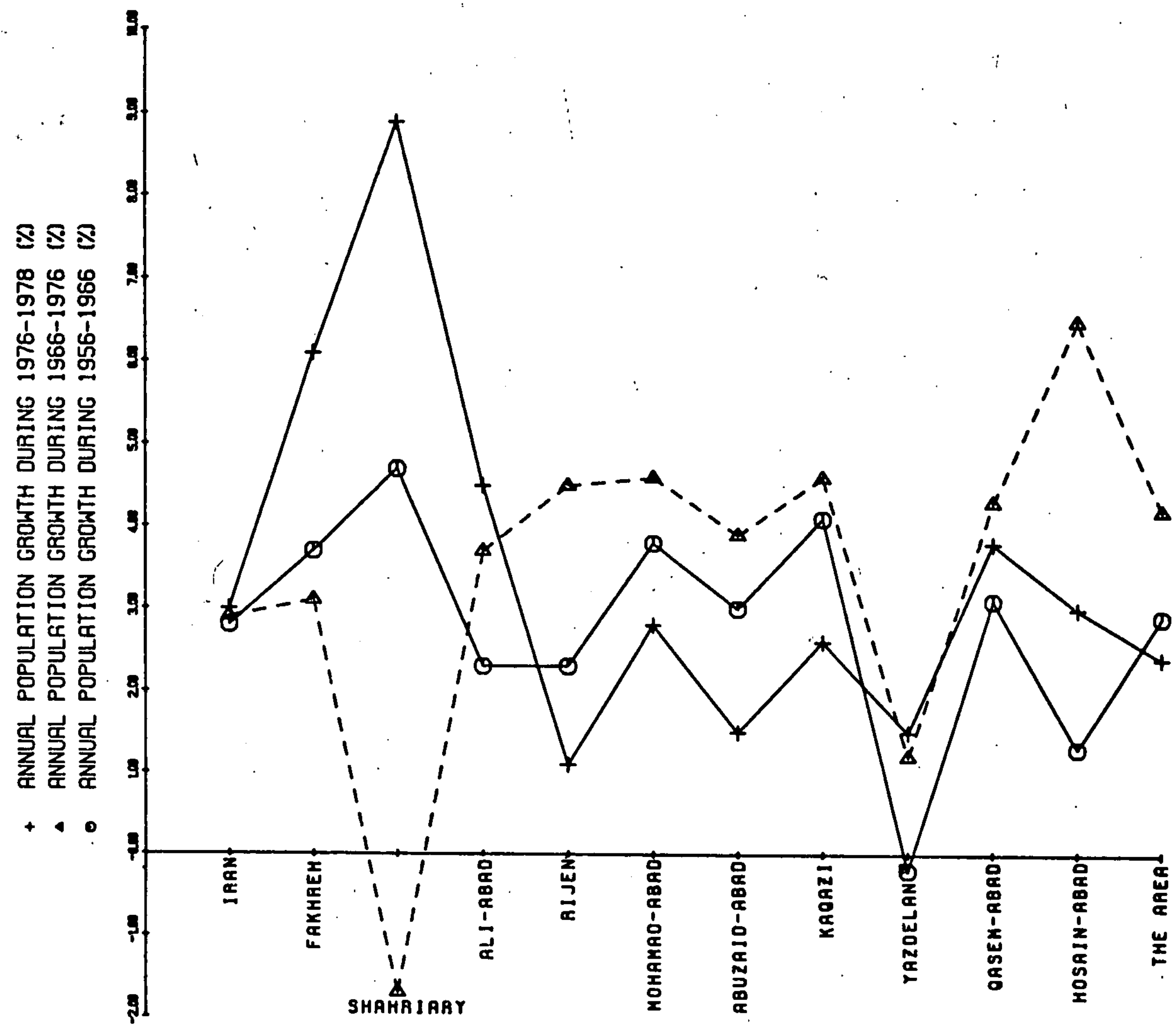


Table 8.4 Population Growth of the Abuzaid-Abad Area During 1956 - 1978

No.	Years / Name	Population 1956	Population 1966	Population 1976	Population 1978	Rate % 56-66	Rate % 66-76	Rate % 76-78
	Iran	18,954,704	25,078,923	33,561,875	-	2.8	2.9	-
1	Fakhreh	116	167	228	257	3.7	3.1	6.1
2	Shahriary	24	38	32	38	4.7	-1.7	8.9
3	Rijen	191	239	346	378	2.3	3.7	4.5
4	Al-Abad	224	281	435	445	2.3	4.5	1.1
5	Mohamad-Abad	311	453	712	752	3.8	4.6	2.8
6	Abuzaid-Abad	1,543	2.085	3,065	3,162	3	3.9	1.5
7	Kaghazi	316	474	749	789	4.1	4.6	2.6
8	Yazdelan	149	147	166	171	-0.2	1.2	1.5
9	Qasem-Abad	153	208	319	344	3.1	4.3	3.8
10	Hosain-Abad	529	601	1,131	1,200	1.3	3.0	3.0
	Total	3,556	4,719	7,188	7,536	2.9	4.2	2.4

Source: National Censuses of Iran (1956,1966 & 1976) and Table 8.3

FIG 8.4 POPULATION GROWTH IN THE ABUZAID-ABAD AREA (1956-1978)



migration from the area.

However, during 1976-1978 the rate of population growth decreased as compared to the second national census. This decrease could be the result of family planning, which was advised by the Ministry of Health, but unfortunately no acceptable data from the Ministry of Health in Iran was forthcoming and it was very difficult for the author to collect any information about family planning in the area. The number of births in 1978 was 260 in the Abuzaid-Abad area, which shows a natural population increase rate of 3.5%. On the other hand the annual population growth during 1978 was 2.4%. Now we estimate that the rate of mortality and migration was about 1.1% in the area in 1978.

According to the investigation carried out during the field work in the area by the author, migration during the last four years, especially in 1978, was very rare. Although migration in the other rural areas play an important role in urban growth, in this area it was not significant. This was because family migration usually leads to a reduction in the family income. However, as this area has the best conditions for carpet production in many instances, some men prefer to go to the cities for seasonal work and their family remains in the area.

According to the author's investigation, about 55 landless farmers were hired by Karaj City landlords in 1978, and they were contracted to work in the market gardens during the spring and summer season. Also about 255 farmers (usually young men) go to work in Tehran, Kashan or other cities for temporary work in late autumn and winter.

However, unfortunately, the exact number of births, deaths and migrations was not registered before 1978. In 1978 the number of births was 260, the number of deaths was 61, and the number of permanent migrants was 28 in the Abuzaid-Abad area. This was calculated by the author by means of questionnaires.

8.6 Age and Sex Structure of the Population of the Abuzaid-Abad Area

As illustrated by the population pyramid of the area (Fig. 8.5), the population of the area is characterized by a remarkable youthfulness. Table 8.5 indicates that in 1978, 44.5% of the total population was concentrated in the age groups under 15 years, and the proportion of adults (15-69) is 48.8% of the total population while the aged (60 and over) formed only 6.8%.

Unfortunately there is no information from the previous census about the age groups of the area's population which makes it difficult to compare the change of percentage of the age groups in the area.

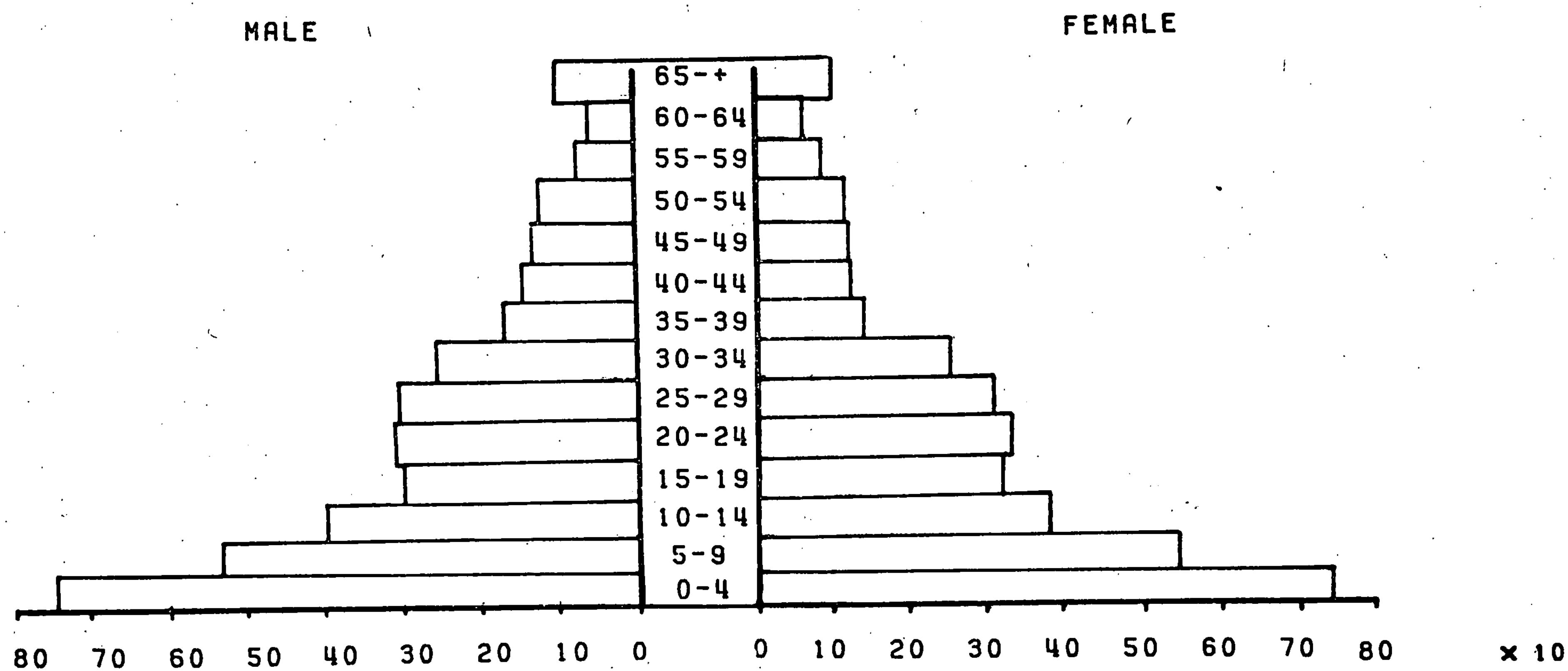
The age structure is the outcome of fertility, mortality and migration. That of the area suggests that it is influenced by a high fertility rate, which results in a high proportion of the population being under 15 years old and by the decline in the mortality rate, especially infant mortality, because immigration was very rare in 1978 in the area (according to the author's field survey). The age pyramid of the population of the Abuzaid-Abad area (Fig.8.5)

Table 8.5 Distribution of Age Structure in the Adjoining Villages of Abuzaid-Abad in 1978

Age Structure	Fakhreh	Shah-riary	Rijen	Ali-Abad	Mohamad-Abad	Abuzaid-Abad	Kaghazi	Yazdelan	Qasem-Abad	Hosain-Abad	Total
All ages	257	38	378	445	752	3,162	789	171	344	1,200	7,536
Under 1 year	9	2	14	16	28	107	29	6	13	41	260
1 - 4	42	7	61	72	121	512	128	28	55	194	1,217
5 - 9	37	5	54	63	167	452	113	24	49	172	1,077
10-14	27	4	40	47	80	329	82	18	37	125	784
15-19	21	3	31	36	61	262	66	14	28	99	622
20-24	22	3	26	31	52	269	67	12	24	102	640
25-29	21	3	32	38	64	262	66	15	29	100	615
30-34	18	3	26	31	53	221	55	12	24	84	523
35-39	11	2	19	22	38	156	34	9	17	52	320
40-44	9	2	15	18	30	117	29	7	14	44	272
45-49	8	1	14	16	28	111	28	6	13	42	260
50-54	8	1	13	15	26	101	25	6	12	38	241
55-59	8	1	11	13.3	23	95	24	5	10	36	226
60-64	6	-	8	9	16	73	18	4	7	27	169
64-70	4	-	7	8	14	54	13	3	6	20	124
70 and over	7	1	11	12	21	89	22	5	10	34	208

Source : Field investigation

FIG 8.5 AGE COMPOSITION OF THE ABUZAID-ABAD AREA IN 1978



illustrates the detailed age structure of the Abuzaid-Abad area by the conventional age pyramid by five year age groups for 1978.

Considering the area as a whole, males outnumber females. There are 107 males for every 100 females (Table 8.6). However, all villages do not follow the general sex distribution pattern. The typical villages, Ali-Abad, Abuzaid-Abad, Kaghazi Yazdelan and Qasem-Abad have masculinity ratios of 103, 104, 107, 101 and 101 respectively. The only exception is Fakhreh with a ratio of 121 males to every 100 females. The rest of the villages, Rigen, Mohamad-Abad and Hosain-Abad have masculinity ratios of 90, 97, 97 and 96 respectively. Figure 8.6 shows the sex structure in the Abuzaid-Abad area in 1978. The area sex ratio is a very interesting feature. The break down by age and sex shows that males outnumber females in the age groups under one year old and 10-14, and females outnumber males in the age groups 1-4 and 5-9; the ratio is reversed in the following three age groups (from 15 to 35). Males outnumber females again in the age groups over 35 (Table 8.7).

The main reason for the decline of the sex ratios in age groups 15-35 is the migration of young males for temporary or permanent employment in the cities or other areas.

The increase of the sex ratio in age groups 35-54, may arise from a high mortality ratio of females in these age groups because of the hard work of carpet weaving, which is carried out by the females and the high level of deliveries, with the limitation of health services. It is very difficult to find the reason why the sex ratios change in some of the

Table 8.6 Age and Sex Structure in the Abuzaid-Abad Area 1978

Age Group	Both Sexes	Male	Female	% Both Sexes	% Male	% Female	M/F x 100
All ages	7,536	3,802	3,734	100	100	100	101
Under 1 year	260	136	122	3.4	3.7	3.2	113
1 - 4	1,217	602	615	16.2	16.1	16.2	98
5 - 9	1,077	531	546	14.3	14.2	14.4	97
10-14	784	397	387	10.4	10.6	10.2	103
15-19	622	303	319	8.3	8.1	8.4	95
20-24	642	310	332	8.5	8.2	8.7	93
25-29	615	307	308	8.3	8.5	8.1	99
30-34	523	259	261	7	7.8	7.9	97
35-39	320	177	143	4.3	5	3.5	124
40-44	272	147	125	3.7	4	3.3	117
45-49	260	138	122	3.5	3.7	3.2	113
50-54	241	127	114	3.2	3.4	3	111
55-59	226	112	114	3	3	3	98
60-64	160	79	91	2.3	2.1	2.4	87
64-65	124	67	57	1.7	1.8	1.5	117
65 and over	208	105	103	2.7	2.8	2.7	101

Source : Field Survey 1978.

Table 8.7 Age-Sex Composition of the Main Groups of the Population of the Abuzaid-Abad Area 1978

Sex / Age	Population			Percentage			M/F x 100
	Total	Male	Female	Total	Male	Female	
Less than 15 years	3,338	1,658	1,670	44.4	22.1	22.3	99.8
15-59	3,721	1,883	1,838	48.8	24.7	24.1	102
60 & over	492	251	251	6.8	3.4	3.4	104
Total	7,539	3,802	3,754	100	50.1	49.9	101

Source: Table 8.6

other groups. Table 8.8 shows the distribution of sex structures in the area in 1978 (Fig.8.6).

8.7 Employment

The labour force of the area has very complicated characteristics stemming from the complexity of the production process and production relations. These complications partly arise from the multiple activities because a high percentage of people are involved in various jobs, e.g. tillage, livestock, carpet weaving, working in the factories or other sectors in the cities, the income from a single job being frequently insufficient.

63% of the total population were aged 10 and over in the Abuzaid-Abad area in 1978. In the population study, people in the age groups 0-14 and 64+ are unproductive, but in the area, the productive age starts from at least 10 years old, because the young people of 10-15 years are very active, males for agriculture and animal husbandry and females for carpet weaving. Also the aged people in the area are usually productive, and they often engage in light agricultural activity or animal husbandry.

Thomlinson (1965)[10] has defined the dependency ratio as follows -

"The dependency ratio compares the proportion of the population in the non-active ages with those of working age". According to this definition the dependency ratio has been calculated for the area. In this study the limits for the young non-active population have been set at 0-9 years, instead of 0-14 and for aged people, 70 and over instead of 65+.

FIG8.6 SEX STRUCTURE IN THE ABUZAID-ABAD AREA 1978

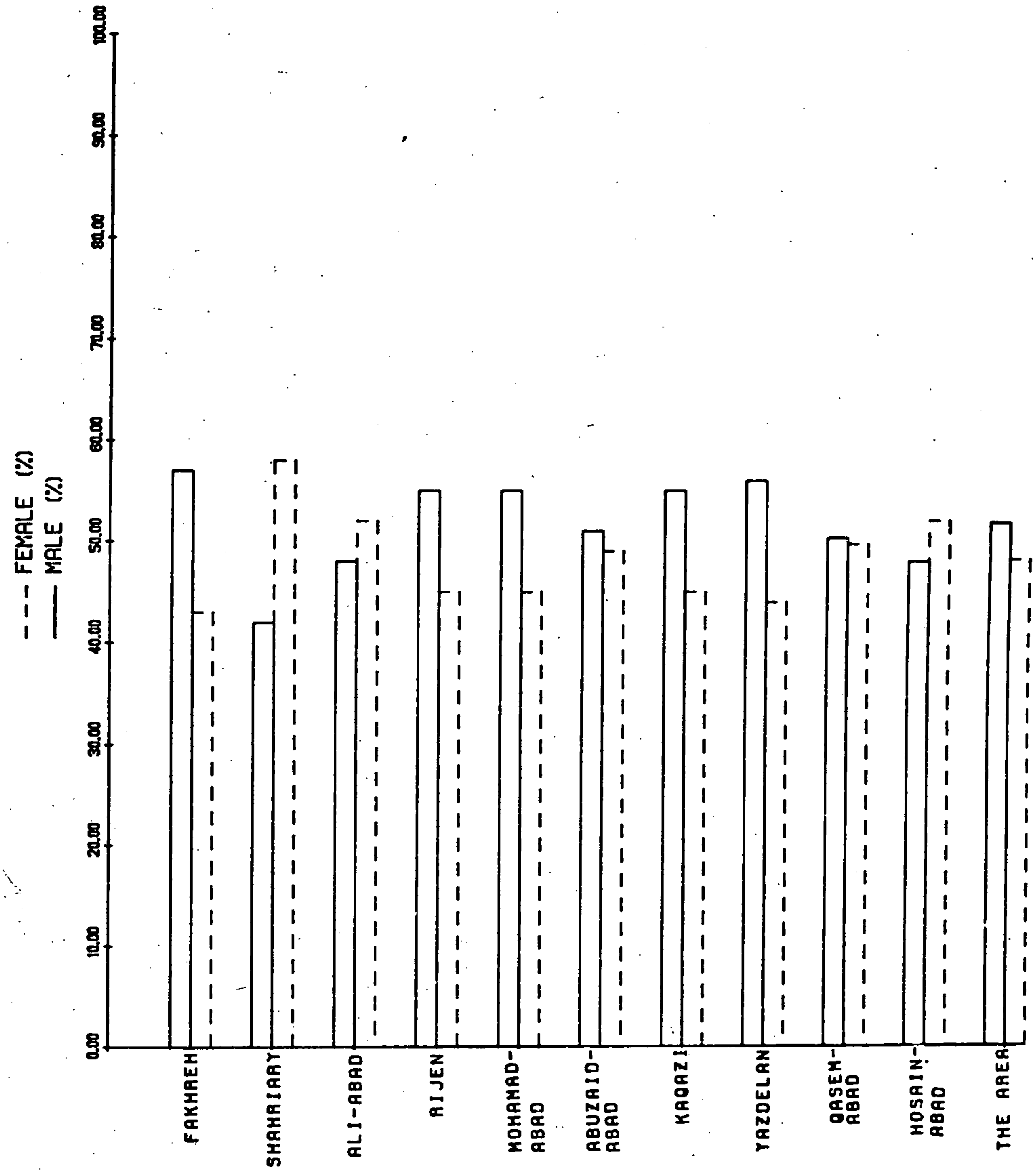


Table 8.8 Distribution of Sex Structure in the Adjoining Villages of Abuzaid-Abad 1978

No.	Variables / Village	Total Both Sexes	Male	Male %	Female	Female %	Sex % M F
1	Fakhreh	257	141	57	116	43	121
2	Shahriary	38	18	42	20	58	90
3	Rijen	378	186	48	192	52	97
4	Ali-Abad	445	226	55	219	45	103
5	Mohamad-Abad	752	371	56	318	45	97
6	Abuzaid-Abad	3,162	1,612	51	1,550	49	104
7	Kaghazi	789	403	55	376	45	107
8	Yazdelan	171	86	56	85	44	101
9	Qasem-Abad	344	173	50.3	171	49.7	101
10	Hosain-Abad	1,200	586	48	614	52	96
	Total	7,536	3,802	51.8	3,754	48.2	101

Source: Field Survey 1978.

The dependency ratio in the area is about 61%, or, in other words, for every 100 population, 61 persons are active. Also the dependency ratio in the rural population of Iran in 1976 was about 60.2% which was calculated by the author from the national census of 1976 (unproductive age 0-10 and over 70).

The possible labour force according to an estimate which was carried out by the author in 1978 in the area was 1,477,035 (11), and of that about 1,096,502 Standard man day/year was done in the given time. In other words about 74.3% of the total possible man power was used in agriculture, animal husbandry, carpet making and service sectors; 380,533 SMD/year or 25.7% of the rest was spent in temporary or seasonal employment in the area or in the cities (Table 8.9).

From the total actual labour force, 48,790 SMD/year or 4.5% of the total actual work force was engaged in cultivation activities, (see the chapter on agriculture, labour force section) with 288,339 SMD/year or 26.2% of the total actual work in animal husbandry, 613,693 SMD/year or 55.7% of the total actual work in carpet making and 146,060 SMD/year or 9.7 of the total actual work in the services. The percentage of people involved in carpet weaving is considerable because the majority of females are busy in this job (see the chapter on carpet weaving). Table 8.10 shows the full details of man power in the various sectors in the area in 1978. Figures 8.7 and 8.8 show the specification of the labour force.

According to the author's field survey, there were 4,581 productive labourers in 1978 in the area, of which

Table 8.9 Characteristics of Labour Forces in the Abuzaid-Abad Area 1978

	Village	Possible Labour forces S.M.D/year	Actual Labour forces S.M.D/year	Available Labour forces S.M.D/years	Employed labour force %	Remaining labour force %
1	Fakhreh	53,010	32,058	20,952	60.5	39.5
2	Shahriary	8,680	4,776	3,904	55.1	44.9
3	Rijen	73,780	49,969	23,811	68.8	32.2
4	Al-Abad	87,420	61,379	26,041	71.3	29.7
5	Mohamad-Abad	138,570	118,336	20,234	85.4	14.6
6	Abuzaid-Abad	620,620	422,393	198,227	68.1	31.9
7	Kaghazi	154,070	104,073	49,997	77.6	32.4
8	Yazdelan	38,325	35,765	2,560	93.3	6.7
9	Qasem-Abad	67,270	56,135	11,135	83.5	16.5
10	Hosain-Abad	235,290	211,623	23,667	90.0	10.0
	Total	1,477,035	1,096,502	380,533	74.3	25.7

Source : Field investigation, 1978.

Table 8.10 Distribution of Actual Labour Forces in the Abuzaid-Abad Area 1978

		Cultivation		Livestock		Carpet weaving		Services		Total actual man power	
		M.D/year	%	M.D/year	%	M.D/year	%	M.D/year	%	M.D/year	%
1	Fakhreh	1,988	5.5	3,488	9.6	21,912	60.7	4,650	24	32,058	2.9
2	Shahriary	744	15.5	884	18	3,168	66.3	-	-	4,776	0.43
3	Rijen	3,263	7.2	5,304	11.7	30,096	66.6	6,510	14.4	49,969	4.5
4	Ali-Abad	6,547	10.6	6,024	9.8	40,128	65.3	8,680	10.7	61,379	5.6
5	Mohamad-Abad	7,893	6.6	28,829	24.3	68,904	58.2	12,710	5.0	118,336	10.7
6	Abuzaid-Abad	16,314	3.8	106,614	25.2	240,245	56.8	59,220	14.0	422,393	38.5
7	Kaghazi	6,015	5.7	16,122	15.5	69,056	64.4	19,880	8.6	104,073	9.5
8	Yazdelan	1,135	3.1	17,010	47.5	14,520	40.5	3,100	9.9	35,765	3.3
9	Qasem-Abad	1,743	3.1	17,112	30.5	31,680	56.4	5,580	10.3	56,135	5.1
10	Hosain-Abad	4,957	2.3	86,952	41.0	93,984	44.4	25,730	9.7	211,623	19.3
	Total	48,790	4.5	288,339	26.2	613,693	55.9	146,060	13.3	1,096,502	100

Sources: Tables 7.6 & 10.4

FIG 8.7 DISTRIBUTION OF LABOUR FORCES IN THE ABUZAID-ABAD AREA IN 1978

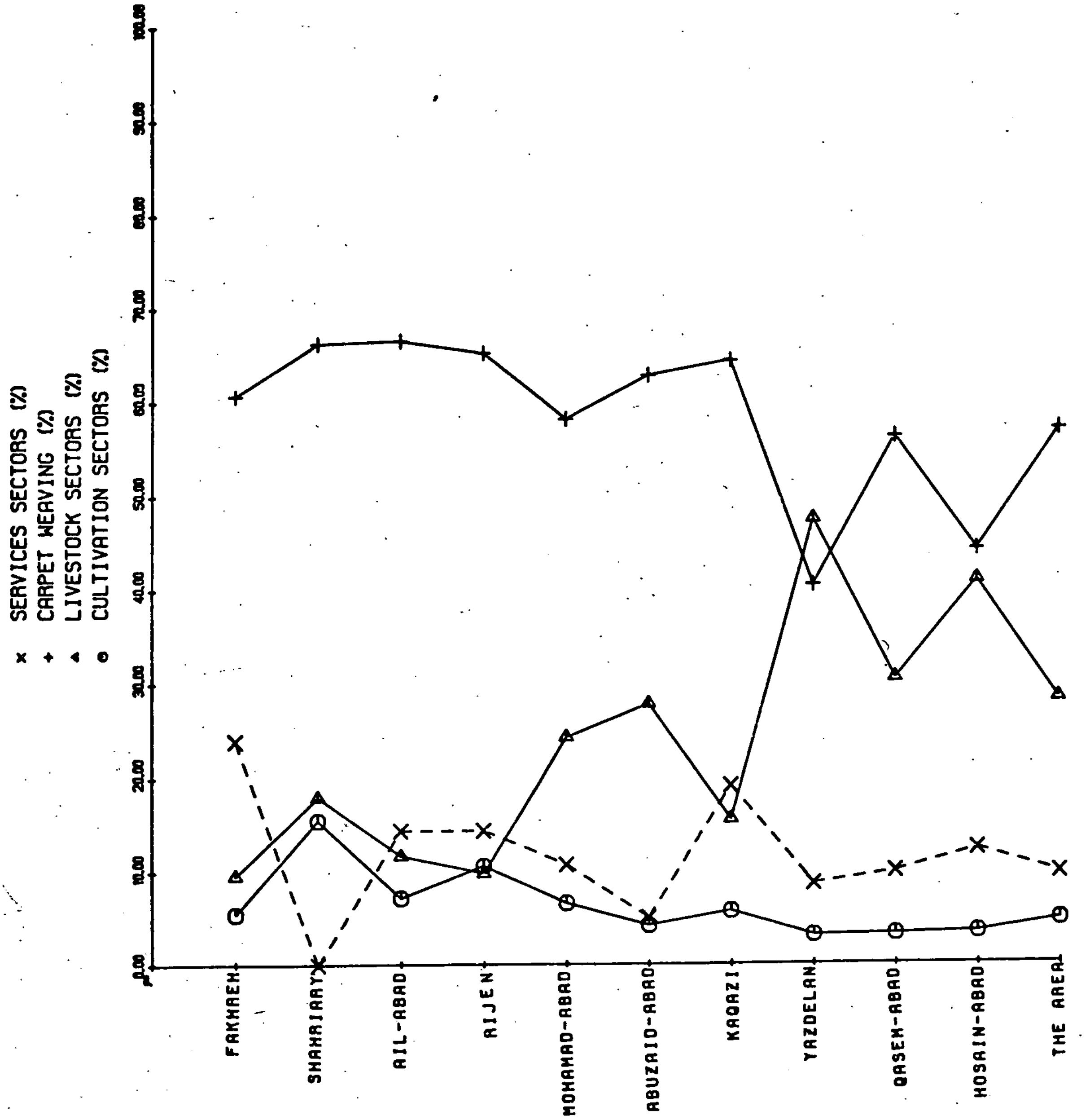
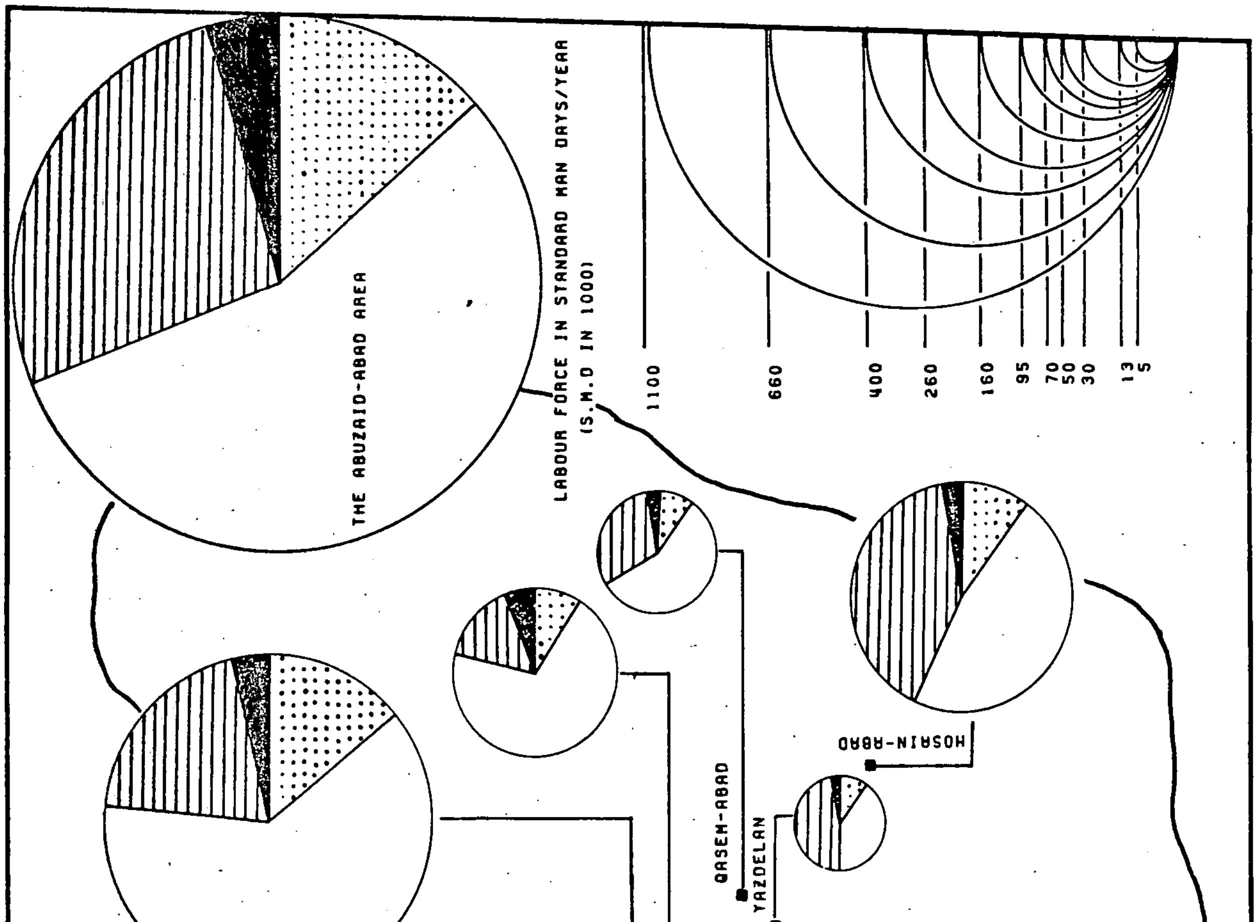


FIG 8.8 DISTRIBUTION OF LABOUR FORCES IN THE ABUZAID-ABAD AREA IN 1978



3,815 person, or 83.4% have been engaged as full time labourers in the various sectors.

The distribution of employees was 23%, 49.6% and 9.3% of the productive population in agricultural activity, carpet weaving and service sector respectively (Table 8.11). The total unemployed population was 816 persons or 16.6% of the total potential labour force. The unemployed, or temporarily employed, are usually landless people, known as <u>khoshneshin</u>. In 1978, 55 persons from the landless people were hired by Karaj City landlords, and they were contracted to work in market gardens (horticulture) in Karaj. 255 of them went and worked for part of the year in Kashan, Tehran and other cities. The rest of the unemployed were hired for temporary labour in the area.(12) Table 8.11 and Figure 8.9 shows the specification of employment in the area in 1978.

8.8 Underemployment

Although 83.4% of the potential labour force seem to be employed in the area, in fact the majority of them are not engaged in fulltime jobs during the year, because the character of village life does not follow a regular job time table. Occasionally a villager may work for a long time within a 24 hour period, for example at harvesting time, or irrigation time etc., and possibly he may not work for a few days after that hard work, or he may work for only 2 or 3 hours per day.

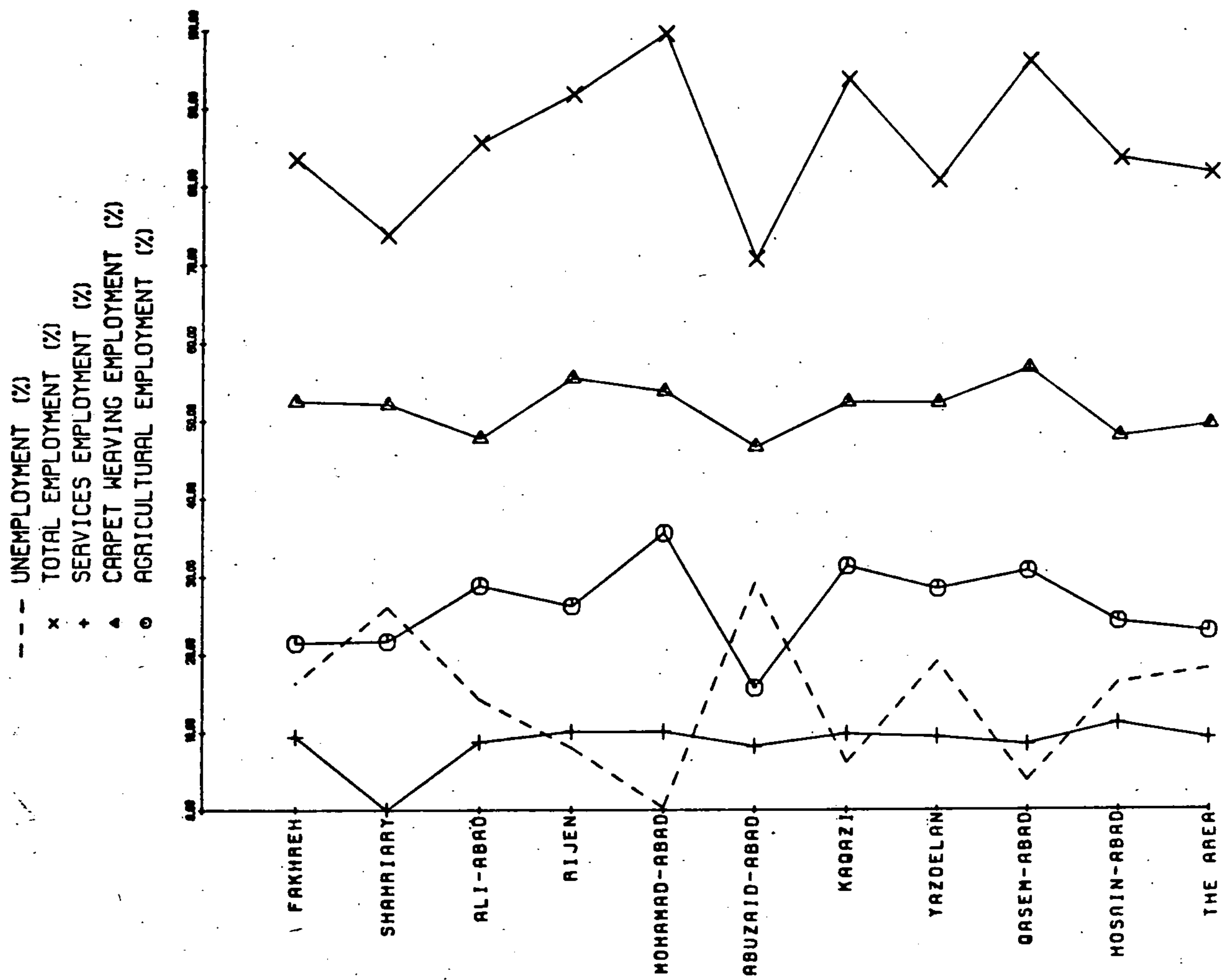
According to calculations carried out by the author in the whole area, 11.1% of the possible labour force were

Table 8.11 Specification of Employment in the Abuzaid-Abad Area in 1978

No.	Variables / Village	Productive labourers	Actual Employment								Unemployment	
			Agriculture		Carpet weaving		Services		Total			
			Number	%	Number	%	Number	%	Number	%	Number	%
1	Fakhneh	158	34	21.5	83	52.2	15	9.5	132	83.5	26	16.4
2	Shahriary	23	5	21.7	12	52.1	-	-	17	73.9	6	26.1
3	Rijen	238	69	28.9	114	47.8	21	8.8	204	85.7	34	14.3
4	Ali-Abad	274	72	26.3	152	55.5	28	10.2	252	91.9	22	8.1
5	Mohamad-Abad	401	143	35.6	216	53.8	41	10.2	400	99.7	1	0.3
6	Abuzaid-Abad	1,948	307	15.7	910	46.7	162	8.3	1,379	70.8	569	29.2
7	Kaghazi	484	152	31.4	254	52.4	48	9.9	454	93.8	30	6.2
8	Yazdelan	105	35	28.5	55	52.3	10	9.5	100	95.2	5	4.8
9	Qasem-Abad	211	65	30.8	120	56.8	18	8.5	203	96.2	8	3.8
10	Hosain-Abad	739	240	24.3	356	48.1	83	11.2	679	91.9	60	8.1
	Total	4,581	1,057	23.0	2,272	49.6	426	9.3	3,815	83.4	816	16.6

Source : Field Studies.

FIG 8.9 SPECIFICATION OF EMPLOYMENT IN THE ABUZAID-ABAD AREA 1978



wasted is disguised employment (Table 8.12). In visiting villages in the area it can be seen that a lot of so-called employed people, are inactive. When asked about their jobs, it was found that they were usually farmers, but had finished their farm work in the early morning, or they had not worked at all that day.

Therefore, disguised employment usually arises from agricultural limitations in the area. Table 8.12 shows that the range of disguised employment lay between 1.9% and 27.9% in the Yazdelan and Kaghazi villages respectively. In Yazdelan and Hosain-Abad (with 1.9% and 2.1% disguised employment respectively) animal raising is more significant than in other villages, and in Abuzaid-Abad, with 3.8% disguised employment, agricultural activity and animal husbandry are both important.

8.9 Settlement

The Abuzaid-Abad area is located at an elevation of approximately 900-950 metres in the east of Kashan region. The area encloses ten villages, which are located close together (Fig.8.10).

It is very difficult to determine the date when these villages first appeared, because there are no historical documents about their origins. The majority of old people who were interviewed by the author in the field, believed that Hosain-Abad village is the oldest one, built some 500 years ago.

Hosain-Abad is a Ghaleh village (walled village), and residents were all inside the walls until recently.

Table 8.12 Distribution of Disguised Employment in the Abuzaid-Abad Area in 1978

Variables \ Villages	Fakhreh	Shah-riary	Rijen	Ali-Abad	Mohamad-Abad	Abuzaid-Abad	Kaghazi	Yazdelan	Qasem-Abad	Hosain-Abad	Total
Possible labour Forces S.M.D/year A	53,010	8,680	73,780	87,420	138,570	620,620	154,070	38,325	67,270	235,290	1,477,035
Percentage of total productive pop. which are employed (%) B	83.5	73.9	85.7	91.9	99.7	70.8	93.8	95.2	96.2	91.9	83.4
Possible employment labour forces S.M.D/year C = A.B	44,263	6,414	63,229	80,339	138,154	439,398	144,517	36,485	64,713	216,231	1,233,743
Actual labour forces in the area S.M.D/year D	32,058	4,776	49,969	61,379	118,336	422,393	104,073	35,765	56,135	211,623	1,096,502
Disguised employment S.M.D/year E = C-D	12,205	1,638	13,260	18,960	19,818	17,005	40,444	720	8,578	4,608	137,241
% of [illegible] lab. force wasted as disguised employment	27.5	25.5	20.9	23.5	14.3	3.8	27.9	1.9	13.2	2.1	11.1

Source: Field Survey, 1978

However, since 1940 the majority of the dwellings have moved outside this protective wall, as a result of the gradual improvement in the security of the rural area during the past 50 years.

The names of the villages, at least, have not changed during the last century. This was confirmed by one 98 year old man from Rigen village(13), who believed that the names of the area villages had not changed during his lifetime.

8.9.1 Housing

The village buildings are usually gathered very closely together. There are a few basic factors which influenced the formation of compact, concentrated rural settlements in the arid area of Iran, in general, and in the Abuzaid-Abad area in particular.

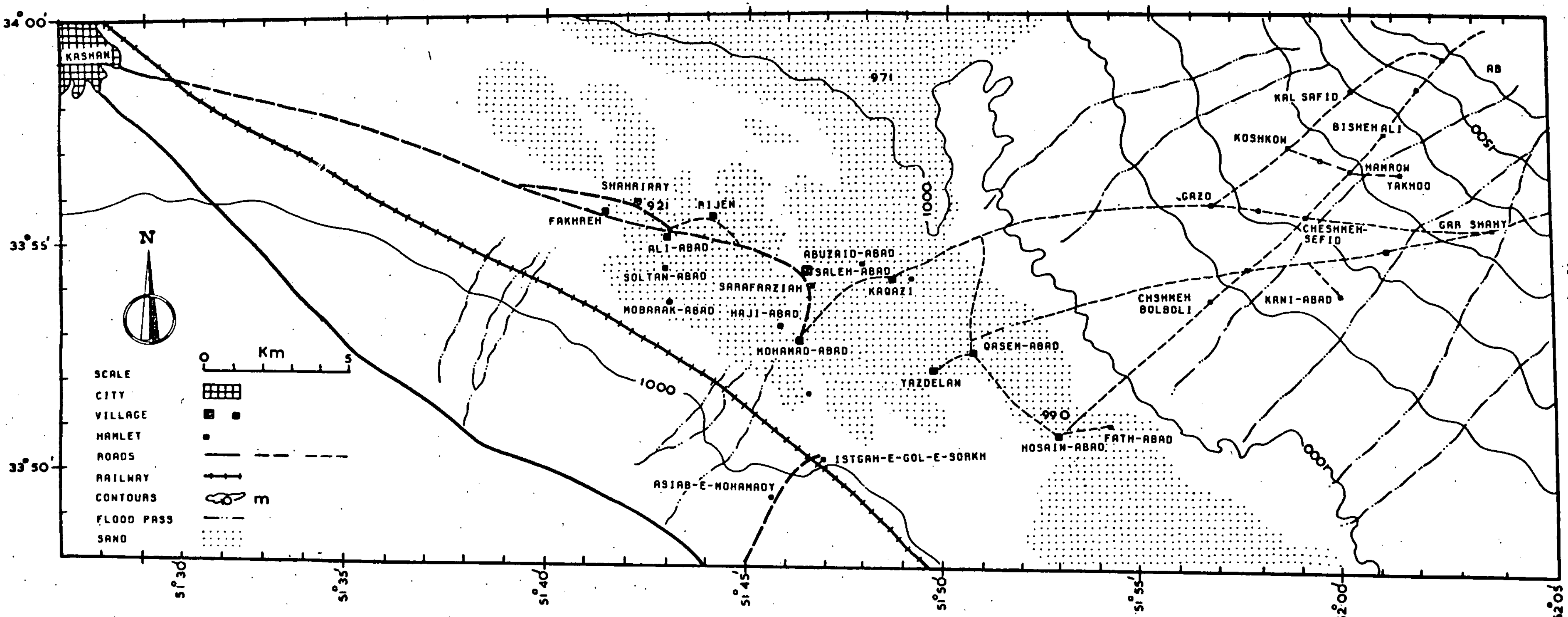
a) Natural Conditions and Factors

(i) Severe Water Shortage

Whenever a source of water has appeared on the surface a group of people have gathered around the water. The amount of water has had a direct impact on the size of population for generations; this condition has been seen in the area because the number of people directly depends on the amount of water which can be extracted from the sub surface by qanat (well construction is new in the area).

According to a calculation which was carried out by this author, the correlation coefficient between the size of population and the value of water discharge (qanat) is about +0.96. This calculation was also done for the size of population and cultivated land, and is about +0.94. These two correlation

FIG 8.10 THE ABUZAID-ABAD AREA



coefficients show there are direct ratios between the number of people and the amount of water discharge and cultivated land. In other words, the adequate water supply and good quality soil, have supported people in the area. Figure 8.11 shows the scattergram with the linear regression equation of population on water and population on land in the Abuzaid-Abad area. These regression equations suggest that the capacity of population changes with respect to the total water supply and cultivated land available in the area.

(ii) Shifting Sand

Shifting sand is one of the biggest settlement problems in the Abuzaid-Abad area, especially in the eastern and northern parts of the area. It occasionally covers the cultivated land and fills the shafts of the qanat, and also fills the village streets and yards, and sometimes, makes a sand dune behind the walls or buildings or even comes up to the house top, which creates trouble for the residents. A concentration of buildings decreases the effects of shifting sand in the area.

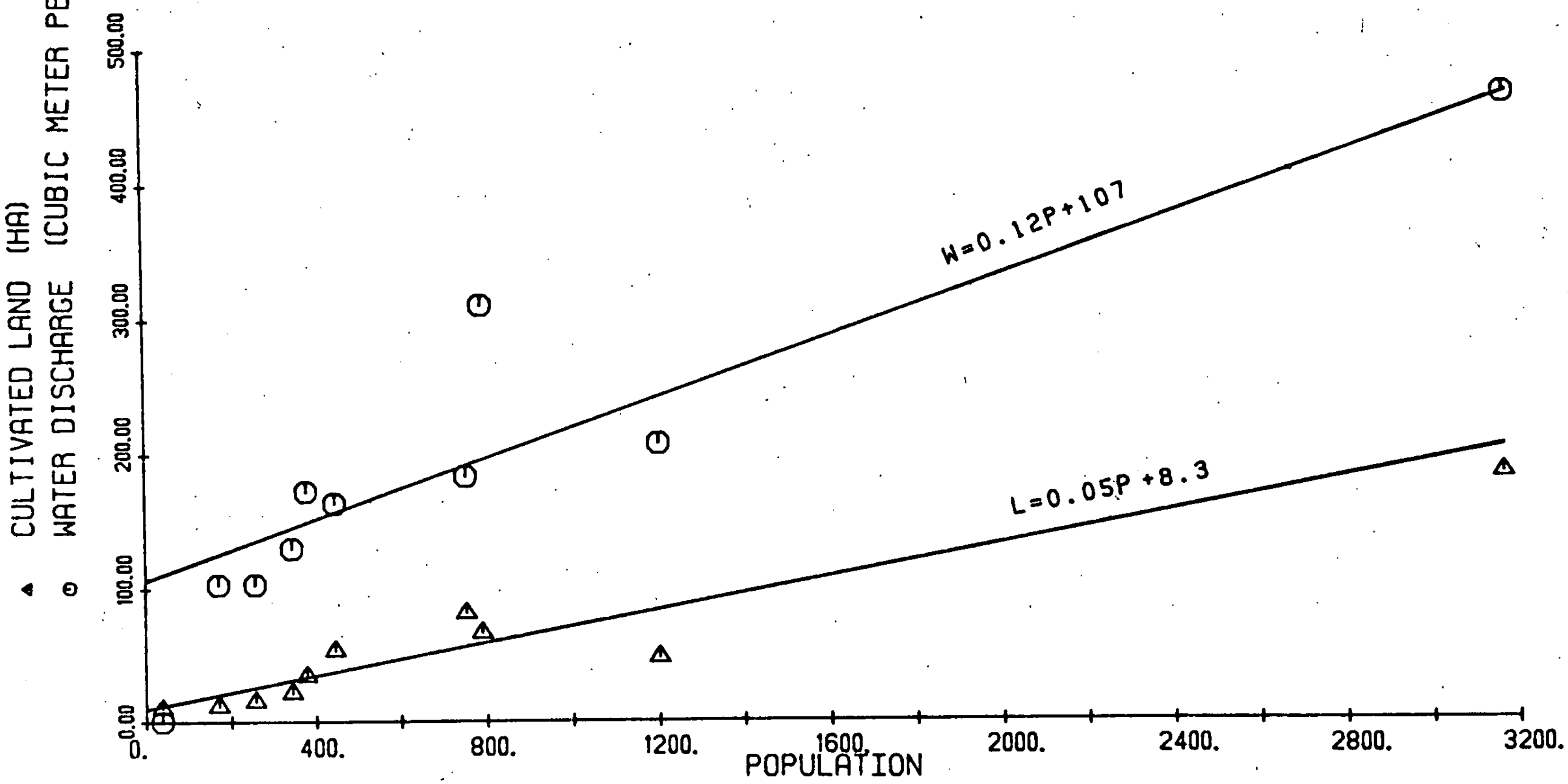
(iii) Wild Animals

The compact settlement and sufficient numbers of population can usually protect themselves from wild animals, usually wolves, which create some problems for livestock, especially sheep and goats, usually during the winter nights. The compact building makes it difficult for wild animals to enter the village itself.

(iv) Limitation of Land

The limited amount of arable land in the area also caused the concentration of settlements and prevented population isolation.

FIG 8.11 LEAST SQUARES REGRESSION LINES



b. Social Conditions

(i) Kinship relations. Cooperation and collective work are the basis of rural life in the arid part of Iran, as well as in the area. Because the rural population is almost self-sufficient, concentration of population is necessary in rural life. On the other hand, clan and kinship relations have played an important role in the formation of concentrated villages in Iran, in general, and in the area in particular. In the area, most of the villagers identify themselves as being members of a clan. So the family names of the majority of the population do not exceed the number of clans. The definition of a clan in the rural area under investigation is an 'assemblage of several households which are related to each other.' They have Moslem (Shiah) religious beliefs, and the members of each clan usually live in a certain part of the village called Mahaleh, which has the same name as the inhabiting clan. According to the investigation which was carried out by Behnam (1971)[14] in several villages, as well as by this author in the area, clanship relations are as follows (Table 8.13).

Table 8.13 Distribution of Clans in the Area

Type of village according to the number of clans	% of the villagers in several observed villages *	% of the villagers in the Abuzaid-Abad area
Village with one clan	7.5	10
" " two "	10.1	20
" " three or more	73.4	80
" " undistinguishable clans	2	-
" clanless villages	6.5	-
not mentioned	5	-
all villages	100	100

Source : Field investigation

* Behnam (1971)

(ii) Water Supply. In the arid climate with a severe water shortage, the water supply necessary for agricultural production is not possible without thedevelopment of some kind of cooperation and collective work. Therefore, when a qanat's water appeared on the surface in one spot in the area in the past, settlement and production activity was centred around it as closely as possible, resulting in the concentration of rural population in that location in the area.

8.9.2 Village Spatial Structure

The structure of the villages is more or less similar; the small mosques in the minor villages are centrally located, while such structures are scattered in the large major, or primary villages. The mosque or Hosainiyeh occupies a central location and often provides a focus for the village with many lanes (roads) leading into an open plaza and a few shops near the mosque.

Two small shrines are located inside the villages and three shrines are found on the edge of the villages. The cemetery and mortuary are always on the outskirts of villages. The public bath is centrally located, usually close to the mosque or on one of the major roads. The bath is also near the qanat open channel, to obtain a regular water supply. Since tea houses are mostly found in central villages, one or more of them usually provide the focal point for informal gatherings and social interchange. Villgge men spend many hours gossiping or discussing their individual and common problems, and making informal village decisions in the area of the tea houses or plaza. The villages are connected to each other by an unmade, widened road which often passes through the villages.

Village Shape. All of the villages are located close to the qanat and the majority of them have a circular shape. In this type of village cultivated lands are near the mouth of the qanat. Some of the villages have a linear shape because the mouth of the qanat is far from the cultivated lands, and houses were built on the edge of the qanat ditch. In some villages the roads make little impact on the shape, because the buildings are not usually constructed on the edges of the road. (Fig.8.12).

The Abuzaid-Abad villages are often divided into two sections, the older and the newer. Beyond this new construction a quite extensive area has fallen into ruin,but no attempt has been made by villagers to make anything of this land occupied by the ruins , either for agriculture or for building purposes. The new houses built mostly during the last ten years have changed the traditional structure of villages. These houses are often built outside the villages, with a large courtyard, and sometimes with unsuitable material and design, e.g. large metal windows, flat roof etc.

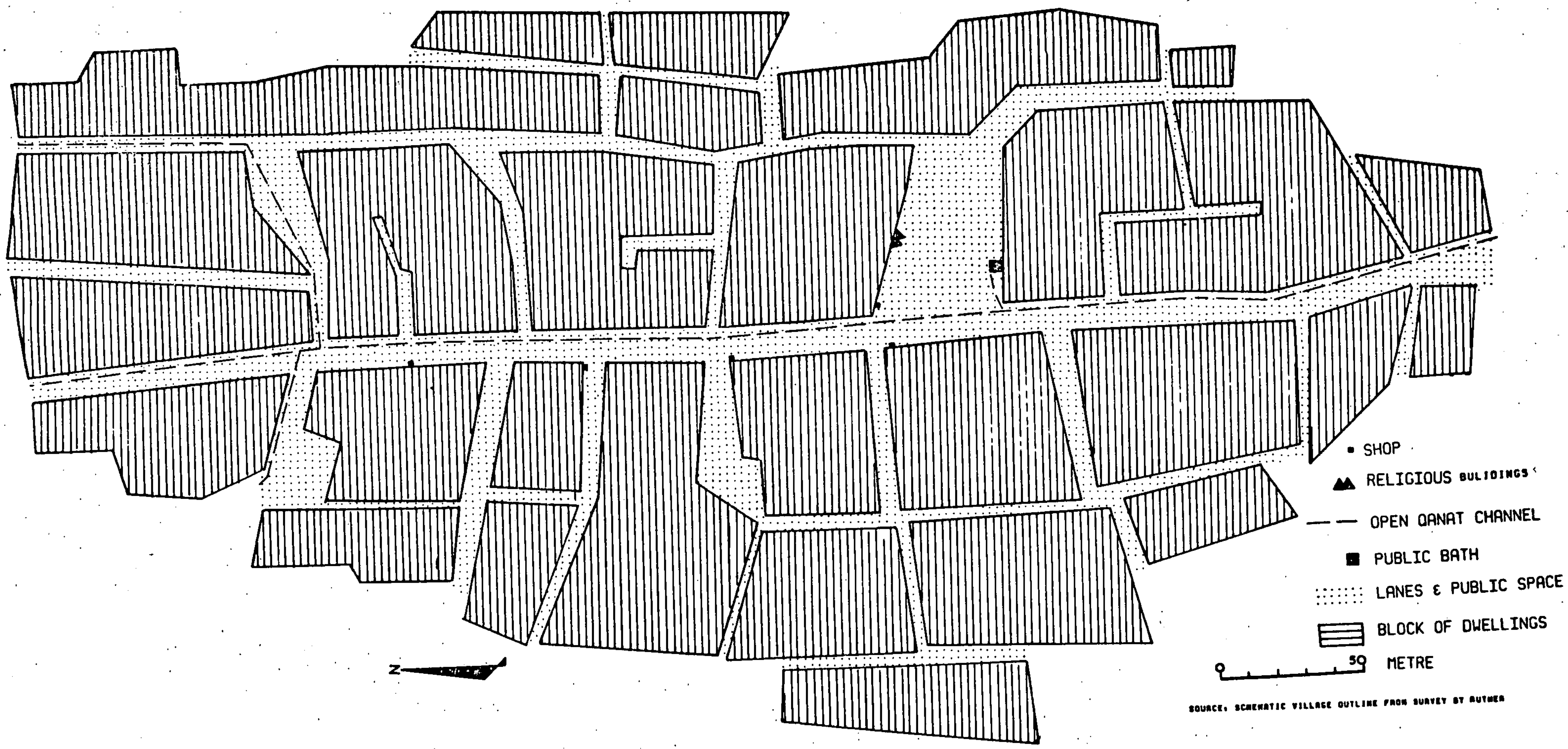
8.9.3 Village Services

The village services can be classified into three major types : religious, governmental and personal.

a) The religious Services. The mosque Masjed is the most common and is found in all of the area villages, excluding Shahriary. Larger villages may have a number of small mosques, but each has one main mosque, which is called Masjed-e-Jomeh or Friday mosque. There are 21 mosques in the Abuzaid-Abad area. Hosainiyeh is the other holy place, which is used for ceremonies marking the death of the third Imam Hosain, the son of Imam Ali and grandson of Hazrat-e-Mohammad who was killed (shahid) by Umayyad forces on A.H.61 (681 A.D). There are four Hosainiyah in the area's villages.

A cemetery (Qabrestan) and mortuary (Qasal khaneh) are located on the outskirts of villages. There are cemeteries in every village, but Shahriary and Fakhreh

FIG 8.12 MOHAMAD-ABAD



villages do not have mortuaries. These villages use Ali-Abad's mortuary.

b) Government & Personal Services

The bath is the other common public facility which is found in all villages, excluding Shahriary. The centre of the traditional bath is a large pool of heated water, once warmed by burning dry vegetation and now heated by kerosene. Recently this kind of bath has been changed to showers for reasons of hygiene, by the government or by the cooperative together with the rural population.

All of the villages, excluding Shahriary and Fakhreh now have an elementary school. There is a primary school in Abuzaid-Abad, and also there are nine schools and a visiting doctor comes to Abuzaid-Abad village clinic one day per week.

The post office, Jan-darmary (rural police) and bank are located in Abuzaid-Abad village. The cooperative societies, village council and headman (kad-khoda) are the public institutions and official services in the area. There are six flour mills in four major villages, and other rural services in the area are the teahouse, butcher, grocery, kerosene shop and baker. Table 8.14 shows the most important public buildings in the Abuzaid-Abad area.

8.9.4 Size of Villages

The size of the villages according to the field survey measured from available aerial photographs [(15)] by the author, was 1,435,000 m^2. About 70% of the area was occupied by buildings and courtyards (field observation) and 30% was occupied by lanes, streets, roads and qanats' Job (open channels).

Table 8.14 Important public buildings in the Abuzaid-Abad Area, 1978

Village \ Facilities	Water storage	Mosque	Castle	Bath house	School	Cooperatives building	Bank	Clinic	Post office	Police Station	Other institutions	Total
1 Fakhreh	1	1	-	1	-	-	-	-	-	-	-	3
2 Shahriary	-	-	1	-	-	-	-	-	-	-	-	1
3 Al-Abad	1	1	1	2	1	1	-	-	-	-	-	7
4 Rijen	-	1	1	1	1	-	-	-	-	-	-	4
5 Mohamad-Abad	1	1	-	1	1	1	-	-	-	-	1	5
6 Abuzaid-Abad	3	7	1	4	2	1	1	1	1	1	1	23
7 Kaghazi	1	2	-	2	1	-	-	-	-	-	-	6
8 Yazdelan	1	2	-	1	1	-	-	-	-	-	-	5
9 Qasem-Abad	1	2	-	1	1	-	-	-	-	-	-	5
10 Hosain-Abad	2	4	1	2	1	1	-	-	-	-	-	11
Total	11	21	5	15	9	4	1	1	1	1	1	70

Source: Field Survey, 1978.

The total number of houses was about 1,258 which were occupied by 1,365 households and 7,536 people. So the average number of people and size of households per dwelling were 5.6 and 1.1 respectively. These figures show that the majority of villagers have private or separate houses; only 1.7% households were living in shared houses. Payment of rent for accommodation is not common in the area. Homeless families were usually living in shared houses without rent. Table 8.15 shows the characteristics of distribution of dwellings and size of villages in the Abuzaid-Abad area.

8.10 Conclusion

The distribution of population in the margin of the Dasht-e-Kawir, as in the other parts of the arid region, is not uniform. The concentration of population in this region depends, first of all upon the water availability and quality. As has been seen, the villages are located in a line from northwest to southeast, close together. This line is approximately parallel with the mountains which are located in the southwest to southeast of the area. The qanats of the villages have been dug parallel and continue until the slopes of the mountains. Fresh water is usually obtained by the qanat system from the mountain slopes. However, the lack of fresh water has limited the spread of villages. The total population use only 3.7 % of the total area for settlement and agricultural purposes. As has been mentioned, a number of small villages (hamlets) have been deserted after the drying up of the qanats in the area. Deserted villages are common in this area. As has been stated, the

Table 8.15 Distribution of Dwellings in the Abuzaid-Abad Area in 1978

No.		Area of dwell-ings in villages m^2	No. of inhabited dwellings	Average size of dwellings m^2	Population	Av.No. of population/ dwelling	No. of house-holds	Average size of hsehold/ dwelling
1	Fakhneh	30,000	48	437	257	5.3	54	1.12
2	Shahriary	15,000	5	1,166	38	4.2	6	1.2
3	Ali-Abad	50,000	68	363	376	5.2	70	1.02
4	Rijen	50,000	77	602	445	5.7	94	1.22
5	Mohamad-Abad	130,000	145	911	752	4.9	150	1.03
6	Abuzaid-Abad	82,000	482	460	3,162	5.0	524	1.08
7	Kaghazi	100,000	152	1,060	789	5.1	156	1.02
8	Yazdelan	50,000	23	500	171	5.1	32	1.10
9	Qasem-Abad	40,000	56	530	344	5.8	69	1.23
10	Hosain-Abad	160,000	196	630	1,200	5.6	210	1.10
	Total	1,435,000	1,258	650	7,536	5.6	1,365	1.11

Source: Field Survey 1978.

density of population in the area, in general, and in the villages in particular, depends upon the quality and quantity of water available. However, severe climatic conditions and brackish water and unsuitable soil have also affected population growth in the area. A limitation upon agricultural output has been caused by the increase in population above the natural population growth. Before the development of carpet weaving in the area the rate of migration was high, but recently, because of the development of carpet weaving and the subsequent increase in incomes, people have been encouraged to remain in the area despite the low agricultural output. However, the rate of population growth in the area between 1956-1965 had been equal to the rate overall of Iranian population growth, but during the period 1966-1976 the rate of population growth in the area has been higher than in Iran as a whole. Carpet weaving has greatly developed in the area and this was a good reason to stop the migration. Family migration usually leads to a reduction in the family income. The population of the area is characterized by a remarkable youthfulness. In 1978, 44.4% of the population was concentrated in the age group under 15 years of age. Unfortunately, since 1978 when this investigation was carried out, little attention has been paid by the government to education for young people in the area. Although there are some schools in the area, there is no encouragement for education. Also, the parents themselves have been more interested in involving the children in carpet making (girls) and agricultural activity (boys).

Multiple activity is one of the very complicated characteristics of employment in the area. If the women involved in the carpet weaving are excluded it is very difficult to recognize the permanent jobs of the people. These complications mostly arise from the limitations of agriculture and insufficient income from other jobs. Notwithstanding this, underemployment or disguised employment is one of the employment problems in the area. This difficulty has arisen from (a) the high percentage of dependency ratio (60%) which has resulted from the wide interval in the active ages (b) the limitation on agricultural activities,(c) the traditional behaviour of the villagers, who start to work early in the morning, usually before sunrise and (d) the lack of official work in factories where a proper time table for work is followed.

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7. Ministry of Power, General Office of Water Resources, Ground Water Section (1977), pp.25-265.

8. Statistical Center of Iran (1977) op.cit., p.51.

9. Annual growth of the population of the area was calculated by using U.N. formular as follows:

$$\text{Annual growth population} = \left(\sqrt[t]{\frac{po}{pt}} - 1 \right) \times 100$$

10. Thomlison, R. (1965) Population Dynamics : cause and consequences of world demographic change, Random House, New York, p.438.

11. A productive person works 8 hours per day and about 300 days per year in the area.

12. Hired labour can take three forms in the area as follows:

    a. Work paid by the day which usually applies to the landless labourers, for harvesting or house building.

    b. Contract work paid by the job such as usually occurs in well digging or qanat maintenance.

    c. Communal work which is often contributed free of charge, labourer exchange on a reciprocal basis is done by the farmers.

13. Abdoalh, Ahmadi (Ali-Abadi).

14. Behnam, J. (1971) <u>Family structures and Relationships in Iran.</u> University of Tehran, p.78.

15. Aerial photograph specification

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CHAPTER 9

LAND REFORM

9.1 Introduction

Land reform in Iran was carried out in three phases as follows:

First Phase - as provided in Article 2 of the land reform Law, approved on January 9th,1962 and henceforth called the "Original Law",[1] any land-owner may keep ownership of only one village, and the remaining estates of persons owning more than one village are covered by the regulations governing distribution and sale of land to farmers.

Second Phase - Kaddie (1968)[2] observed that

> "The second phase of land reform, covering most of that large majority of villages untouched by the first phase, is of a much more conservative nature than that put through by Arsanjani." (3)

An amendment law, which was called "Annexed Article Law", was approved on January 17, 1963, and stipulated to be enforced after the completion of the first phase of the enforcement of the original Law; that is, the land distribution phase. The following are some brief explanations of the provisions of the Annexed Articles.

a) According to this amendment the limit of ownership is to be determined on the basis of the area of the village, instead of being one whole village.

b) As in the original Law, no limitations are imposed on mechanized farming and gardens.

c) For lands bought under the amended law, the price of estates is to be paid over a period of fifteen years instead of ten years.

d) Landlords are bound to take one of the following three actions with regard to the land which has remained in their ownership under the provisions of the original law -

i. Cede these lands to their farmers for a period of thirty years, under lease.

ii. Divide the lands with the farmers in proportion to the crop shares that have been in effect. As a result, what land remains in the possession of the landlord will be without tenants and the landlord can cultivate this land any way he desires.

iii. Sell his lands to the tenant farmers with their mutual agreement. Also, besides private estates, there are some villages which have been endowed for public benefit. These villages shall be ceded to their tenant farmers under 99-year leases, as provided in the supplementary law.

Third Phase - Most landowners, not surprisingly, preferred to lease land to their sharecroppers, a procedure which defeated the purpose of the amended law. As a result, a further amendment was made on the 7th March 1969, thus making the third phase of land reform. According to the amendment, landowners who had leased their lands or who had set up joint farming units, were now required either to sell all their lands to tenants, or to divide them in accordance with the proportions prevailing under the previous traditional sharecropping agreements.

On 30th January, 1971 a law was passed fixing 22nd September 1971 as a deadline by which time all unresolved settlements were to be completed. If by that time the landowners had not agreed with the tenants in the villages how to divide the land, a vesting process was put into motion. As from Farmers' Day September 23, 1971 (4) the land was deemed to have been sold to the tenants, and the rental payment next due, and the subsequent payments, were to be accepted as instalments of the purchase price to be paid for the land.

The actual structure and forms of land ownership, before the land reform in Iran is illustrated in Table 9.1.

Table 9.1 Structure of ownership before the Land Reform in Iran

Types of ownership	Number of villages	%
Large landed proprietors owning more than 5 villages	19,000	38
Medium landed proprietors owning 1-5 villages	7,000	14
Waqf-e-Am & Waqf-e-Khas	6,000	12
Khaleseh & Royal land	3,000	6
Petty landlord and land owner peasant	15,000	30
Total	50,000	100

Source : Golabian (1977) (5)

9.1.1 The Land Reform at National Level

The results obtained from the land reform in general are unreliable, because despite government pretensions, which were published in different figures on official sources, it can be seen that there remain many unaffected land reform villages in some parts of Iran. Furthermore,most of the reasons for this neglectfulness are usually unreasonable. However, according to official government figures which were published by the Ministry of Cooperation and Rural Affairs in 1972,(6) the results obtained during the first phase - up to October 1972 are as follows.

During the first phase a total of 15,710 villages and 801 farms, chiefly Government holdings and Pahlavi Foundation Lands,were purchased by the Government at a cost of 9,654,580,791 Rials and distributed among a total of 726,274 families (or a population of 3,544,374). By then the Government had paid over 2,997,861,487 rials - or nearly a quarter of the total price to farmer owners.

The second phase of the Land Reform began in 1964. By June, 1970 a total of 9,443 plots of public waqf (endowed) land had been rented to 131,259 farmers for a period of 99 years. A further 968 plots of private waqf lands were rented to 31,595 farmers for a period of 30 years. At the same time 209,656 smallholders had rented their lands to a total of 1,147,889 farmers for a period of 30 years.

During the same period, a total of 3,414 land-owners sold their lands to 54,653 farmers by mutual consent. There was also a contrary trend and 16,993 farmers sold their Nasaq to 7,851 land owners. Furthermore, on 5,791 plots of land a total of 180,679 farmers and landlords had created joint stock units. This was done according to the regulations passed by the Parliamentary Joint Committee on Land Reform. A total of 17,621 landlords divided their lands between themselves and 156,159 farmers, in accordance with the rate of landlord's/farmer's share put together. All this meant that a total of 2,457,982 rural families, amounting to 12,073,067 people, had their position clarified as far as land ownership was concerned.

The third phase of the Land Reform began in 1970. Under the third phase of the Land Reform, according to government pretensions, an estimated 70% of the sharecroppers in Iran had by September 1973 received ownership of the land they cultivated.(7)

Under the third phase of the land reform, 87.3% of leased land was sold outright to peasant tenants, and 12.7% of leased land was divided between landlords and peasants.(8) By 18th September, 1973 some 3,540 villages and farms endowed have been transferred to 112,741 peasant families.(9)

9.2 The Land Reform at the Abuzaid-Abad Area

The Land Reform has been carried out in the area as follows:

a) Large Holdings. In this category the proprietor had one, or more than one village (Shash-Dang - meaning each distinct rural settlement, or total village lands). Before the land reforms started, a part of one of the villages under consideration in this study fell into this category. This village was redistributed in the first phase of the land reform in 1962. Therefore, only 7.9% of the area was redistributed amongst its peasants according to the first phase of land reform in 1962.

b) Small Holdings. The lands in this category can be divided into two groups.

i) Absentee landlords. The land is worked by tenant farmers for the owners who usually live in towns. 32% of the Abuzaid-Abad area belonged to owners who mostly lived in Kashan, Tehran and other villages (often in Abuzaid-Abad). This type of land excludes 683 units of Rijen village and has been purchased and redistributed among the peasants by the government since 1971.

In Rijen village, one group of farmers who were farming 683/1,500 units of the village, did not accept the land reform law. Residents of this village are very religious, and they believe that according to Islamic law they cannot accept land transferred to them by the government without the owner's concent. Up to now the lands have not been redistributed in this village.

In the area about 5% of the owners and farmers agreed on the price of the land and the circumstances of payment, and the rest (27%) of the owners sold their property to the government, and the government transferred it to the farmers.

ii) Land owner peasants. This type of ownership occurred in nine of the villages in the area (excluding Hosain-Abad). 54% of the land was worked by the owners, although some of them also frequently employed hired labour for cultivation. The land reform law did not affect these farm labourers at all.

c) Waqf land (Endowed lands)

The Waqf lands of the Abuzaid-Abad area comprised 5.6% of the total area. Of the endowed land in the area, 1.1% of the total land (167 units of the Abuzaid-Abad village) was waqf-e-khas (privately endowed) and the rest, or 4.5% of the total land, was waqf-e-Am (public waqf). These lands, according to the second phase of the land reform law, were to be turned over to their tenant farmers on a 99 year lease. The waqf lands have been redistributed during the third phase of land reform. Table 9.2 shows more details of land ownership in the Abuzaid-Abad area before land reform (Fig. 9.1).

9.3 Land Valuation and Payment to the State

As provided in Article 10 of the original Land Reform Law, (10) in order to evaluate the estates which are to be purchased from the landlords, the Ministry of Agriculture first determines a standard index for each region. To determine the index, agricultural experts in Ostan (County) and the chiefs of the Agriculture Administrations usually conduct some studies on the values of the villages in each region. These studies are based on the distance of the village from the cities, village revenue, and the manner in which the crop is divided between tenant farmer and landlord.

The product of the index and the land tax of any estate determines the value of the estate. Therefore the land

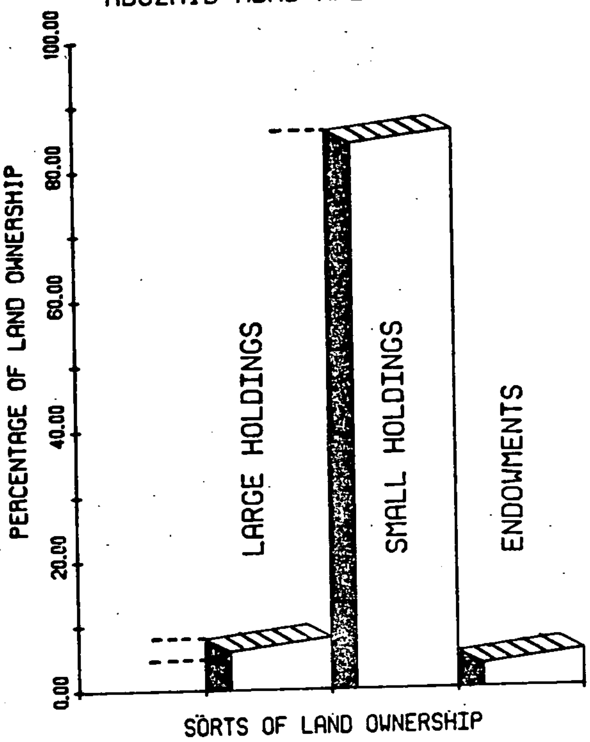
Table 9.2 Specification of Land Ownership before the Land Reform in the Abuzaid-Abad Area

Variables / Villages	No. of village units Nasaq	Large Holdings		Small Holdings				Endowments			
				Worked by the owners		Worked by tenant farmers		Private		Public	
		Units	%	Units	%	Units	%	Units	%	Units	%
Fakhreh	120D*	-	-	17 D*	14.3	95 D	79.1	-	-	8 D	6.6
Shahriary	120D	-	-	120 D	100	-	-	-	-	-	-
Rijen	1500**S	-	-	357 S	23.8	1153 S	76.2	-	-	-	-
Ali-Abad	120 D	-	-	45 D	37.5	61 D	50.8	-	-	14 D	11.7
Mohamad-Abad	120 D	-	-	72 D	60	44 D	36.6	-	-	4 D	3.3
Abuzaid-Abad	1465 S	-	-	1151 S	78.5	147 S	10	167 S	11.4	-	-
Kaghazi	1500 S	-	-	874 S	58.2	426 S	28.4	-	-	200 S	13.4
Yazdelan	120 D	-	-	98 D	81.6	16 D	13.3	-	-	6 D	5
Qasem-Abad	120	-	-	105.5S	87.9	8	6.6	-	-	6.5D	5.4
Hosain-Abad	1800 S	1435	79.7	-	-	365	20.3	-	-	-	-
Percentage	-	-	7.9	-	54.1	-	32.1	-	1.1	-	4.5

* Dang = 1/120 of a village
** Sarageh = 1/1500 or 1/1800 of a village

Source : Field Studies, 1978

FIG 9.1 SPECIFICATION OF LAND OWNERSHIP BEFORE THE LAND REFORM IN THE ABUZAID-ABAD AREA 1978



valuation according to this article can be summarised by the following formula -

$$P = U.I.L.$$

where P is the land price, U is the number of units of each village, I is the region index and L is the tax per unit. Table 9.3 shows the specification of land valuation in the Abuzaid-Abad area.

9.3.1 Period for Payment for the Estates

As provided in Article 11 of the original Law, the price of the purchased villages is to be paid in ten equal instalments. The first instalment is paid to the landlord at the time of purchase and the remaining nine instalments are paid over a period of nine years. However, by Article 4 of the Amendment in March 1962,[11] the original ten year payment period was changed to fifteen years. For lands purchased after this amendment was passed, one fifteenth of the price of land is paid in cash at the time of the transaction, and the balance paid in equal instalments over a period of fourteen years.

The total price of the area which was purchased by the government was 23,651,324 Rials,[12] which was paid in fifteen equal instalments. The first instalment, 1,576,754 Rials, was paid to the landlords in cash at the time of purchase and the remaining purchase price was paid in instalments over a period of fourteen years.

Table 9.3 Estimation of Village Prices according to the Land Reform Law in the Abuzaid-Abad area

Variables / Village	No. of Village Units	The factors for the calculation of the village prices				Proportion of units distributed	Total of money paid for the re-distributed land Rials
		Index I	Land tax L Rials	Unit price I x L = P Rials	Village price (P)		
Fakhreh	120 D	120	170/D	20400/D	2,448,000	95/120	1,938,000
Shahriary	120 D	120	100/D	9500/D	1,440,000	-	-
Rijen	1500 S	120	20/S	1900/S	3,600,000	465/1500*	1,116,000
Ali-Abad	120 D	120	475/D	45125/D	6,840,000	61/120	3,477,000
Mohamad-Abad	120 D	120	750/D	90000/D	10,800,000	44/120	3,960,000
Abuzaid-Abad	1465 S	120	110.5/S	10497/S	19,425,900	314/1495	4,430,924
Kaghazi	1500 D	120	54.5/S	5177/S	9,810,000	426/1500	2,786,040
Yazdelan	120 D	120	200/D	15300/D	2,880,000	16/120	384,000
Qasem-Abad	120 D	120	256/D	19125/D	3,686,400	8/120	245,760
Hosain-Abad	1800 D	120	24.6/3	1886/S	5,313,600	1800/1800	5,313,600
Total					66,243,900		23,651,324

Source : Land Reform Ministry, Kashan branch (1978)

* 684 Sarageh of this village was not redistributed.

9.4 Agricultural credit

Introduction

Availability of credit to farmers at economic rates of interest when credit is needed by them for specific purposes, is an essential condition for the proper functioning of an agricultural economy. The majority of farmers in the margin of Dasht-e-Kawir have insufficient invested and working capital, low income and poor scientific farming knowledge. These are conditions generally associated with illiteracy and ignorance which in turn result in prejudice against adoption of new methods.

Therefore, credit must be designed so as to give a strong positive inducement to improve farm techniques, institution and organisations. Credit alone is not of much avail if it is not accompanied by complementary services which will help the borrowers to use the money productively. It must also be recognised that agricultural credit, though crucial, is only one of the many factors playing a part in the complicated process of stepping up agricultural production. However, the main sources for farm credit in the Abuzaid-Abad area are rural cooperative associations, the agricultural cooperative bank, and in a few cases, private creditors.

9.4.1 Formation of Cooperative Association

The Deputy Ministry of Agriculture (1963) has stated in his report(13) :

"One of the conditions in the land reform law for the sale of land to a farmer was that the farmer

> must first accept membership in a village cooperative. For the formation of these associations, Agricultural Bank officials accompanied by Land Reform officials travelled to the villages, which were covered by the provisions of the Law. These officials jointly explained to farmers the advantages of cooperative, and how to form cooperative associations. They then took action to form the cooperative associations and to collect the farmer's subscription capital. The amount of capital subscribed by these associations depends on the number of members, economic conditions of the region, and the financial status of members. The minimum permissible share for membership in a cooperative association is 50 rials."

Each village had its own cooperative, unless it was too small, in which case the cooperative was set up for a group of villages situated close to one another. The qualifications for membership which were approved by the High Cooperative Council were as follows:

Farmers and persons engaged in agriculture and living in the area of the operation of the society are eligible to become members of the society. According to the official government figures, since 1962-1971 a total of 8,467 were brought into being, claiming in all 1,876,341 members. At the same time the capital and assets of the cooperative amounted to 3,742,789,692 Rials.(14)

9.5 Rural Cooperatives in the Abuzaid-Abad Area

Two rural cooperative associations were formed in 1963 in Abuzaid-Abad and Mohamad-Abad villages. Following these, four other rural cooperatives have been organized since 1968, in Kaghazi Hosain-Abad, Rigen and a group of villages, including Ali-Abad, Fakhreh and Shahriary. Two villages in the area of this study, Qasem-Abad and Yazdelan, did not form rural cooperatives, but the farmers from these villages shared in the Hosain-Abad and Kaghazirural cooperatives respectively. Thus the number of cooperatives so far established is six.

In 1977, this group of rural cooperative associations formed an affiliation, which is called the Abuzaid-Abad group of Rural Cooperative Associations. A permanent office was established in Abuzaid-Abad to supervise the activities of the group.

Altogether there were 944 members in 1978 (usually one person per family). In other words about 90% of the farmers, or 69% of the residents of the area joined the Rural Cooperatives (Table 9.4).

These cooperatives were formed initially with capital, which came from the members - 1,670,400 Rials. The total number of shares sold to the farmers was 33,408, each of which was 50 Rials (Table 9.4). Every member can buy any number of shares. The size of the loan which every member receives depends on the number of shares he owns. Thus the main source for short term farm credit, both in Iran in general, and in the Abuzaid-Abad area in particular, is the rural cooperative association.

Farmers who seek loans (annual) from the cooperatives, usually act as guarantors for each other. The cooperatives rarely have difficulties in collecting monies due, because if a member fails to pay, he cannot obtain credit the following year. There was, however, a more severe penalty which was decided on by the Abuzaid-Abad group of cooperative associations; if any <u>one</u> of the members does not pay his

Table 9.4 Specification of Rural Cooperative Associations in the Abuzaid-Abad Area

Variables / Cooperative	Date of establishment	Number of members	Number of bonds shares	Price per bond	Initial capital paid by the farmers	% of house holds hholding share in coops.
Abuzaid-Abad	1963	290	5,261	50	263,050	94
Mohamad-Abad & Qasem-Abad	1963	184	10,188	do	509,400	86.7
Kaghazi	1968	154	5,148	do	257,400	93
Hosain-Abad	1968	104	5,536	do	276,800	50
Ali-Abad, Fakhreh, Shahriary & Yazdelan	1988	150	6,133	do	306,650	90.9
Rijen	1968	61	1,142	do	57,100	88.4
Total		944	33,408		1,670,400	68.7

Source : Ministry of Cooperation and Rural Affairs, Kashan branch (1978) liability due, the whole membership of the rural cooperative becomes ineligible for any loan. This regulation was not fair, but it was still in force when this investigation was carried out.

798 members obtained loans from the cooperatives in 1978. The value of the loan varied from 4,000 Rials to 36,000 Rials. The total sum paid out in loans by the cooperatives in 1978 was 5,647,000 Rials, on average every member received 7,076 Rials, which paid for chemical fertilizers, improved seed and other cultivation requirements.

The second most important source of credit is the Agricultural Cooperative Bank. The Agricultural Cooperative Bank functions as the banking authority for rural cooperatives and farmers as a whole. It is not only responsible for the provision of loans to the cooperatives, but also for those to individual farmers. The Bank's shares may be purchased by the cooperatives. The Agricultural Cooperative Bank usually provides medium and long term loans and until 1979 the interest rate was 6% per annum. These loans are usually for farm improvements and the establishment of new farms. After the Revolution the Agricultural Cooperative Bank rate of interest decreased.

The Bank continues to be the most important agency, accounting for 89.8% of the credit supplied. A large proportion of the money loaned by the Bank went for the construction of the three deep wells in Kaghazi, Ali-Abad and Abuzaid-Abad villages, each of which required 2,000,000 Rials. The Agricultural Cooperative Bank also paid 1,035,000 Rials for the fattening of sheep. 52 families benefited from this loan which was for one year. The residents of Kaghazi obtained 400,000 Rials from the Bank for qanat maintenance in 1978, and when this study was carried out, two groups of Mogani were working on the qanat of Kaghazi.

The third source of loans is private credit. Very few farmers obtained loans from private creditors for agricultural purposes, because of the high rate of interest (usually about 20%), but in the case of carpet making, the money is credit from the contractors with a specific condition. (see the Chapter on carpet weaving). However, the total sum of private loans for agricultural purposes was calculated from the questionnaire to be 299,000 Rials in 1978.

Table 9.5 shows the total of credit received by households in 1978 for agricultural purposes to be 13,239,000 Rials, on average 14,000 Rials/farmer's family.

Unfortunately, some of the farmers benefiting from the loans spent the money on non-agricultural purposes, such as buying push bikes, motor bikes, radios or for financing the marriage of their sons, or going to a shrine (usually Mashhad). Figures 9.2 and 9.3 show the amount of cash loans provided by various services in the Abuzaid-Abad area in 1978.

Table 9.5 Amount of cash loans provided by various sources in 1978

Variables / Cooperative	Cooperative		Agricultural bank		Private		Total amount of loans
	Rials	%	Rials	%	Rials	%	
Fakhreh	102,216	100	-	-	-	-	-
Shahriary	10,221	100	-	-	-	-	-
Rijen	356,000	100	-	-	-	-	356,000
Ali-Abad	159,457	7	2,000,000	93	-	-	2,159,457
Mohamad-Abad	395,900	84	-		142,000	16	537,900
Abuzaid-Abad	2,455,000	55	2,000,000	45		-	4,455,000
Kaghazi	490,000	18.5	2,400,000	75.5	157,000	5.9	2,647,000
Yazdelan	65,410	100	-	-	-	-	-
Qasem-Abad	191,020	100	-	-	-	-	-
Hosain-Abad	275,800	100	-	-	-	-	-
Total	6,682,000	49.9	6,400,000	47.8	299,000	2.2	13,381,000

Source : Ministry of Cooperation and Rural Affairs Kashan branch, 1978.

FIG 9.2 AMOUNT OF CASH LOANS PROVIDED BY VARIOUS SERVICES IN THE ABUZAID ABAD AREA IN 1978

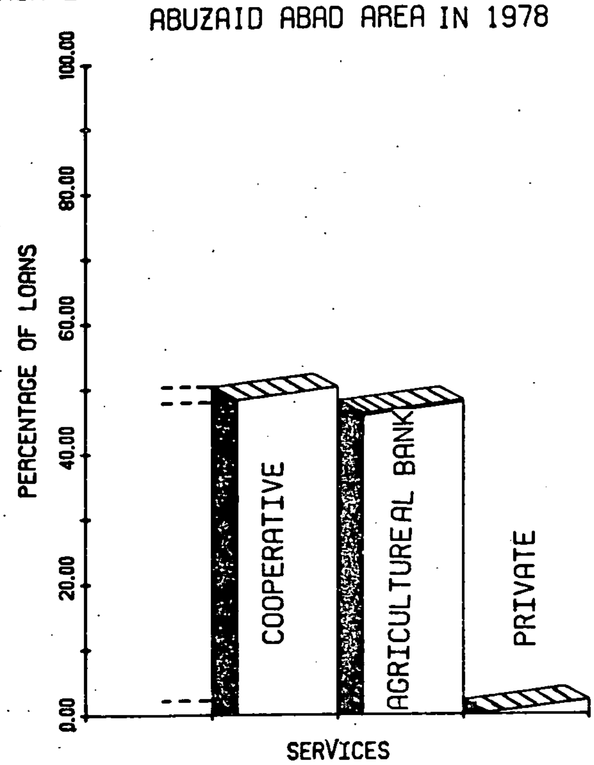
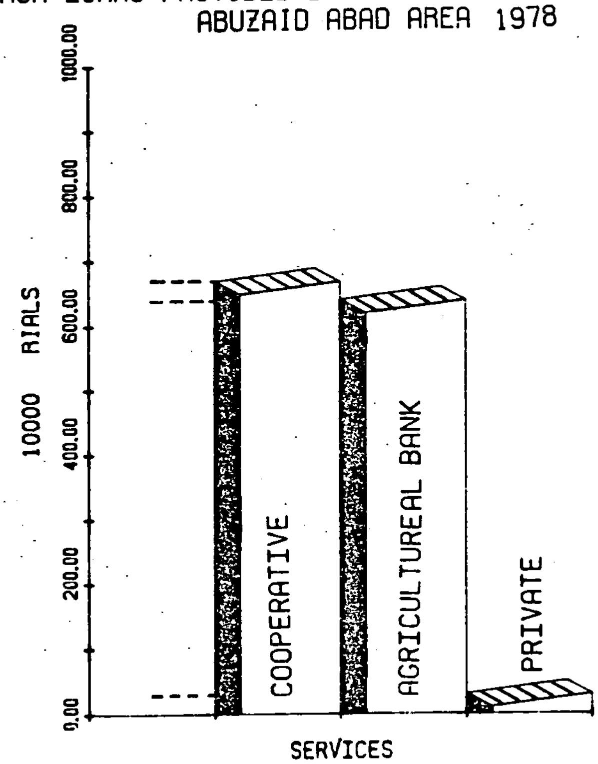


FIG 9.3 AMOUNT OF CASH LOANS PROVIDED BY VARIOUS SERVICES IN THE ABUZAID ABAD AREA 1978



9.6 Conclusion

The reform did not increase the general level of agricultural output in the region, which remained unchanged because the farmers of the area continued to employ the same production techniques as were used prior to land reform.

A problem which has arisen from land reform in the region is the maintenance of qanats, because before the land reform in Iran, ganat repair and maintenance was the duty of the owner. The owners have usually been keen to maintain the qanats and keep them in good condition, deciding on repairs very quickly and carrying them out promptly. Unfortunately, since land reform, qanat repair has not been done so quickly because, first of all, it has been difficult to get all the farmers to agree to the method of repairs, and secondly, the collection of money from poor farmers has been another problem. Although the Shah's regime had tried to provide some loans for qanat repairs, this had not been successful because of the many difficulties in borrowing money, and so the farmers had usually not been able to take advantage of the facility. However, they needed water for irrigation, and so some of them who could raise enough money, or who were rich enough, dug deep wells and shallow wells. This action has resulted in two main problems for qanats. First, the farmers' attention has turned from qanats, which are public, to wells that are often private. Secondly, the wells themselves are often a cause of the decrease in qanat discharge. This condition has occurred in most parts of Iran, and the region has suffered along with other areas. For example the qanat discharge during 1968 to 1978 has decreased by 36% in the Abuzaid-Abad area. Although there are other reasons for this reduction, one factor has been the land reform.

Neglect of the rotation system is another problem which has arisen from the reform. Before the land reform, the farmers had to follow the landlords' decision about the rotation system, but after the land reform, they chose the land for cultivation according to their own wishes. So they usually leave the more distant fields fallow and cultivate the fields close to the village. Therefore, taking into consideration the climate of the region, if the land is not cultivated on a regular basis it will become saline. On the other hand, over-cultivation leads to a decrease in crop production.

Notwithstanding, according to interviews carried out by the author in the area during the field investigation, the majority of farmers were satisfied with the land reform, and were experiencing a greater sense of freedom.

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CHAPTER 10

CARPET WEAVING IN THE ABUZAID-ABAD AREA

10.1 History of Carpet Weaving in the Abuzaid-Abad Area

There is no doubt that carpet weaving is not a new phenomenon in the Kashan region. However, unfortunately, there are no accurate documents about when carpet weaving started in the Kashan region, in general, and in the Abuzaid-Abad area, in particular. Therefore, it is very difficult to determine with accuracy, the design and production of carpets in the past in the area, though there are some carpets in the famous museum which indicate the level of skill and progress of art in the region (Fig. 11.1).

Edwards (1956)[1] has described in his book "The Persian carpet" a carpet which was woven in Kashan, in the middle of the sixteenth century. Now it is to be seen in the Austrian Museum for Art and Industry, Vienna. He says:

> "This carpet is in the first rank of the great carpets of the world. Some authorities, indeed, have declared it to be the finest carpet ever woven. It is the only carpet listed here in which warp, weft and pile are of silk. Parts of the figures are brocaded in silver or silver gilt. It counts 27 x 29 knots to the inch which is far closer in weave than any other of the Sefavi carpets. The hunt[2] is a catch-as-catch can affair."

Also, he has described the design in more detail and added:

> "...it was probably woven about the middle of the sixteenth century, for Sultan Mohamad died about A.D 1555. The carpet has been attributed to Kashan, on the grounds that the Kashanis were accustomed to weave silken fabrics and that some silk carpets were undoubtedly woven there in the sixteenth century."

Fig.10.1. The carpet of Kashan
Source: Edwards, 1953.

The Abuzaid-Abad area weavers, especially Mohamad-Abad, Abuzaid-Abad and Kaghazi weavers, have skill in weaving carpets with silk. They choose the hunting design for their carpet. This skill shows that carpet weaving has been practised for a long time and was passed on from generation to generation in the area. In other words, according to an interview with old people, which was carried out in the area, they believe that carpet weaving has been carried out for a long time and it is not a new craft skill industry. However, there is not any accurate information about the start of carpet weaving in the area. Edwards has shown in his book in a table(3) which is illustrated, the number of looms in the Kashan and District. He has indicated the number of looms in local villages. In 1915 there were 1,000 looms in the surrounding villages (including Abuzaid-Abad). This means that carpet weaving was common in 1915 in the local villages as well as in the Abuzaid-Abad area.

10.2 The Technique of Carpet Weaving

The technique of carpet weaving changes from region to region in Iran. Basically it depends on the social conditions, skill and intellect of the weaver. The carpet resembles a painting and the weaver, a painter. When a weaver weaves a carpet, it is very difficult to produce another one exactly the same because one or more elements which are involved in the carpet weaving, e.g. material, design and the weaver's emotion and feeling, may be changed. These factors affect the quality of the carpet and as a result, its cost. Therefore, in general, the quality of carpets changes from one region to another. So, basically, each region, city, even village, is known for a special type of carpet in the Iranian carpet markets.

The main points which cause these variations are the shape of the loom, the method of weaving and the sort of material and design. These factors are described as follows:-

10.2.1 Structure of Loom

Two types of looms are used in Iran in general. First, the horizontal loom which is only used by the tribal people, or in some parts of Iran. Secondly, the vertical loom which is used in most parts of Iran, as in Kashan City and all the villages of the region.

The Vertical Loom

The vertical loom consists of a fixed sar dar warp beam (upper beam) and a zir dar (cloth beam or lower beam), the ends of which fit into slots in the side pieces. Pahlu-Dars (Fig.10.2).

10.2.2 Warp Winding

Chelah-davani (warp winding). The work is carried out by a very skilled specialist, Chelah-Davan (warp winder). The warp has been twisted formerly and has been wound up in the spools onto the loom. The lower ends of the warp are laced to a rope which is wrapped around the Zir-Dar. The upper ends of the warp are wrapped around a rod, which is called Fandak. It is suspended with a pair of strong ropes from the warp beam. The loose upper ends of the warp are twisted together into ten or more bunches and tied to

Fig. 10.2 Structure of Vertical loom

This carpet has been woven by the author during his study in Durham University as a pattern. Now it is to be seen in the Geography Department, University of Durham.

Fandak or Sar-Dar, which is used for the next carpet (Taie-Qali). Tension of the warp is obtained by driving Goveh (wedges) into slots. Also, there is a Neirah-Pich (rod, heddle) - about 6-10 cm., diameter - which is formed by winding a strong cotton twine in continuous loops around a horizontal pole and every second warp thread. A second horizontal thin rod 3-5 cm., in diameter which is called Haf, is inserted to form the shed rod between the front and behind the warp strings.

The weaver sits on a Takhteh (plank), the end of which rests on the bottom rungs of two ladders. As the work proceeds the plank is raised, so that in time the weaver may be working 1-1.5 m. above the floor level. When the height of the plank has reached about 0.5 m., below the end of the carpet (usually the length of the carpet is about 2 m., in this area), the height is enough for completion of the carpet. Now the plank is withdrawn from the first position, and the upper ends of the warp are loosened for the next carpet (two small ones which are often woven as a pair or Joft) and the lower end of the warp are laced again to the rope which is wrapped around the Zir-Dar. Tension is again maintained by wedges, and the action is repeated as before, until the next carpet is finished. Sometimes, before each single carpet is finished, the carpet is withdrawn because possibly the weavers cannot work at such a high level, or the height of the side pieces of the loom or the roof of the work place is low, so the carpet is free. The Cheleh-Davan (warp winder) is then lowered and sewn along its whole length to the rope wrapped around the cloth beam. The loose ends of the warp are again bunched and tied along the Fandak. Tension is restored by driving the wedges into the side slots, and the work of weaving begins again.

10.2.3. Instruments

A few simple instruments are used for carpet weaving.

(a) A sharp knife for cutting the yarn after the knot is made. Usually the knife which is used is a special one. Its length is about 20 cm.,and the handle of the knife is about 10 cm.,(Fig.10 .3).

(b) A pair of shears is used for trimming off the ends of the yarn after each row of knots is finished. The size of the shears varies and usually there is no standard size used in the area.

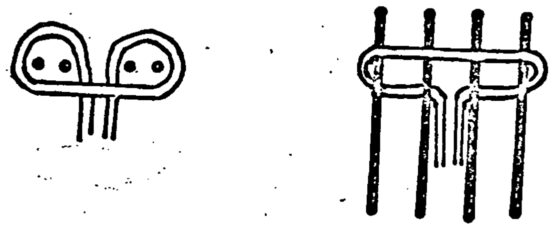
(c) Another essential instrument is a Dafeh or Shaneh (comb) for beating in the wefts. A normal comb-beater is used in the area, and has a heavy wooden body with an upstanding handle and projecting iron teeth. These pass through the warp strongs to beat in the wefts.

(d) Another instrument used,looks like a scale for measuring the size of the carpet. It is called a Gerah. It is a piece of flat iron, its length is 6.5 cm.,or equal to the size of old-fashioned cigarettes in Iran, which are called Oshno. It is exactly 6.5 cm.

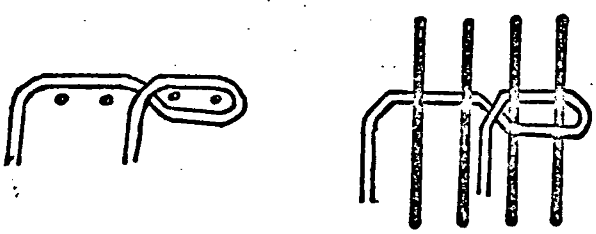
10.2.4 Knotting the Pile

The carpet is woven using two kinds of Risheh (knot), Persian knot Farsi baf or Shahry baf (town carpet) and Turkish knot Turky baf or Dahaty baf (village carpet) in Iran (Fig.10.4).

FIG 10.4 TYPES OF KNOTS



TURKISH KNOT



FARSI KNOT

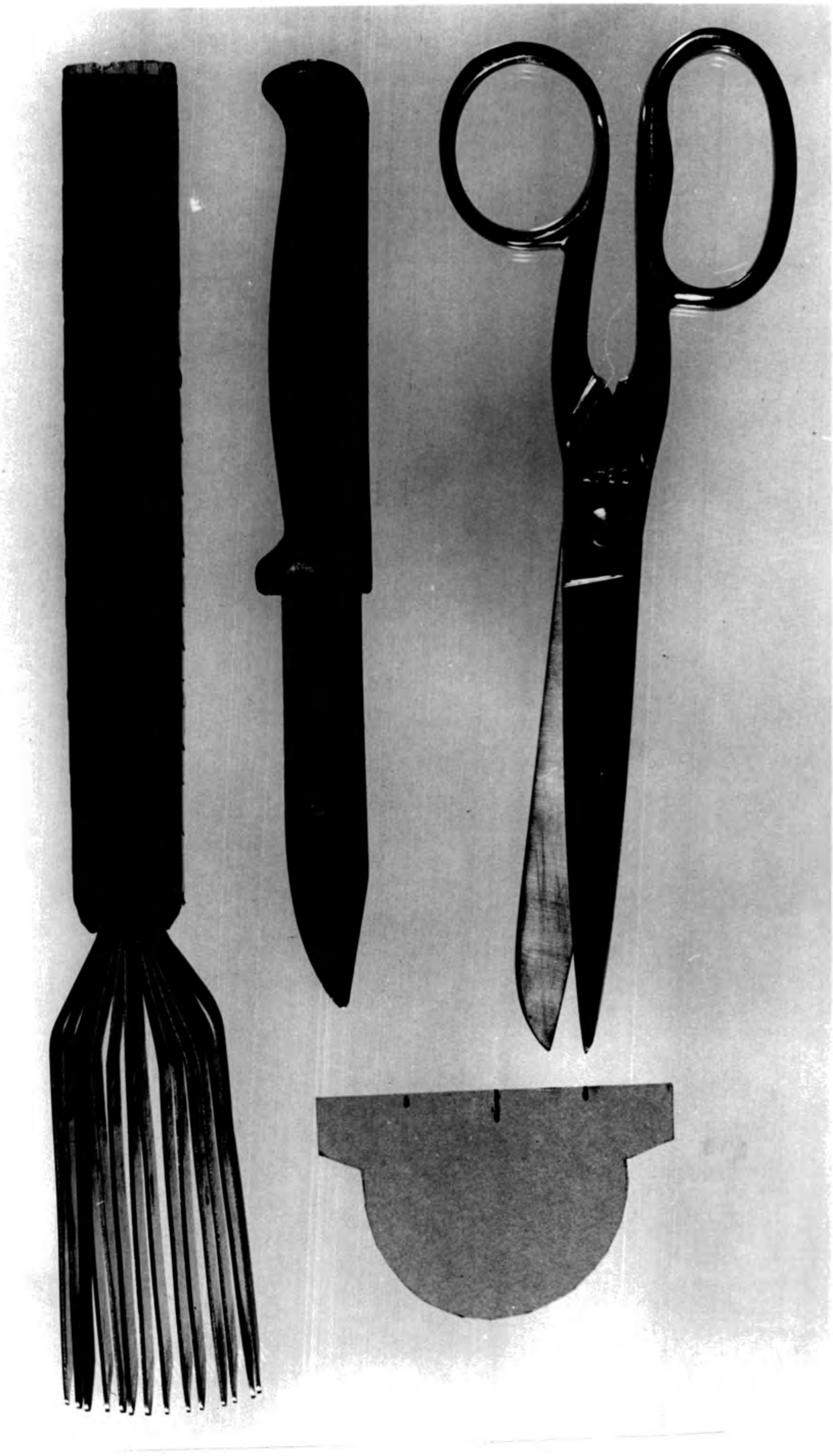


Fig. 10.3. Instruments of carpet weaving.

After the warp is laid, the weaving begins. Hanks of various coloured yarn hang above the weaver's head and the yarn is woven into the carpet according to a prescribed Pattern.

The knotting in the area is Farsi baf (town carpet). The weaver grips two adjacent warp threads with her fingers (the weavers are often the women of the area), draws them towards her and slings a thread of Rang or Cork (pilewool) behind these two warp threads, and winds the end of the woollen thread into the right side of the warp thread. She then pulls the knot tight and cuts the thread ends with the sharp edge of the knife. When one Rag (row)of knots has been completed, the weaver pulls down the Haff, and turns down the Nineh pich and with this action makes a gap between the front and back warp threads. Then the Pud (weft threads) are woven (pass) in the gap.

The Abuzaid-Abad area carpet is double wefted. First the Pud -e-Zaklim (thick weft) is woven and after, the Pud -e-Nazek (thin weft). When the wefts have been woven, the weaver returns the shed rod and heddle rod to the first position.

Now the weaver carefully takes hold of them between finger and thumb and pulls them towards her to tighten the knots.

Next the weaver compacts (Shaneh-Zadan) the wefts and knots with the beater comb, and the ends of the yarn are trimmed. After the trimming off the ends of yarn, one Rag of weaving is finished, and the work of knotting begins again.

10.2.5 Carpet Material

Four important materials are used for carpet weaving in the area. Wool, which is called Rang is used in the area and is of high quality being spun in a factory. The best quality wool which is called Kork, is used for first-class carpets in the area and is imported from other parts of Iran.

The production of wool in the Kashan region is not of prime importance and usually the wool producers sell their wool to the wool merchants in Kashan City. Hand spun wool is not used in the Abuzaid-Abad area carpets because it is not of the best quality and is not suitable for Kashan carpets. So they prefer to buy the high quality Rang or kork from the market, and sell raw wool to the wool merchant. Wool usually makes up two thirds of the carpet materials in weight,in the area. Silk is the least important but is still used,mainly in the area under investigation. The output of silk rugs is small. The pure silk carpet is woven very rarely in the area, but about 10 per cent of carpet production has been in silk, usually for depicting flowers or animals.

Cotton is used as Tar (warps)and Pud (wefts) in the carpet. Millspun cotton is produced by the mills (factories) which have been built in Kashan. The production quality of these factories is very good and most of the cotton which is produced in the region is sold to these factories. The Faghihi factory produce is very famous in the Kashan region. Cotton (warps and wefts) makes up one third of the weight of the carpets of this area.

One of the most important things in carpet making is the quality of colour of pile wool in the area. The weavers and contractors themselves prepare pile wool, and order suitable colours from the <u>Rangrazis</u>, (dye houses) to dye the wool in accordance with the design which they have prepared beforehand.

The large <u>Rangrazis</u> are located in Kashan City. Dyes are boiled in large earthenware vats,1 to 1.5 m. in height. They are heated by kerosene under pressure and one vat is capable of handling as much as 50 to 60 kg.,of wool in one batch.

The principal traditional dyes which were used in Kashan were <u>Nill</u> (indigo), <u>Ronas</u> (Maddler), <u>Qarmez-Daneh</u> (cochineal), walnut husks, pomegrante rind, henna, and straw, but recently European dyes have been used in the majority of dye houses (although a few of the main Kashan carpet merchants still have their yarns dyed in the traditional manner). All pile wools are dyed at the dye-house by the specialist dyer. The most important point which the weavers have to watch,is to ensure that each batch of wool of the same colour is dyed in one vat at the same time, in order to get the same colour. If this does not happen it is very difficult for a dyer to dye another vat of wool to exactly the same shade and this can result in a difference in pile colour, especially if it is used as the background <u>Zamineh</u> (field) of the carpet, which will show up after weaving. This is called <u>Rageh</u> (contrast) and it is one of the important faults in carpet manufacturing, but rarely found in carpets from this area. This is undoubtedly one of reasons for the high cost of carpets from the area.

10.2.6 Design

In the Abuzaid-Abad area the carpets are woven according to a pattern which is drawn by a Naghash (designer). Although there are many villagers and nomad weavers who work their traditional designs without any drawing or plan, many of the designs are passed on from generation to generation.

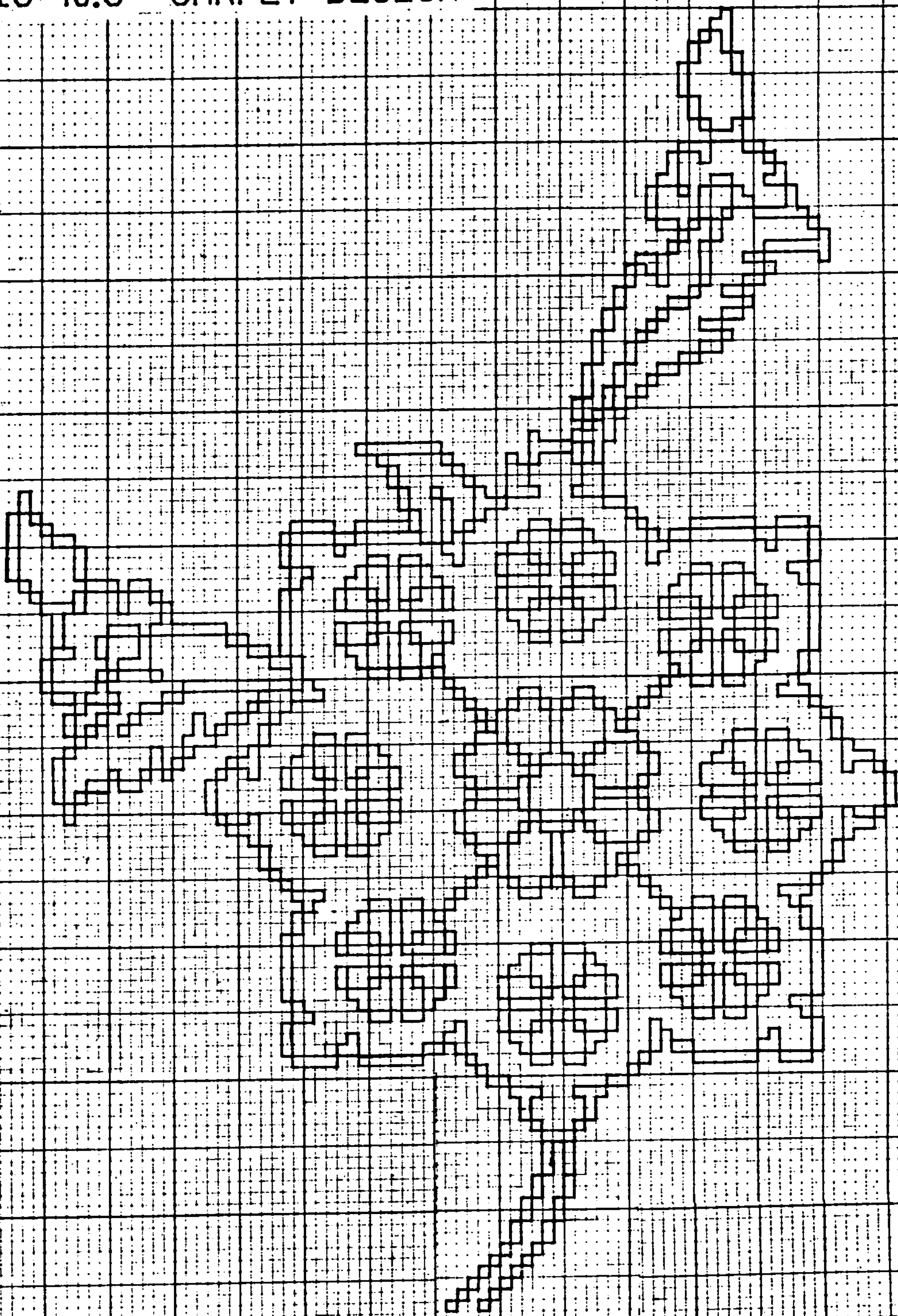
The Nagsheh (design) are drawn on graph paper, every khaneh (square), representing one knot. (Fig.10.5) A design often consists of a part of a carpet design, usually a quarter of the outer medallion, one quarter of the field and one corner of the border.

Because the first and most important element is, in the majority of Persian carpets, balance, the left and right halves of the carpet must be identical, and in most carpets the top half and bottom half must also be the same.

The most common designs at the present time in the area are Torange Mehrab (centre medallion), Shah-Abasi (King Abasi), but other kinds of designs like Shekargah (hunting or hunting garden) Gol va Goldan (floral), Torang-Ardabili, Mina Khani, and Bid-Majnuni (the weeping willow) have been used in the past. About 90 per cent of the designs which are used in the area at present are Torang Mehrab, with a red or dark blue Zamineh (field) and about 10 per cent of the rest, usually made of silk, are from the Shekargah (hunting and floral design).

The number of designs needed for an identical carpet of a size 208 x 143 cm ., (the Abuzaid-Abad standard carpet) consists of 3.5 sheets. They comprise of a quarter of a

FIG 10.5 CARPET DESIGN



medallion, one corner, one quarter of the field and a part of the border which is to be repeated a certain number of times . The number of designs for a floral or animal design for the above size, consists of six sheets.(4) The cost of each sheet was 1,000 Rials (£9) in 1978. These drawings have been prepared by specialized carpet designers (Naqash) in Kashan City. In many cases the carpet designers have previously been skilled weavers.

10.3 Availability of Labour (Weavers)

The total population of the ten villages in the Abuzaid-Abad area came to 7,536, or 1,374 households, and the total number involved in carpet weaving (weavers) was calculated, from the questionnaire connected with the survey conducted by the author in the area, to be about 2,313 persons, or 31.6 per cent of the total population (Fig.10.6).

The range of ages was between 7 - 50 years. About 99% of the weavers were female, there being only 23 male adults classified as permanent full-time weavers.

In the whole of the area it was found that there were 46 persons who gave miscellaneous services in connection with carpet making - Cheleh-davans (servicemen) were hired to prepare the looms and wind the warp around the beams. They are paid per day by the owners. There were also 26 brokers involved in the buying and selling of the carpets. Brokers usually try to satisfy both purchaser and seller as regards an average price - often two prices are proposed, one from each side. After the transaction usually each side pays 2.5% of the cost of the carpet to the broker. Table 10.1 shows the specification of labour in the area in 1978.

FIG 10.6 THE PEOPLE INVOLVED IN THE CARPET WEAVING (%) IN THE ABUZAID-ABAD AREA
1978

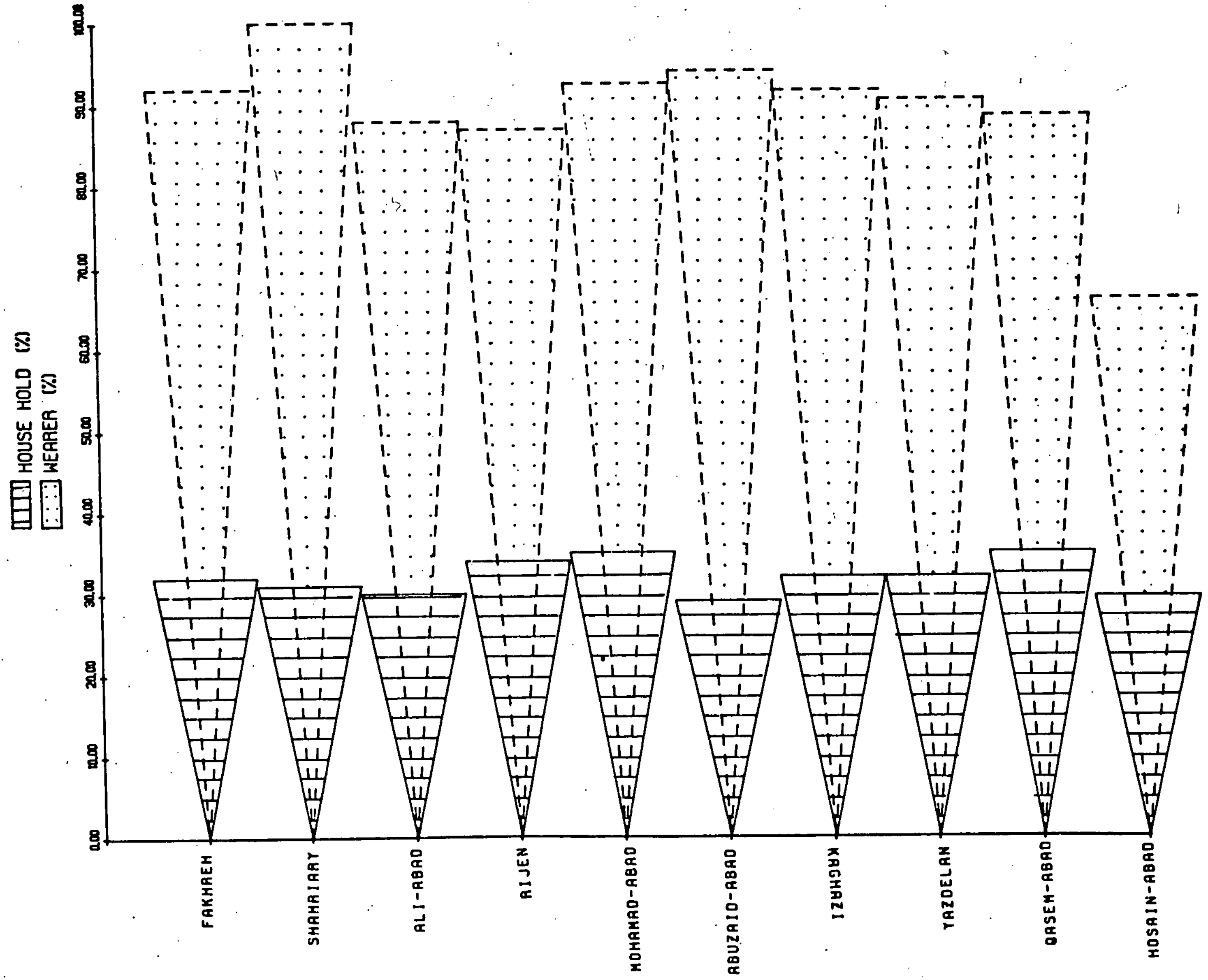


Table 10.1 The Specification of the Labour in the Area in 1978

Variable	Number
Number of households	1,373
Population	7,536
Average number of persons in each household (Size of family)	5.46
Total number of weavers (over 7 years old)	2,313
Male weavers	23
Female weavers	2,290
Private weavers	2,056
Under contract weavers	261
Servicemen (Cheleh-davan)	46
Brokers	26

Source : Field survey in 1978.

10.4 Utilization of Labour

According to the questionnaire survey made in the area by the author in 1978, there were 1,252 dars (operated looms) in operation in the villages. The total households numbered 1,379 and, on average, each loom was operated by 1.1 families. In other words, there was approximately one loom per household, i.e. 91 per cent of families were engaged in carpet weaving and only 9% of the households, usually consisting of an elderly couple or single man, were not involved in carpet weaving (Fig.10.7).

As stated previously, the total number of carpet weavers was 2,313 persons with a range of 12 in Shahriary village to 910 persons in Abuzaid-Abad village (Table 10.2). The average age of the female weavers was about 18 years old but the average age of male weavers was 25 years because younger men often preferred to engage in agricultural activities, or go to cities and work in the factories, or take up employment as building labourers. But the women, especially young girls, have to stay at home and so carpet weaving is a very suitable occupation. In addition, agricultural activity is not developed in the area, and cultivation does not usually need more than the available male labourers. Also, the income from carpet weaving (which will be discussed later) is much higher than any other activity carried out in the area.

The total number of annual man-hours per year was calculated for each village, and the results are shown in Table 10.2. The working timetable for weaving is divided into two parts, daily and yearly. First we will consider the daily

FIG 10.7 SPECIFICATION OF WEAVERS AND LOOMS IN THE ABUZAID-ABAD AREA

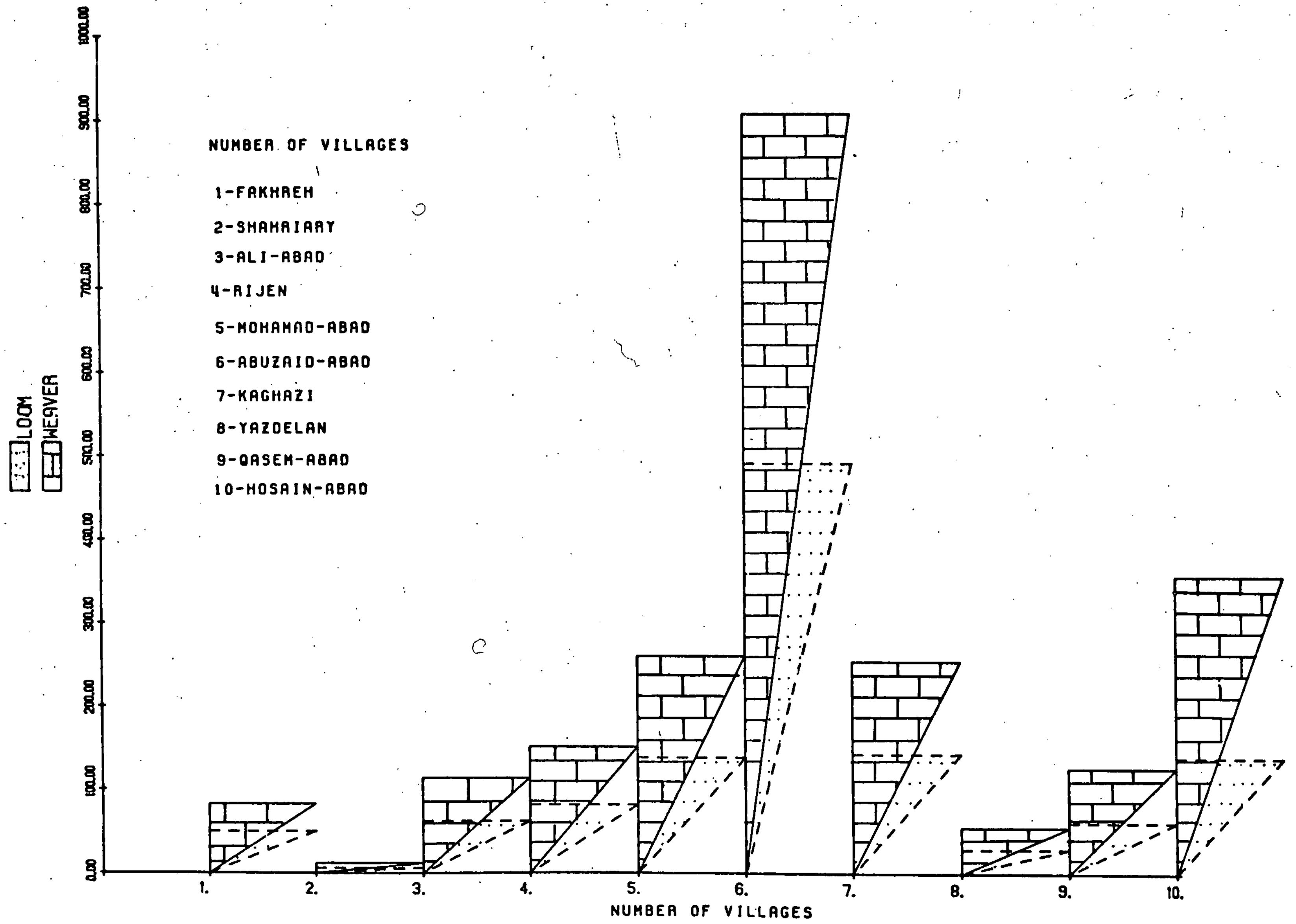


Table 10.2 Utilization of Labour (weavers) in the Abuzaid-Abad Area in 1978

No. of villages	1	2	3	4	5	6	7	8	9	10	
Variables / Villages	Fakhreh	Shahr-iary	Rigen	Ali-Abad	Mohamad-Abad	Abuzaid-Abad	Kaghazi	Yazde-lan	Qasem-Abad	Hosain-Abad	Total & Average
No. of looms in each village	50	6	62	82	139	492	143	29	61	139	1,252 T
No. of households	54	6	70	94	150	524	156	32	69	210	1,379 T
Population	257	38	378	445	752	3,162	789	171	344	1,200	7,536 T
The size of family	4.8	6.3	5.4	4.7	5	6	5	5.3	5	5.7	5.4 A
No. of weavers	83	12	114	152	261	910	254	55	120	356	2,317 T
% of weavers of population	32%	31%	30%	34%	35%	29%	32%	32%	35%	29.6%	30.6 A
Total annual labour forces man-day/year	21,912	3,168	30,096	40,128	68,904	240,240	67,056	14,520	31,680	93,989	610,632 T
Total ann. labour forces man-ho/year	175,296	25,344	246,768	321,024	551,232	1,921,920	536,448	116,160	253,440	751,872	4,885,056 T
Average weavers per loom	1.53	2	1.83	1.85	1.87	1.84	1.77	1.9	1.96	2.56	1.84 A
Average weavers per household	1.66	2	1.63	1.61	1.74	1.73	1.62	1.71	1.73	1.69	1.67 A
Tot. ann. miscellaneous service man-day/year	315	45	459	747	1,026	4,320	801	189	459	1,340	8,127 T
% of family involved in carpet making	92	100	88	87	92.5	94	91.6	90.5	88.5	66	90.8

Source : Field survey in 1978.

timetable. The weaving starts at 7.0 a.m, continues until 12 noon when there is a lunch break of one hour. Work starts again at 1.0 p.m and continues until 5 p.m. There are two breaks, in the morning and afternoon, which together total about one hour. However, the majority of weavers work for a minimum of 8 hours per day and even though most of the weavers work for themselves and are not under contract, they still work according to a daily timetable. Those who are under contract do not take such long breaks because any neglect in the weaving will mean a reduction in income. On occasions some of the housewives have to interrupt their weaving in order to look after their young children or do housework, but then they may work during the night or start earlier in the morning.

Secondly, the yearly timetable. The yearly timetable for the weavers is divided into two sections : formal holidays and informal holidays (times of illness or incapacity).

Formal holidays during the year consist of 52 Jomah (Fridays) and 19 holidays (religious days), together with celebrations for the Now-Roz (New Year festival at the beginning of Spring).

As for informal holidays, all female weavers usually have some problems or illness which, on average, was calculated to be about 20 days per year for each weaver. Also, when a carpet is finished, before the work of weaving begins again, at least 10 days are needed to prepare the materials, design and warp winding, etc.

However, on average, during a year there are at least

82 days when weavers are off so they work 263 days, at an average of 8 hours per day.

In summary, in 1978 on average, about 4,885, 056 standard man hours/year work was done by the 2,313 labourers (Fig.10.8). In fact each labourer worked 2,104 smh/year. Also the total man-days/year (md/year) was estimated at about 610,632.

The survey showed that there was 1.84 weavers per loom and 1.67 weavers per household (Table 10.2).

10.5 Carpet Weaving System

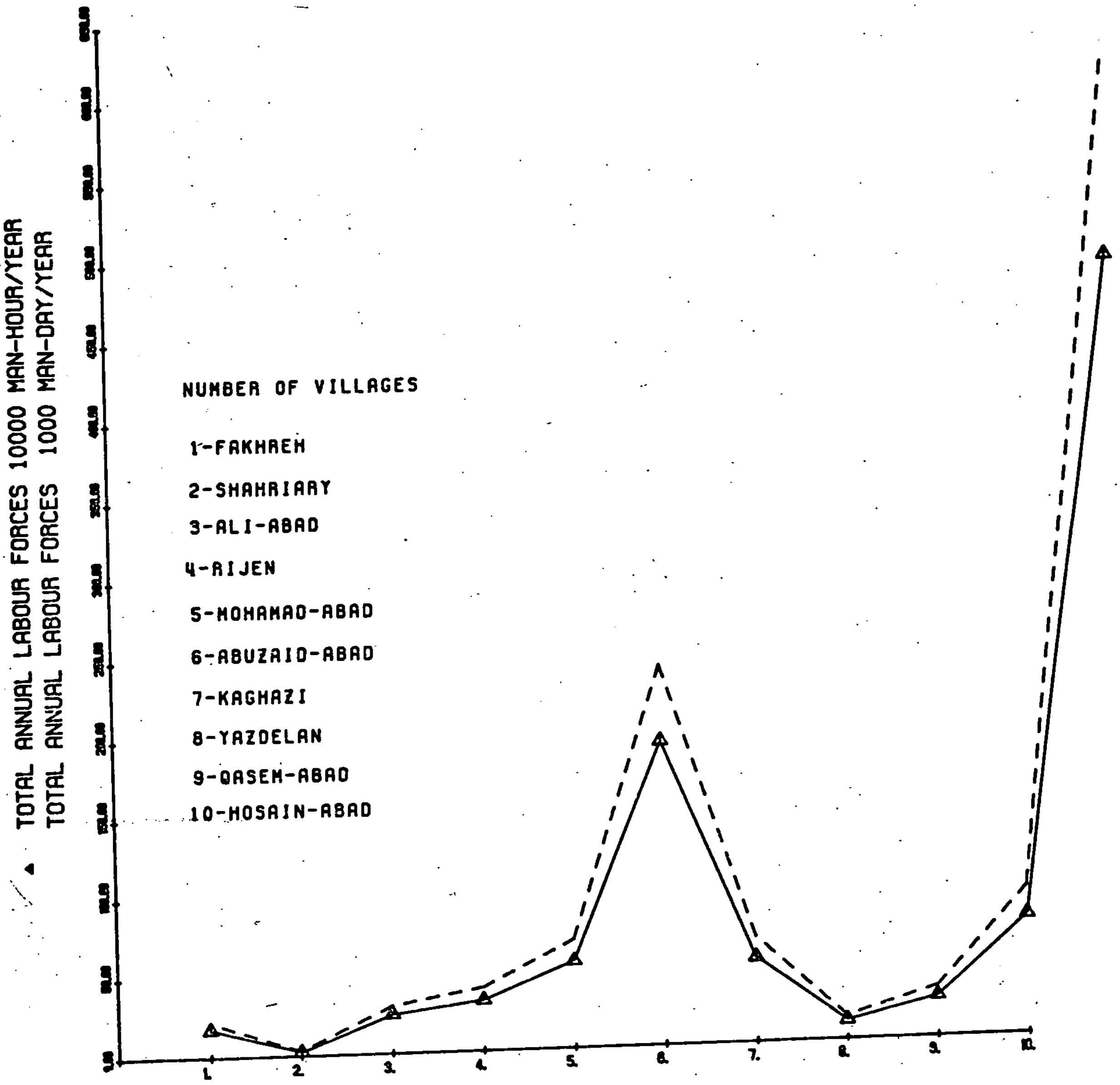
Two types of carpet are woven in the area : Qalie-shakhsi (private carpets), and Qalie-mozdei (contract carpets).

(a) Private weaving

All private carpet materials are prepared by the weaver and the carpet is woven according to a certain design. The materials are often purchased from the Kashan wool merchants, and the design is ordered at least one month before weaving begins.

The private weavers usually observe traditional rules of time and holidays, etc., which are common in the area, although their work is not under such strict regulations as contract carpet weaving. However, private weavers usually try to finish the carpet as soon as possible and sometimes work overtime for long hours because of the financial benefits. According to the field investigation carried out by the author in 1978, about 89% of the total carpets produced in the Abuzaid-Abad area.

FIG 10.8 UTILIZATION OF ANNUAL WEAVERS IN THE ABUZAID-ABAD AREA 1978



were woven privately. In other words, approximately 2,056 m^2 of the carpets produced, were woven by the private weavers. From about 2,317 weavers, 2,056 persons or 89% of the total weavers have been involved in private weaving and 261 or 11% of the total weavers have been under contract with merchants and only a few of these received a daily wage (Table 10.3 and Figure 10.9).

The daily wage of a weaver depends on her skill in weaving. Usually the wage of a good weaver was 400 Rials (£2.60). Young girls, who usually fill in the rest after the skilled weaver has worked out the outlines, received 100 to 200 Rials (75p to £1.30).

Receiving a daily wage is very rare, because nearly all the weavers are involved in private or contract weaving. Sometimes, however, weaving may have to stop for one reason or another, e.g., the loom has broken, the wool has finished, or the carpet is finished. In which case the unemployed weavers are hired by other weavers and are paid by the day.

(b) Contract weaving

Contract carpet weaving usually consists of three types in the area. In each type of weaving contract, the carpet contractor (Dar gardan) supplies all materials to the sub-contractor, except for the loom.

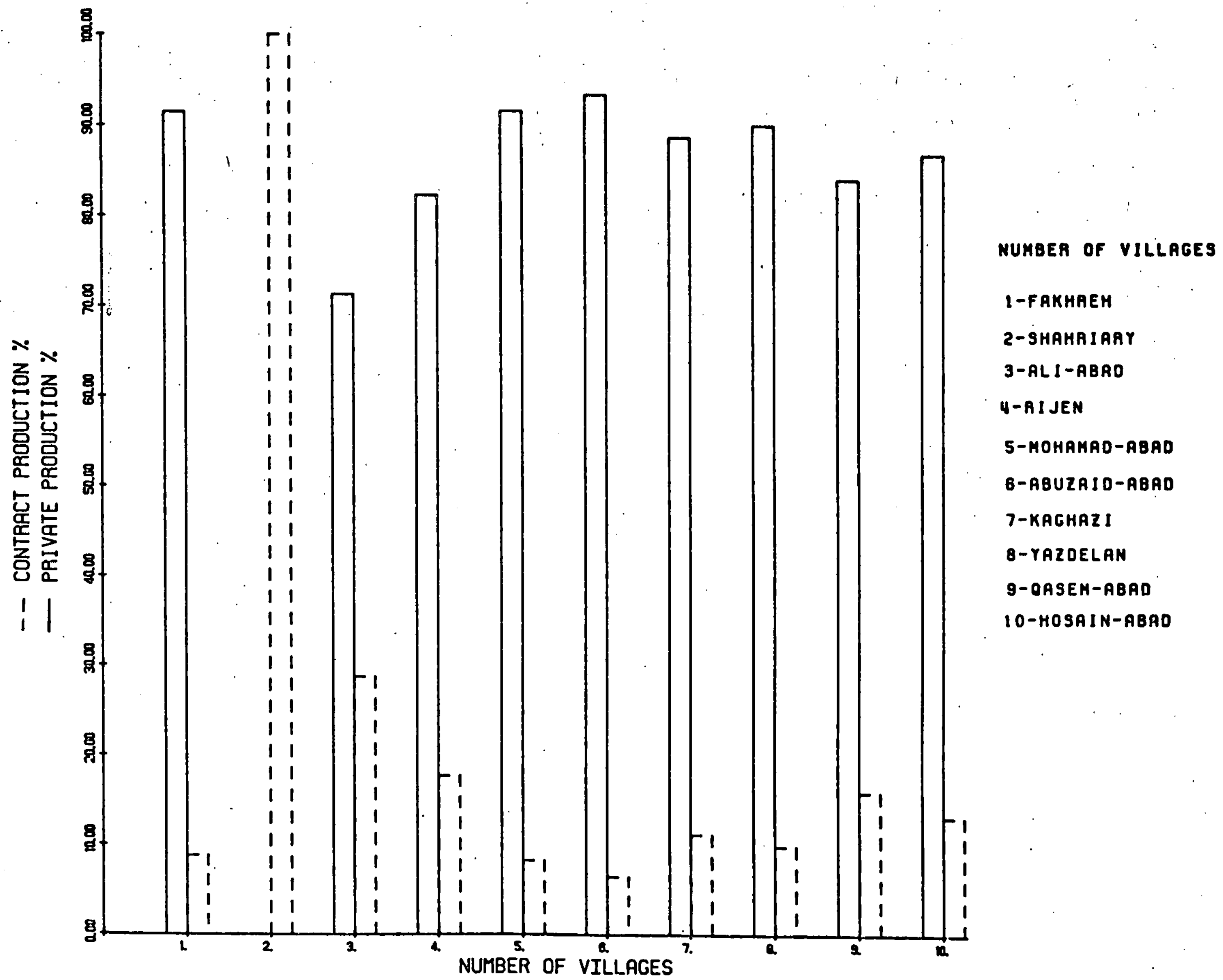
(i) In the first type of contract, a fixed amount of money is paid to the weavers by the Dar gardan in five or six instalments. The first instalment is paid when an agreement has been reached. The prices paid to the sub-contractor vary from 120,000 to 130,000 Rials (£800-866) per Joft-Qali

Table 10.3 The Type of Carpet Production in the Abuzaid-Abad Area in 1978

No.	Name of village	Total carpet Prod. (m^2)	Private Prod. (m^2)	Contract Prod. (m^2)	% of Private Prod.	% of Contract Prod.	No. of Private weavers	No. of Contract weavers
1	Fakhreh	205	187	18	91.2	8.8	76	7
2	Shahriary	32	-	32	0.0	100	-	12
3	Rigen	300	214	86	71.3	28.7	81	33
4	Ali-Abad	524	350	72	82.3	17.7	125	27
5	Mohamad-Abad	678	622	48	91.7	8.3	239	22
6	Abuzaid-Abad	2,550	2,385	175	93.5	6.5	851	59
7	Kaghazi	527	468	59	88.8	11.2	225	29
8	Yazdelan	122	110	12	90.1	9.9	49	6
9	Qasem-Abad	302	254	48	84.1	15.9	101	19
10	Hosain-Abad	892	776	117	86.9	13.1	309	47
	Total	6,033	5,366	667	88.9	11.1	2,056	261

Source : Field investigation in 1978

FIG 10.9 PRIVATE & CONTRACT WEAVING (%) IN THE ABUZAID-ABAD AREA (1978)



(2 carpets) 32 x 22 Gerah or 5.94 m^2 of 80/40 quality carpet (80 warp strands and 40 knots every 6.5 cm., or about 15 x 15 knots per square inch).

In this type of contract the subcontractors are sure of a fixed income which will be paid to them.

(ii) In the second type of contract (piece work), the weavers are paid by the number of knots woven. The unit of payment in the area is 880 knots, or one Rag. The usual wage per Rag was 60 Rials (40 p). A skillful weaver can produce 6 Rag in a day. This type of contract encourages the weavers to work hard each day.

In this type of contract, constant surveillance is absolutely vital because some dishonest weavers may fail to tie the knot in the yarn, or alternatively may tie Jufti (a double) knot around four warp strands instead of two. In the former case, the design becomes blurred, and in the latter the carpet loses density and weaving quality, but by using such techniques a weaver can weave twice as rapidly.

(iii) In the third type of contract, the wage of the weavers is determined by the cost of the carpet. After the sale of the carpet, the contractor takes the value of the materials and credit, which he has paid formerly, plus usually 15,000 Rials (£100), as interest on his capital. The rest of the selling price, minus an amount for brokerage, is paid to the weaver. In this case the weavers try to weave the carpet to the best quality because they will benefit from a higher selling price according to its standard. In this type of contract, the wage of the weaver also depends on the level of the carpet market, nationally and internationally. This type of contract is more commonthan the others in the Abuzaid-Abad area.

There were about 18 contractors in the area in 1978, each of whom had, on average, 8 contracts. The contractors were living in Kashan or in the village of Abuzaid-Abad, and two of them were living in Hosain-Abad. The contractors are usually capitalists and some of them had been landlords before the land reform in the area, or they were merchants.

10.6 The Qualities of the Abuzaid-Abad Area Carpet

The carpets of the Abuzaid-Abad area are double wefted and woven with the Farsi knot. The quality, which is generally woven in the area, is a nominal 40 x 40 knots to the Gerah (one Gerah = 6.5 cm.). This is equivalent to 15.5 x 15.5 knots to the inch. For comparison, the Kashan hunting carpet that is held at the Austrian Museum for Art and Industry, Vienna, had 27 x 29 knots to the inch (Edwards 1953). The Abuzaid-Abad carpet is one of the best quality carpets on the Iranian markets and is usually classified as a first class carpet in the Kashan market.

The usual size of these woven in the area is 22 x 32 Gerah, or 143 x 208 cm., (2.97 m^2). These are called Qalicheh. Two small ones are often woven as a pair. Qalicheh (each measuring 2.97 m^2,).

The number of knots which are tied in a pair of carpets in the area is calculated as follows:

$$(32 \times 40) \times (22 \times 40) \quad \times 2 \; = \; 2,252,800 \text{ knots},$$

where 32 is the length of the carpet in Gerah, 40 is the number of knots per Gerah and 22 is the width.

10.7 Carpet Production in The Area

All the carpets which are produced in this area have approximately the same quality, although the merchants do recognize differences in quality from one carpet to another. They also easily recognize the place of weaving, even sometimes the names of the weavers because this may affect the quality of the carpet and, as a result, the cost. According to the author's investigations and interviews carried out with weavers in the area and carpet merchants in Kashan's Bazaar (market), they believe that the quality of carpets changes very little from village to village in Abuzaid-Abad and adjoining villages. This makes it easy to estimate production, and give a statistical analysis of carpet production in the area.

10.7.1 Potential Production

A skilled woman weaver ties, on average, ten knots a minute; (this includes wefting, beating and trimming). This scale has been measured by the author in all the villages in the area. The weavers themselves, however, believe that a skilled woman weaver weaves 5 to 6 rows (rag) per day (8 hours) of standard size Abuzaid-Abad carpet (32 x 22 Gerah).

Thus, according to the first estimation, a pair of standard size Abuzaid-Abad carpets has 2,252,800 knots, which will be woven in 468 days.

According to the second estimation a pair of standard size carpets will be woven in (32 x 40)/5.5 x 2 = 465.5 days where 32 is Gerah, 40 is the number of knots per Gerah and 5.5 is the average rows which are woven per day. The two estimations are very close together : on average 5.94 m^2 of carpet are woven by a skilled weaver in 466.5 days. Therefore, a square metre of carpet is woven in 80 days by a skilled weaver. The total production was calculated from the above estimation to be about 7676 m^2 for 1978.(5) (Table 10.4).

The actual production was calculated,from the questionnaires filled out in the area in 1978 for each village,to total about 6033 m^2 (Table 10.4) The range of carpet production varies from 32 m^2 - 2550m^2 in Shahriary and Abuzaid-Abad villages respectively (Fig.10.10).

The coefficient of potentiality for increasing production (per cent) was calculated from the following formula:

$$P_{in} = \frac{100\ (P_p - A_p)}{A_p}$$

where P_{in} is the coefficient of potentiality for increasing production as a percentage, P_p is the potential production, and A_p is the actual production. On average the coefficient of potentiality for increasing production was calculated for 1978 at about 27.2%. P_{in} varies from one village to another; the range of variation being 19% in Abuzaid-Abad to 59.7% in Kaghazi (Table 10. 4 & Figure 10.11).

There are a few basic reasons for the cause of decreasing potential production in the area and these are as follows:

Table 10.4 Specification of carpet production in the Abuzaid-Abad area in 1978

Variables \ Village	Fakhreh	Shahriary	Rijen	Al-Abad	Mohamad-Abad	Abuzaid-Abad	Kaghazi	Yazdelan	Qasem-Abad	Hosain-Abad	Total & Average
Actual production m^2 in 1978	205	32	300	425	678	2550	527	122	302	892	6033 T*
Potential prod. m^2/year	275.7	39.8	379	507	867.6	3034.2	841.8	182.5	398.7	1182.6	7676.0 T
The coeffic. for increasing of production %	34.5	24.4	26.3	19.3	28	19	59.7	49.6	32.0	32.6	27.2 A
The number of standard carpets (5.95 m^2/year)	47	5	51	83	114	480	89	21	51	150	903 T
Average production per household/m^2	3.7	5.3	4.3	4.5	4.52	4.86	3.3	3.8	4.3	4.2	4.3 A
Average production per weaver/m^2	2.46	2.66	2.6	3.25	3.2	2.6	2.0	2.2	2.5	2.5	2.3 A
Average potential production per household m^2	5.5	6.6	5.4	5.3	5.8	5.8	5.4	5.7	5.7	5.6	5.5 A
Average potential production per weaver/m^2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3 A

* T = Total
A = Average

Source : Field Study and calculation

FIG 10.10 ACTUAL & POTENTIAIL CARPET PRODUCTION (M2) IN THE ABUZAID-ABAD AREA 1978

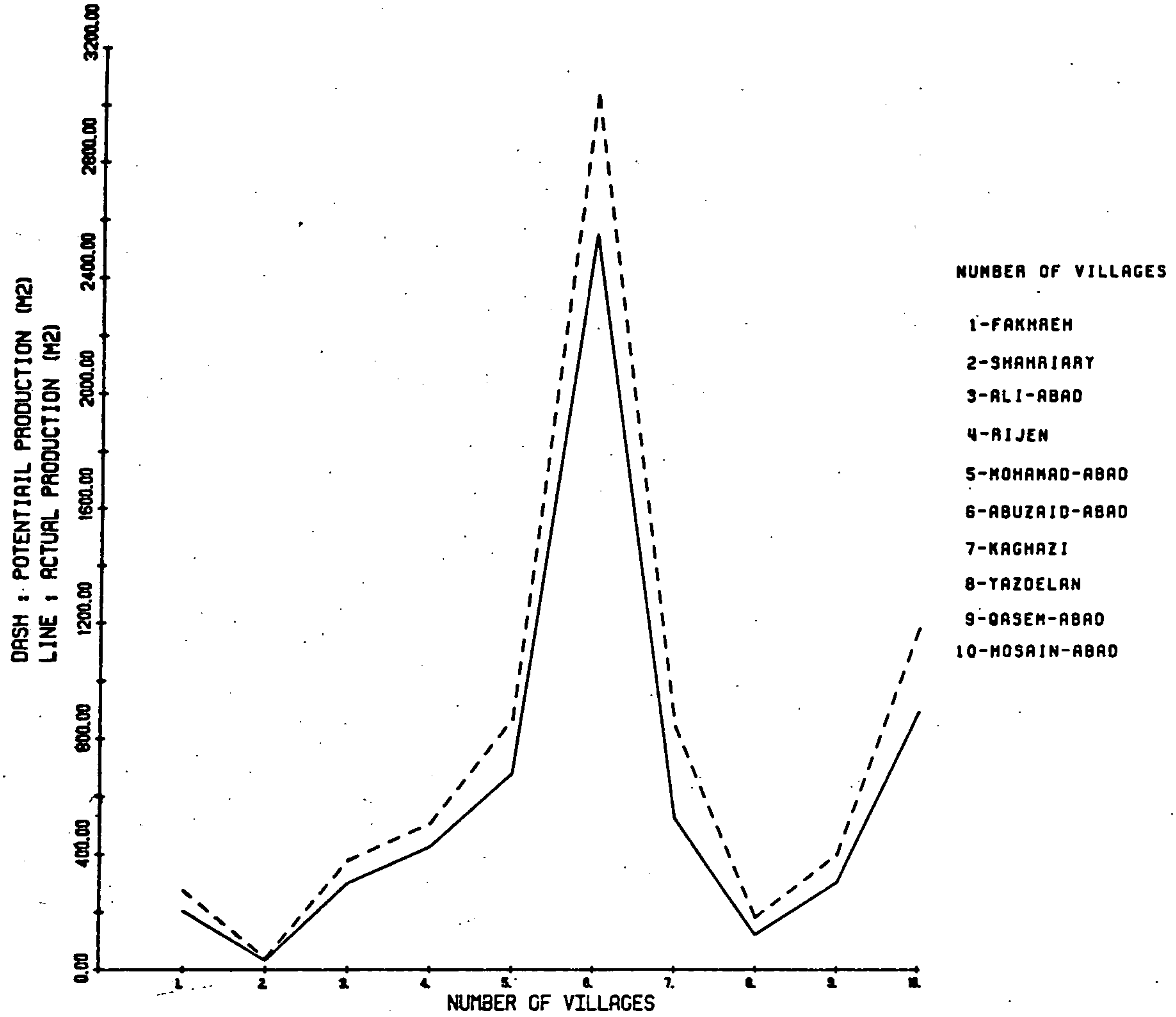
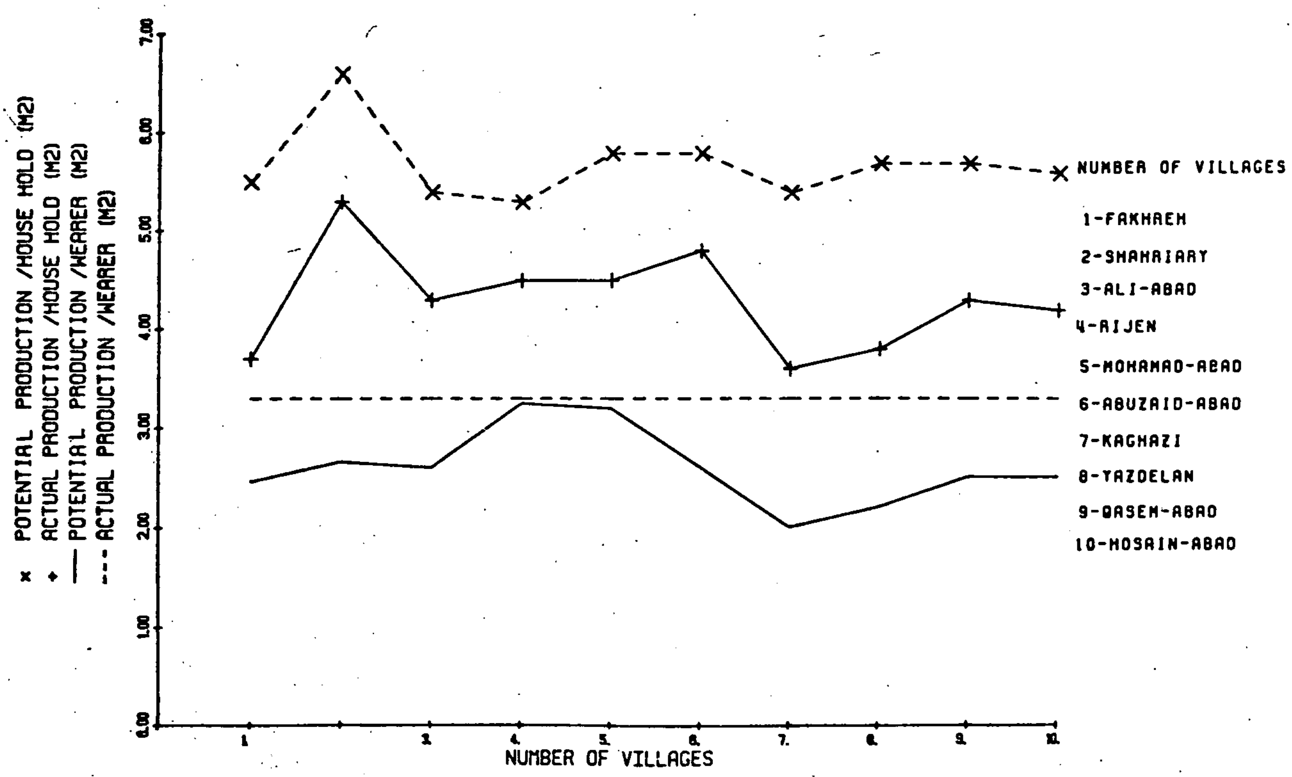


FIG 10.11 DISTRIBUTION OF CARPET PRODUCTION IN THE ABUZAID-ABAD AREA (1978)



(a) Skill in Carpet Weaving

The technique of weaving in the area is often shown to a child by her mother who, in the same way, learnt it from her own mother. Girls start carpet weaving at an early age i.e.,6 to 7 years old but, of course, at that age they do not have the ability to do it as well as their mothers. Also, it is customary for the forewoman (head weaver or skilled weaver) to weave the design outlines, whereas the younger weavers fill in the rest. The potentiality was calculated by counting the production of a skilled worker (i.e. an adult skilled weaver) but, in fact, some weavers (especially young weavers) are not skilled and so cause a decrease in production.

(b) Seasonal Conditions

The hot summer weather which occurs for at least four months of the year (June - September), decreases the potential carpet production, because looms are often located inside the houses and there are not many coolers or much air conditioning in the area. Sometimes some of the forewomen change the time of weaving from the daytime to night time, and often the youngest weavers go to sleep in the evening. In addition, during the summer is the harvesting time,and the women occasionally help their husbands, so obviously, for one reason or another, production decreases during summer months.

(c) Working Conditions

Most of the work places are not suitable for carpet weaving because there are no factories and the looms are located in the houses. If the house is large it may be occupied by two or more families and there may be two or more looms. So often, bad conditions such as lack of light, hot weather, uncomfortable or unsuitable planks for the weavers to sit on, etc., have an impact on decreasing production.

(d) Health Services

A high percentage of carpet weavers usually suffer from the lack of health services because there is no permanent health service centre in the area. On Saturdays only, a visting doctor and two nurses come to Abuzaid-Abad village clinic for 5 or 6 hours; therefore, weavers have to go to Abuzaid-Abad from surrounding villages, or during the week they have to go to Kashan for that facility.

10.8 Conclusion

Although the carpet weaving is not a new phenomenon, it has developed over the last ten years. In the Abuzaid-Abad area, unlike the rest of the rural areas in Iran, high quality carpets are woven. The technique of carpet weaving is similar to that for the Kashan carpet and in the national market it is known as the Kashan carpet. Their design, material and quality (40 x 40 Gareh) are approximately similar.

The carpets have been produced mainly, by the majority of households in the area, about 91% of the households are engaged in carpet weaving. According to field observations and the author's experience, the carpet is produced by a suitable method in the Abuzaid-Abad area, although suggestions have been made by specialists for increasing carpet production, such as locating all the looms in one area i.e. a factory, and using a particular design, size and material etc. However, it should be noted that, according to local interviews with the author, the majority of weavers do not like to go to a public place for carpet weaving because of private and social problems. Moreover many weavers work overtime, e.g. during the night, earlier in the morning or at the weekend. However, in order to reach potential production the following suggestions are made:

a) to advise and help the people to organise good working conditions.

b) to establish carpet cooperatives for financial help facilities.

c) To make certain health and social services available for the weavers.

d) To establish a nursery for helping the mothers.

On the other hand, we should not forget that high production is not the only aim of these suggestions; it is important to provide suitable social security and social services facilities for the weavers, and children should be prohibited from carpet weaving.

To increase the carpet income, the raw materials should be prepared by cooperative shops in the area and supplied to the weavers directly. The role of middlemen should be eliminated as far as possible, thus reducing the gap between producer's selling price and the purchaser's buying price.

References

1. Edward, A.C. (1956) The Persian carpet : A Survey of the carpet weaving industry of Persia. G. Duckworth and Co. London, p.22.

2. Shekary or Shekargah (Hunt or hunting garden) is a name of design in the Persian carpet.

3. Edward, A.C., (1956) op.cit., p.334.

4. 22 (Gareh = 6.5 cm) x 40 (number of knots in each gareh) = 880 knots in width
   32 (Gareh) x 40 = 1280 knots in the length or 1280 mm^2 in design
   880 x 1280 = 1126400 knots in carpet or 1126400 mm^2 in the design
   1126400 ÷ 6 = 187733.5 mm^2 on one sheet of design extent.

5. 610632 (smd/year) ÷ 80 (one m^2/80 days) = 7676 m^2.

CHAPTER 11

RURAL INCOME

There are two sources of income for the rural population in the Abuzaid-Abad area : agricultural income, and non-agricultural income. The agricultural income consists of income from annual crops, perennial crops and livestock. Non agricultural income comprises : carpet weaving, social welfare assistance, private jobs and labouring at the factories or buildings in the cities.

11.1 Agricultural Income

The agricultural income, in general, comprises; firstly, income from crops, both annual crops and perennial crops, and secondly, income from animal husbandry.

The farmers' income from crops depends mostly on the size of farms and share in the village units (see the chapter on irrigation - Nasagh section). As we have seen, a unit of a village shares a particular area of land and available water of the village. Therefore, there is little difference between the income of units in each village.

In the area under consideration, in order to get an average agricultural income, the author gathered his information by using questionnaires from 20% of each village unit's income, and estimated the total agricultural income. This was because some of the farmers are not used to statistical inquiries, or they do not know the correct income themselves. Also some of the farmers are prone to confuse surveys with pending taxation measures etc.

11.1.1 Income from Annual Crops

Cereals (wheat and barley) are the main annual crops in the area. Also cotton, poppy and some of the safie crops like onion, and beet are a most significant source of cash income. Alfalfa in this part of the study, which has been included in the annual crops, is one of the most important crops, which are produced in the area.

The total production of crops (see the Chapter on Agriculture), the total price of production (at farm gate price) and the distribution of gross income from annual crops, is illustrated in Table 11.1 and is summarized as follows:

(a) Wheat

Wheat accounted for about 22.2% of the total gross income, or 6,616,500 Rials, in 1978. The average income from wheat was 35,310 Rials/ha., in the area. Because of the cost of labour, wheat was grown at a loss because of the low price of wheat (16.5 Rials/kg., since 1978) and the high price of labour (on average 500 Rials/day at the harvesting time). However, the farmers had to grow it because this is their sustinence crop. After the Revolution, the government decided to increase the price of wheat. Although this decision made the price of wheat go up in the markets, it guaranteed farmers against any loss. While wheat prices have increased, the cost of labour has not gone up since that time.

(b) Barley

Barley accounted for about 20.2% of the total gross income, or about 5,921,005 Rials. The average income from barley was 38,440 Rials/ha. The average income from barley was about 8% higher than the income of wheat in the area, because barley is more resistant than wheat to the saline soil and water.

(c) Cotton

According to the 1978 survey, the total gross income from cotton in the ten villages of the area was 1,352,500 Rials. Cotton accounted for about 4.6% of the total gross income from annual crops. The cotton is sold non-ginned to buyers who come to the area. The average income from cotton was 60,900 Rials per hectare in 1978.

(d) Summer crops

Beet and onions are the most important of the summer crops and their production is not usually very considerable. They accounted for 3.6% and 7.5% respectively of the total gross income from annual crops in 1978.

(e) Alfalfa

Alfalfa accounted for the highest percentage - about 33.7% of the total gross income. This crop is harvested four times during the year. The average gross income from alfalfa was about 299,363 Rials/ha. The total gross income from this crop was 9,879,000 Rials in the area in 1978.

(f) Poppy

Poppy accounted for 7.7% of the total annual crops income. The opium was purchased by the government. The poppy is one of the best cash annual crops in the area because the yield is high, since the soil and climate are suitable for this crop, and the price is very high. Also, it does not need

Table 11.1 Total Production of Annual Crops/Commodities in the Abuzaid-Abad Area in 1978

	Land under cultivation ha	Quantity in metric ton	Yield kg/ha	Price per metric ton Rial	Value in currency Rials	Percent
Wheat	187.3	400.928	2,140	16,500	6,616,500	22.2
Barley	153.6	380.99	2,480	15,500	5,921,005	20.2
Cotton	22.38	54.527	2,436	25,000	1,362,500	4.6
Onions	11	161.89	14,717	6,500	1,053,000	3.6
Beets	24.9	713.382	28,649	3,000	2,198,766	7.5
Alfalfa	33		94,166	3,000	9,879,000	33.7
Opium	25	0.075	3	30,000,000	2,250,000	7.7
Total	457.18				29,280,771	100

much irrigation. It is harvested in the middle of May, and this releases the land for the sowing of summer crops, like green vegetables, or biennial rotation crops.

However, opium production is risky, because the growers become accustomed to using opium themselves. Opium accounted for 7.7% of the total gross annual crops income in the area in 1978. However, since 1979 the sowing of poppy has been prohibited by the government. Figure 11.1 shows the distribution of annual gross income in the area.

11.1.2 Annual Crops Production Costs

The total use of goods and services for annual crops production has been estimated and has been illustrated in Table 11.2.(1)

The production cost has accounted for all goods and services purchased, e.g. the price of home grown seed, improved seeds, manure, chemical fertilizer, insecticides, hired labour, hire of tractor for ploughing and sowing, instalments of land price etc. Furthermore, the cost of production on farmers' labour has been accounted as a farm expenditure, although because of rising labour costs, the farmers' profit margin is decreasing. Also, as stated earlier, other causes contributing to this decrease are the low yields, low price of agricultural production (excluding opium) and the small size of farms.

However, according to the 1978 survey, the total cost of goods for annual crops (seeds) was 1,256,600 Rials or 3.7% of the total expenditure. The cost of agricultural

FIG 11.1 TOTAL GROSS INCOME OF ANNUAL CROPS IN THE AREA IN 1978

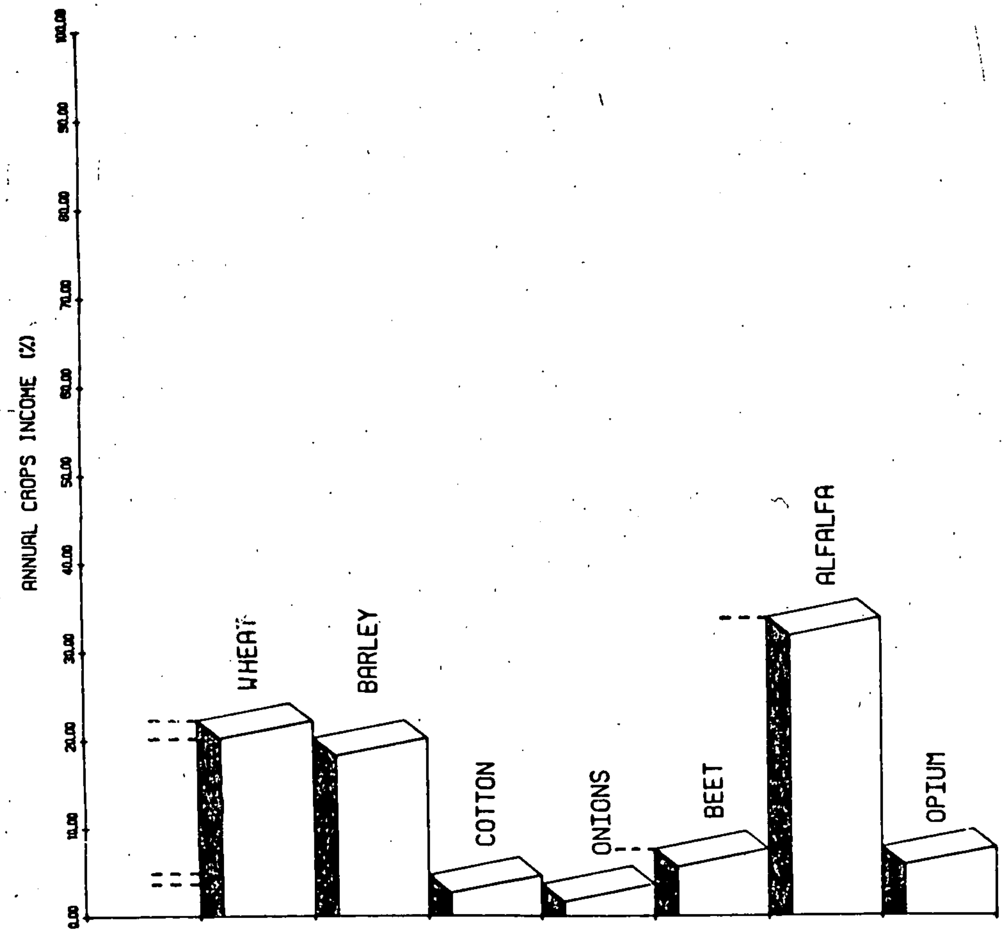
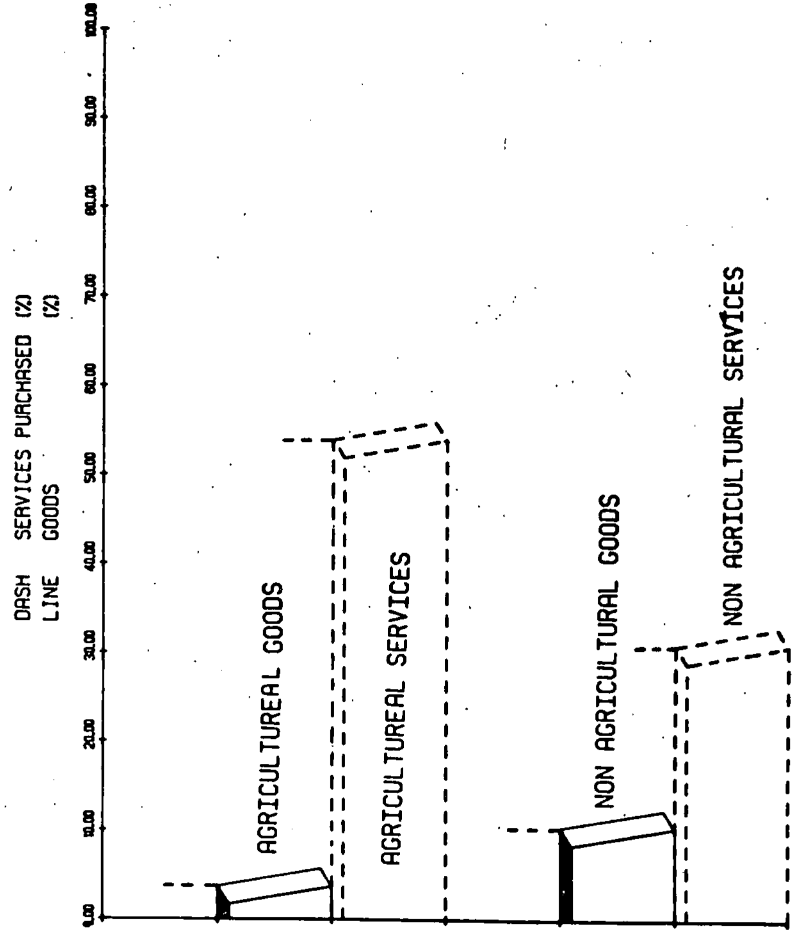


FIG 11.2 TOTAL USE OF GOODS & SERVICES FOR ANNUAL CROPS PRODUCTION IN THE ABUZAID-ABAD AREA IN 1978



services purchase, comprising the farmers' labour itself, land cleaning and soil preparation, cultivating, pest and disease control, sowing and harvesting and farm transport, was about 18,464,700 Rials, or 54% of the total production cost.

Non-agricultural goods, consisting of manure, poultry waste, chemical fertilizer, fuel, and lubricants was approximately 3,565,000 Rials, or 10.4% of the total expenditure of the annual crops.

Non-agricultural services purchased, comprising land improvement, qanat maintenance, irrigation canal structure, annual cost of initial investment (well drilling), machinery, compensation of employees - watchmen, headmen and motormen[2], interest on debits for agricultural operation and instalment of land price, altogether was about 10,476,468 Rials, or 31% of the total production cost (Fig. 11.2).

Thus the total expenditure on annual crop production was about 33,762,768 Rials in the Abuzaid-Abad area in 1978, which was about 73,847 Rials per hectare.

According to the above estimation for which more details have been shown in Table 11.2, about 115% of the total gross income has been expended in order to produce crops in the area.

Thus, as we have mentioned before, annual crops, taking into account the farmers' labour, were grown at a loss, comprising only 15% of the total gross annual crops income in the area in 1978. However, the total net income from annual crops, excluding wages and net profit, was about 13,982,702 Rials, or 47.2% of the annual gross income in 1978.

Table 11.2 Total Use of Goods and Services for Annual Crops Production in the Abuzaid-Abad Area in 1978

Variables / Kinds of goods and services	Quantity in metric ton	Price per metric ton-Rials	Value in currency units-Rials
1. Agricultural goods			
- Seed			
Wheat	23.6	16,500	389,400
Barley	19	15,500	295,200
Cotton	1.5	30,000	45,000
Beet	0.73	50,000	36,500
Alfalfa	0.48	200,000	96,000
Onions	0.3	220,000	66,000
	man-days/year	Rials/day	
2. Agricultural Service purchased			
2.1 land clearing and soil preparation	10,030	400	4,012,000
2.2 planting	10,200	400	4,080,000
cultivating	9,053	400	3,621,200
pest and disease control	310	500	155,000
mowing, harvesting & farm transport	13,393	500	6,596,500
	Quantity in metric ton	Price per metric ton-Rials	
3. Non agricultural goods			
3.1 Fertilizer			
Manure	3,210	500	1,505,000
Poultry waste	81	2,000	162,000
Chemical fertilizer	3.2	4,500	14,400

Supporting Table 11.2 Total use of Goods and Services for Annual Crops Production

Variables / Kinds of goods and Services	Quantity	Price per unit Rials	Value in currency unit price Rials
3.2 Fuel, lubricants and other			
Diesel Oil	612,000 lit.	2.5/lit	1,530,000
Motor Oil	6,800 lit.	40/lit	272,000
Grease	680 lit.	120/lit	81,600
4. Non-Agricultural Services purchased			
4.1 Land improvement	20 ha	14000/ha	280,000
4.2 Qanat maintenance			2,970,800
4.3 Irrig.channel construction	1.3 km	1730 70/km	225,000
4.4 Annual cost of initial investment (wells and farm buildings)			2,004,028
4.6 Machinery			
4.6.1 Tractor		9232 6/year	92,326
4.6.2 Threshers		15 900/year	15,900
4.7 Dasht ban (watchman)	3510 m-d/year	250/day	877,500
4.8 Kad Khoda (head man)	10 persons	4860/year	48,600
4.9 Motorban(who has responsibility for care of engines of wells)	4590	400/day	1,836,000
4.10 Instalment of land price		1/15th of tot. land price	1,576,754
4.11 Interest on debts for agricultural operation		4% /year	549,560
Total annual crops production cost			33,762,768

11.1.3 Perennial Crops Income

As we have seen in the Crop Production chapter, the most important perennial crops comprise grapes, pomegranates, and apricots, with smaller amounts of other fruits like apples, figs, plums etc. Fruit produced in the Abuzaid-Abad area is in great demand in Kashan City.

Grapes accounted for about 45.5% of the total perennial crops gross income. The average gross income from grapes per hectare was about 634,000 Rials.

The pomegranate is the most important crop, as this fruit grows widely in the area. According to the 1978 Survey, 46% of the total perennial gross income came from pomegranates. The gross income of this crop was 1,049,400 Rials. The average income per hectare of pomegranate trees was about 60% higher than the average income per hectare of vines.

The income from apricots and other fruits is not significant and most of them are not supplied to the markets. Their gross income is 2.6% and 5.8% respectively of the total perennial crops income. More details of perennial crops production and income are illustrated in Table 11.3

In three villages, Fahkreh, Shahriary and Ali-Abad, because of soil and water quality, there are no fruit trees. The people from these villages often purchase fruit from the other villages and some of them do not eat any fruit all the year round.

However, the total gross income from fruit was about 35,012,350 Rials in the area in 1978. The average gross income per hectare from perennial crops was 683,835 Rials in the Abuzaid-Abad area in 1978 (Fig.11.3).

Table 11.3 Total Production of Peren nial Crop Commodities in the Abuzaid-Abad Area in 1978

Variables / Perennial Crops	Land under perennial crops ha	Quantity in metric tons	Yield ton/ha	Price per ton Rials	Value in currency units Rials	Percent
Grapes	25.13	796.8	31.7	20,000	15,936,000	45.5
Pomegranates	15.37	733.5	47.7	22,000	16,137,000	46
Apricots	5.6	82.8	14.8	11,000	910,800	2.6
Other fruits	5.1	139.9	27.4	14,500	2,028,550	5.8
Total	51.2	175.3	34.2		35,012,350	100

Source : Field Survey, 1978.

FIG 11.3 PRODUCTION OF PERENNIAL CROPS COMMODITIES IN 1978 IN THE ABUZAID ABAD AREA

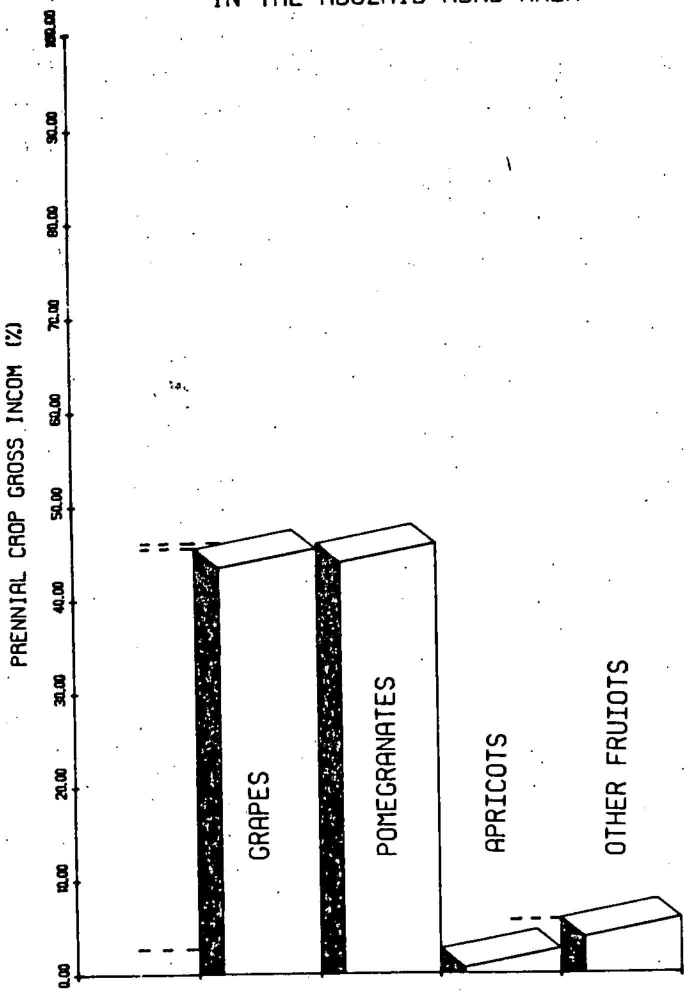
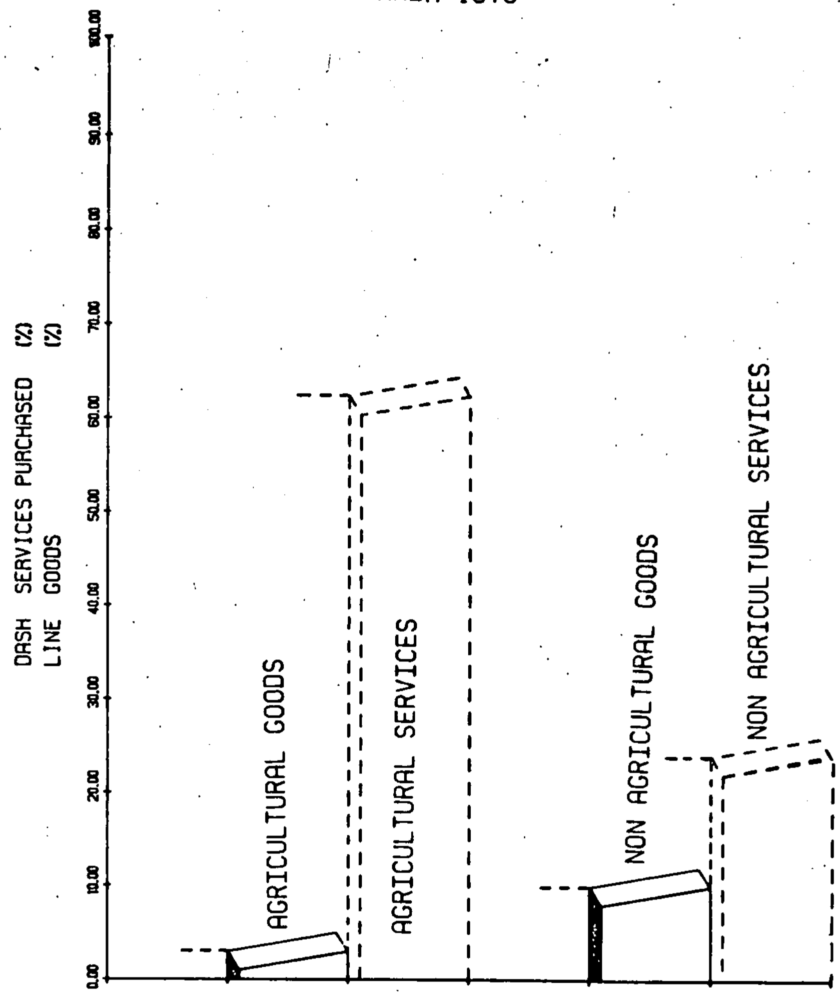


FIG 11.4 TOTAL USE OF GOODS & SERVICES FOR PERENNIAL CROPS PRODUCTION IN THE AREA 1978



11.1.4 Production Cost of the Perennial Crops

The annual production costs of perennial crops can be divided into four parts. Firstly, agricultural goods. About 13,400 seedlings had been planted in 1978. These seedlings were usually bought from the Ravand villagers. The total value was 268,000 Rials, or 3.2% of the total perennial production cost.

Secondly, agricultural services purchased comprise planting, ploughing, weeding, cultivating, mowing, harvesting, farm transport and storage, and preparation for market. The total services have been carried out by 14,215 man-day labour/year. The cost of these services for perennial crops was about 5,686,000 Rials, or 62% of the total perennial crops expenditure. Thirdly, non-agricultural goods - these consist of fertilizers and pesticides at a total price of 919,700 Rials or 10% of the total perennial crop production cost. Fourthly, non-agricultural services purchased. Qanat maintenance is the most important of this kind of service. As we have mentioned before the perennial crops are usually located under qanat irrigation. The share of perennial crops with respect to the proportion of irrigation water which was used for these crops, was 2,224,100 Rials. (Fig.11.4).

However, the total expenditure of perennial crops was 9,097,800 Rials, or 26% of the total perennial gross income in the Abuzaid-Abad area in 1978. More details of production cost has been shown in Table 11.4. However, the net profit of perennial crops was 26,015,550 Rials or 74% of the total perennial crops gross income. This figure in comparison with net profit of annual crops is significant.

Table 11.4 Total use of goods and services for Perennial Crop Production in the Abuzaid-Abad Area

Variables / Kinds of goods and Services	Quantity in metric ton	Price per metric ton - Rials	Value in currency units Rials
1. Agricultural goods			
Seedlings	13,400 trees	20	268,000
2. Agricultural Services purchased			
Planting, ploughing and weeding	5770 M-D/year	400/day	2,308,000
Cultivating	6695 M-D/year	do.	2,678,000
Mowing and harvesting	1750 M-D/year	do.	700,000
3. Non agricultural goods			
3.1 Fertilizer			
Manure	1,395	500	697,000
Poultry waste	45	2,000	90,000
Chemical fertilizer	1.6	4,500	7,200
3.2 Pesticides			
Insecticides			125,000
4. Non agricultural Services purchased			
Qanat maintenance			2,224,100
Total perennial crop production cost			9,097,800

Source : Field Survey

11.2 Income from Livestock

The animals are responsible for a high percentage of agricultural cash income in the Abuzaid-Abad area. As we have seen, animal husbandry has been very important in the area in the past, but more recently as the pastures have been protected by the government, animal raising has decreased considerably.

Animals are kept in all of the villages in the eastern part of the area, where regulations governing the protection of pasture are not so severe, and the income from animal husbandry is therefore higher (Hosain-Abad, Qasem-Abad and Yazdelan).

The highest gross income from livestock is from cattle and dairy products which are sold in the area, or in Kashan City in various forms, e.g. cheese, yoghurt, butter and purified butter. The gross income from cattle was 45,014,000 Rials or 49.9% of the total animals' gross income. The average gross income per head of cattle was 61,747 Rials (milking cow).

The income from goats was second, being 30,132,900 Rials, or 33.8% of the total gross income. The average gross income per head was 1,919 Rials (Fig.11.5).

Sheep contributed 9.7% of the total gross income from livestock, the average income per head being about 2,368 Rials. The total gross income from sheep was 8,749,500 Rials. According to an estimation which was carried out by this author in the area, the average gross income from sheep was about 10% less than the gross income from goats, because of the high expense of sheep raising in the area.

Donkeys do not usually provide cash income because they are used for transport on the farms. Thus donkeys do not contribute anything very much to the cash income.

Camels and poultry provided a gross income of 1.4% and 4.5% respectively of the total gross income from animal husbandry.

However, according to the field survey, which is illustrated in tables 11.5 and 11.5.1, the total gross income from the animals according to the currency price in 1978 in the Abuzaid-Abad area, was 90,697,800 Rials, 58.5% of the total agricultural gross income.

11.2.1 Animals Husbandry Production Cost

The expenditure of animal raising comprises, firstly, goods or animal feed. In the winter the animals are kept in stables, and fed with dry alfalfa, barley and chaff. In the other seasons only goats and sheep go to graze. Even in the dry seasons they are fed at night at the Aghols (open stables).

However, according to the field survey estimate,(3) the price of animal feed was about 34,549,134 Rials or 30% of the total gross income from the livestock. Secondly, the cost of the services which were purchased, or carried out by farmers' themselves, consists of feeding, watering, milking, and general care. The total cost of services purchased, including the farmers' family labour, was about 48,466,080 Rials, or 53% of the total gross income. Table 11.6 shows the total use of goods and services purchased for livestock production in the Abuzaid-Abad area in 1978 (Fig.11.6).

FIG 11.5 PRODUCTION OF LIVESTOCK IN 1978

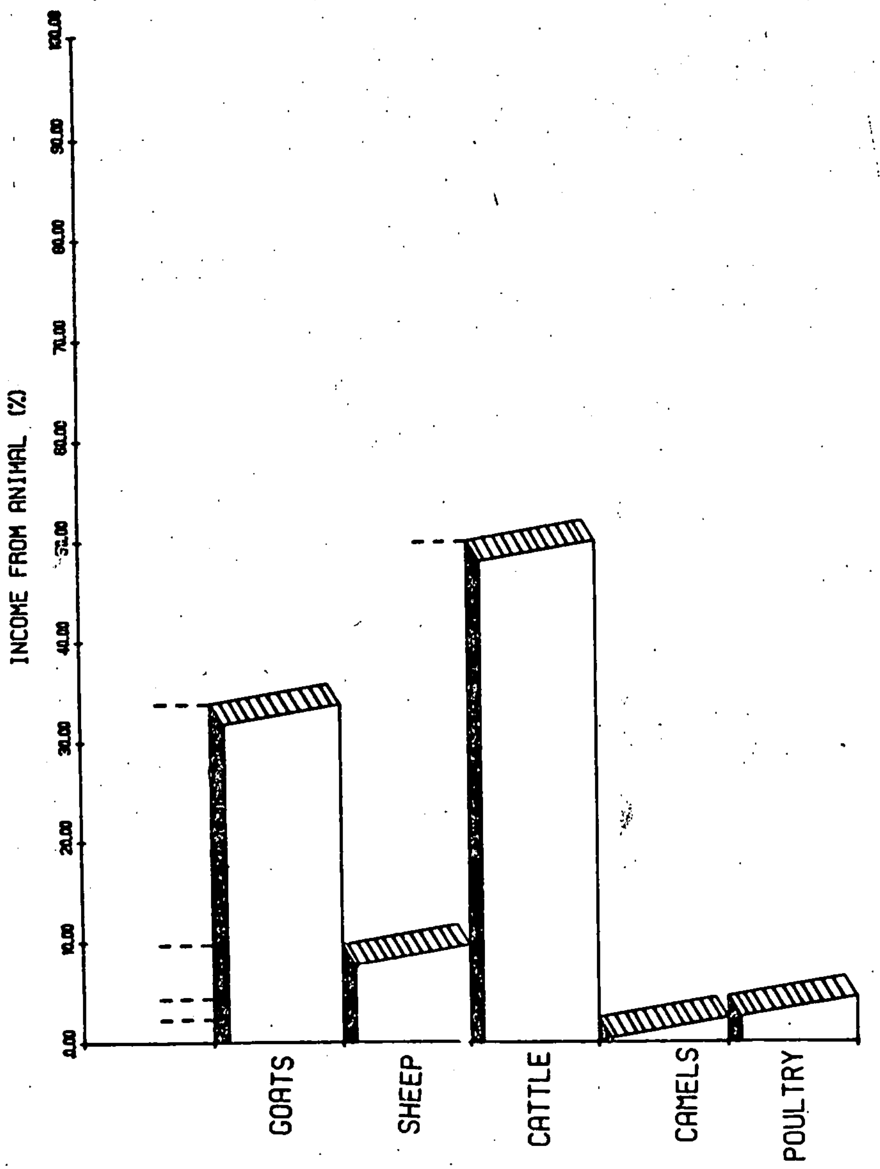


FIG 11.6 TOTAL USE OF GOODS & SERVICES FOR LIVESTOCK IN 1978

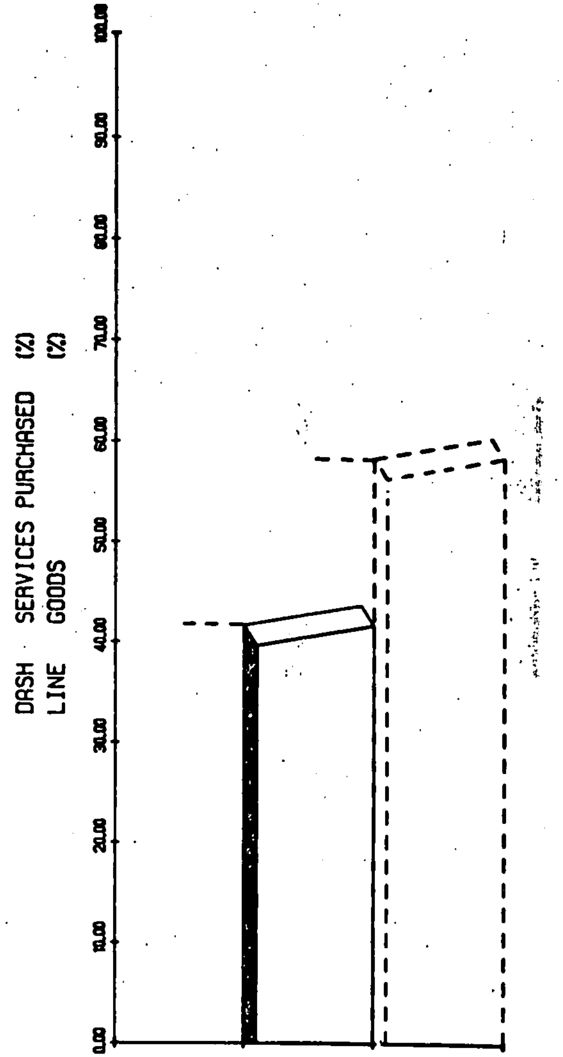


Table 11.5 Total gross income of livestock in the area in 1978

Animals	No. of Animals	Value in currency units Rials	%
Goats	15,701	30,132,900	33.8
Sheep	3,695	9,724,900	9.7
Cattle	729	45,014,000	49.9
Donkeys	614	480,000	0.5
Camels	372	1,266,000	1.4
Poultry	7,058	4,080,000	4.5
Total of percentage		90,697,800	100

Source : Field Survey

Table 11.5.1 Total Production of Livestock commodities in The Abuzaid-Abad Area in 1978

Variables / Goods Production	No. of animals	Quantity in metric ton	Price per metric ton Rials	Value in currency units Rials
Milk cows	583	1,314	30,000	39,420,000
Milk, goats and sheep	14,358	783	30,000	23,490,000
Sheep wool	3,695	3.5	250,000	875,000
Goat hair	15,701	7.8	150,000	1,170,000
Camel hair	372	0.75	200,000	150,000
Manure	20,739	4,210	500	2,105,000
Hen eggs	3,500	102	40,000	4,080,000
Veal	503	503 head	1000/head	5,030,000
Lamb	2,586	2586 head	1300/head	3,361,800
Kids	11,775	11775 head	800/head	9,420,000
Camel baby	93	93 head	12000/head	1,116,000
Foals	320	320 head	1500/head	480,000
Total				90,697,800

Source : Field Survey

Table 11.6 Cost of goods and services for Livestock Production in the Abuzaid-Abad Area in 1978

Cost / Kind of goods & Services	Value in currency units Rials
1. Goods	
1.1 Animal food	34,549,134
2. Services purchased	
2.1 Rearing, feeding, watering milking, indoor and out-of doors care	48,465,080
Total livestock production cost	83,015,214

However, the total animal production cost was 83,015,214 Rials or 91.5% of the total selling price. The total net income from animal husbandry, including wages and net profit, was about 62% of the total gross income in 1978.

11.3 Income from carpet weaving

11.3.1 Production Costs

Expenditure on carpets is divided into two basic parts - labour force and materials.

1. Details of the labour force are shown in Table 11.7. According to this table, one square metre of the Abuzaid-Abad area carpet is woven in 80.5 days by one skilled weaver. From the information in Table 11.7, the average daily wage of a weaver is about 207.9 Rials. This table shows in more detail the specification of a weaver's wages in the area in 1978.

The wage of a weaver, per hour, ranges between 20 Rials and 28 Rials in Kaqazi and Abuzaid-Abad respectively. The average wage of a weaver per hour, according to the total wages and total man hours per year, was about 26 Rials in the Abuzaid-Abad area in 1978.(4)

2. Materials. The materials which are used in carpet making are wool, silk, warp, weft thread, design cost and instruments. On average, for weaving a qali of 5.94 m^2 in the Abuzaid-Abad area, the following materials are used :

(a) Wool - 22 kg., of wool yarn of high quality, which is called kork, at 1,000 Rials per kg., or of second class quality rang, at 850 Rials per kg., in 1978. The contractor, or weaver,

Table 11.7 Specification of weavers' Wages in the Abuzaid-Abad Area in 1978

Villages / Variables	1 Fakhreh	2 Shahriary	3 Rijen	4 Ali-Abad	5 Mohamad-Abad	6 Abuzaid-Abad	7 Kaghazi	8 Yazdelan	9 Qasem-Abad	10 Hosain-Abad	Total & Average Rials
Total wages of weavers in each village/year (Rials)	4,313,973	673,400	6,313,131	8,943,602	14,267,676	53,661,616	11,090067	2,567,340	6,355,218	18,771,043	126,957,078
Total annual man-day/year	21,912	3,168	30,096	40,128	68,904	240,240	67,056	14,520	31,680	93,984	610,632
Total annual man-hours/year	175,296	25,344	246,768	321,024	551,232	1,921,920	536,448	116,160	253,440	751,872	4,885,056
Average wage per weaver, per day (Rials)	196.8	212.5	210	22.8	207	223.3	165	176.8	200.6	199	207.9
Average wage per weaver, per hour (Rials)	24.6	26.5	26.2	27.8	25.8	28	20.6	22.0	25.0	25	25.9

Source : Tables 10.2 & 11.9.

often chooses only one kind of yarn for a carpet; they do not use a mixture.

(b) Pud cotton thread with fifteen or less twisted strands is used (weft). The carpets of this area are woven with double weft, one of which is very thin. For a qali from this area, 4.5 kg., thick and 1.5 kg., thin wefts are used. The first class price for both of them was 300 Rials, and for the second class 250 Rials.

(c) Cheleah cotton thread with 8 or less very well twisted strands is used for warp. The price of cheleah is the same as that of the weft. For a standard Abuzaid-Abad carpet, 4.5 kg., of warp is used.

(d) Silk. As noted previously, in some of the carpets, the animals or flowers are worked in silk. Silk is frequently used as a basic material in Mohamad-Abad, Abuzaid-Abad and Hosain-Abad villages. For producing a qali with a mixture of silk and kork, 1.5 kg., of silk at 3600 Rials per kg., is used.

(e) Design. For weaving a hunting design, six sheets of design are used, and for a symmetric design, 3.5 sheets are used. The price of each sheet is about 1,000 Rials. A design is usually used for two or three carpets.

(f) Warp laying. The warp is laid by the cheleah-davan (warp layer) and the action of warp laying is called cheleah-davani. A cheleah-davani is a skilled worker, and is paid 500 Rials per day. For a standard carpet of the Abuzaid-Abad area, it takes 1.5 days to lay the warp.

(g) Miscellaneous Expenditure. There are some miscellaneous expenditures for carpet making, e.g. preparing the loom, the frame for design etc. on average for a carpet, about 550 Rials can be estimated. (Fig. 11.7)

However, the total expenditure for weaving the standard carpet of the Abuzaid-Abad area (5.94 m^2) with first class materials (without silk) from a symmetrical design, and quality 80/40 (5), giving attention to the price of materials for a qali in Kashan's market in 1978, was as follows:

Materials	Quantity in kg.	Price per kg. Rials	Value in currency units Rials
Wool	22	1,000	22,000
Weft	6	300	18,000
Warp	4.5	300	1,350
Design	3.5 sheets	1,000/sheet	3,500
warp laying	1.5 days	500/day	750
Miscellaneous	-	550	550
Total			29,950

This means one square metre of expenditure was about 5,050 Rials. The expenditure on carpet production has been calculated by using the questionnaires connected with the survey in the area in 1978, and it is shown in Table 11.8.

Table 11.8

Specification of carpet materials in the Abuzaid-Abad Area in 1978

Village	Production m^2	Wool					Weft					Warp					Silk		Design Val. Rials	Services		Total Expenditure
		First Class		Second Class		Total Rials	First Class		Second Class		Total Rials	First Class		Second Class		Total Rials	Q	V		Warp Laying Rials	Others Rials	
		Q	V	Q	V		Q	V	Q	V		Q	V	Q	V							
Fakhreh	205	222	222	703	597	819	60	21	155	46	68	46	159	144	43	59	-	-	94	27	121	1,079
Shahriary	32	118	118	-	-	118	32	11	-	-	11	24	8	-	-	8	-	-	11	3	1	152
Rijen	300	333	333	777	660	993	90	31	210	63	94	68	24	159	48	71	-	-	108	31	14	1,313
Ali-Abad	425	688	688	906	770	1,458	180	63	245	73	136	137	48	245	7	55	-	-	143	41	18	1,838
Mohamad-Abad	678	1,776	1,776	732	622	2,398	480	168	198	59	227	365	128	148	44	172	15.1	54	245	69	32	3,129
Abuzaid-Abad	2,550	6,660	6,660	2,775	2,358	9,018	1,800	630	750	225	855	1,350	473	575	199	672	126.2	454	861	246	113	12,220
Kaghazi	527	1,776	1,776	174	148	1,923	480	168	147	44	212	364	126	112	33	159	30.3	109	248	72	33	2,756
Yazdelan	122	-	-	451	384	383	-	-	122	37	36	93	32	-	-	32	-	-	42	14	7	522
Qasem-Abad	302	444	444	673	572	1,016	120	42	182	55	97	91	32	138	41	73	-	-	105	30	14	1,335
Hosain-Abad	892	933	932	2,368	2,014	1,476	252	88	640	192	280	189	66	640	192	258	29.9	107	245	69	32	3,940
Total	6,033	12,951	12,951	9,560	8,126	19,607	3,494	1,222	2,649	975	2,016	2,728	954	2,068	618	156	201.5	726	2,110	603	278	28,284

Q = Qantity in Kilograms. V = Value in currency units, in 1000 Rials.
Source : Field Survey (1978)

11.3.2 Income from Carpet Weaving

According to my investigation, in the Abuzaid-Abad area in 1978, about 6,033 m^2 carpet were produced (Table 10.3). At that date the price of a joft (one pair) of the Abuzaid-Abad area carpets was, on average, 177,000 Rials. Often the size of a carpet of this price is 208 x 143 cms., or 32 x 22 Gareh, and the quality is often 80/40 knots. In other words the price of one square metre was about 29,798 Rials. So the total selling price or gross income, was 179,771,200 Rials in 1978 (Table 11.9). The total expenditure on this production was about 155,241,000 Rials (Tables 11.7 and 11.8).

Therefore the weavers' net income from carpet making was about 148,493,510 Rials; this includes wages and profit, but excludes the contractors' profits.

The total average gross income can be broken down into about 16% on materials, 70% on wages, 1.6% on contractors' benefits and 12.4% on private weavers' benefit.

The net income from carpet weaving in the area equals the net benefit plus the wages, because the weavers do not pay any taxes etc. Hence the net benefits and wages came directly to the families, and it is about 82.2% of the selling price. The net income has been shown in three types as follows:

(a) The number of looms is the case of this type. The average net income for one loom in 1978 (in one year) was 118, 605 Rials. The range of net income per loom lay between 159,104 Rials and 88,688 Rials in the Hosain-Abad and Kaghazi villages respectively. The Hosain-Abad carpet is of the best quality, and carpet weaving in this village is taken very seriously. This is because the village is located on the edge of Dasht-e-Kawir and therefore, agricultural activity is not important when compared with carpet production. In the villages of Hosain-Abad and Kaghazi, the ratio of weavers to looms is 356/139 and 254/143 respectively - in other words on average, 2.6 weavers are engaged per loom in Hosain-Abad, but an average of 1.7 weavers are engaged per loom in Kaghazi. Therefore, the rate of income for each loom is high in Hosain-Abad villages.

(b) The average net income per family (for the whole of the population) was about 107,682 Rials, because about 91% of the families were involved in carpet weaving. The range of net incomes lay between 81,297 Rials and 120,192 Rials in Kaghazi and Abuzaid-Abad respectively.

The total production per family is the main cause of this differentiation, because carpet production, on average, in the villages of Abuzaid-Abad and Kaghazi, was 4.8 m^2 and 3.3 m^2/year, per family respectively, and the average for the whole area was about 4.3 m^2/year per household.

There was, however, high production per family at 5.3 m^2 in Shahriary village, but the Shahriary weavers were under contract. Average benefit for contractors was about 20,736 Rials per loom per year, which caused a decrease in income per household in this village. Therefore, the net income in the area is 107,682 Rials per year, per household.

(c) The average per capita net income from carpet weaving was about 19,704 Rials/year , with a range of 23,602 Rials and 16,074 Rials in Ali-Abad and Kaqazi villages respectively.

The average size of family in Ali-Abad is 4.7 persons (see the Chapter on Population). This point is the main reason for the high personal net income in this village, because the average size of family for the area was 5.5 and for Kaqazi village it was 5 persons.

Figures 11.8 and 11.9 show the distribution of carpet income in the area.

Table 11.9

Specification of Carpet Income in the Abuzaid-Abad Area in 1978

1000 Rials

No. of villages	Village	Expenditure (E) Rials			Selling Price (S) Rials	Profit (P) P = S - E Rials	Contractors' Profit (c) Rials	Net Profit (n) n = p-c	Net income (N) N = n+w	Net income per loom Rials	Net income per family Rials	Net income per capita Rials
		Materials (m) Rials	Wages (w) Rials	Total Expenditure E = m + w								
1	Fakhreh	1,079	4,313	5,393	6,108	714	35	679	4,993	99	92	19
2	Shahriary	152	673	825	953	127	127	-	673	112	112	17
3	Rijen	1,313	6,313	7,626	8,939	1,312	385	927	7,240	116	103	19
4	Ali-Abad	1,838	8,943	10,782	12,664	1,883	322	1,559	10,503	128	111	23
5	Mohamad-Abad	3,129	14,267	17,397	20,203	2,806	376	2,430	16,697	120	111	22
6	Abuzaid-Abad	12,220	53,661	65,882	75,984	10,102	783	9,319	62,980	128	120	19
7	Kaghazi	2,756	11,090	13,846	15,703	1,856	264	1,592	12,682	88	81	16
8	Yazdelan	522	2,567	3,089	3,635	545	53	491	3,059	105	95	17
9	Qasem-Abad	1,335	6,355	7,690	8,998	1,308	214	1,097	7,452	122	108	21
10	Hosain-Abad	3,940	18,771	22,711	26,579	3,868	523	3,344	22,115	159	105	18
	Total & Av.	28,284 T	126,957 T	155,241 T	179,771 T	25,925 T	2,986 T	24,529	148,493 T	118 A	107 A	19 A

A Average T Total

Source : Field Survey.

FIG 11.7 TOTAL USE OF GOODS & SERVICES FOR CARPET WEAVING IN 1978

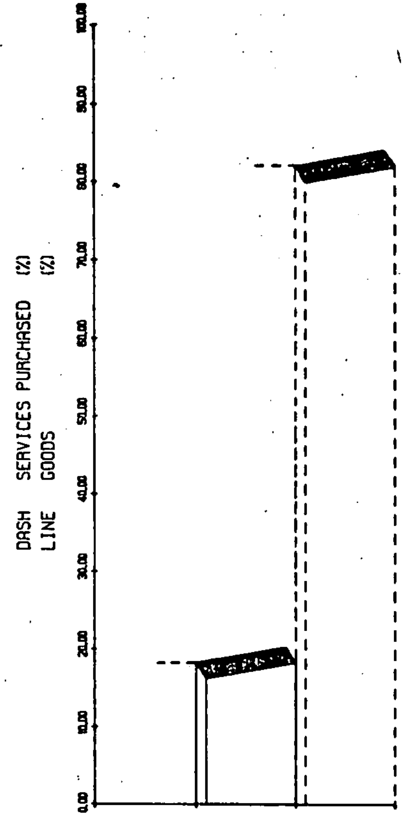


FIG 11.8 DISTRIBUTION OF CARPET INCOME IN THE ABUZAID-ABAD AREA (1978)

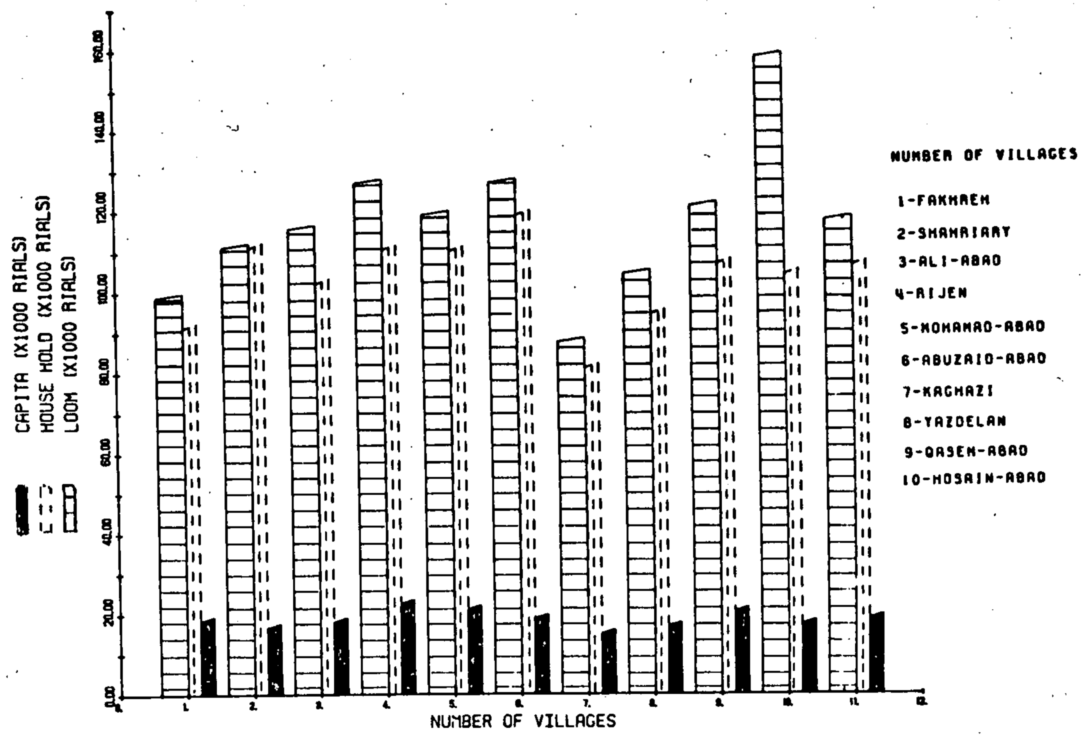
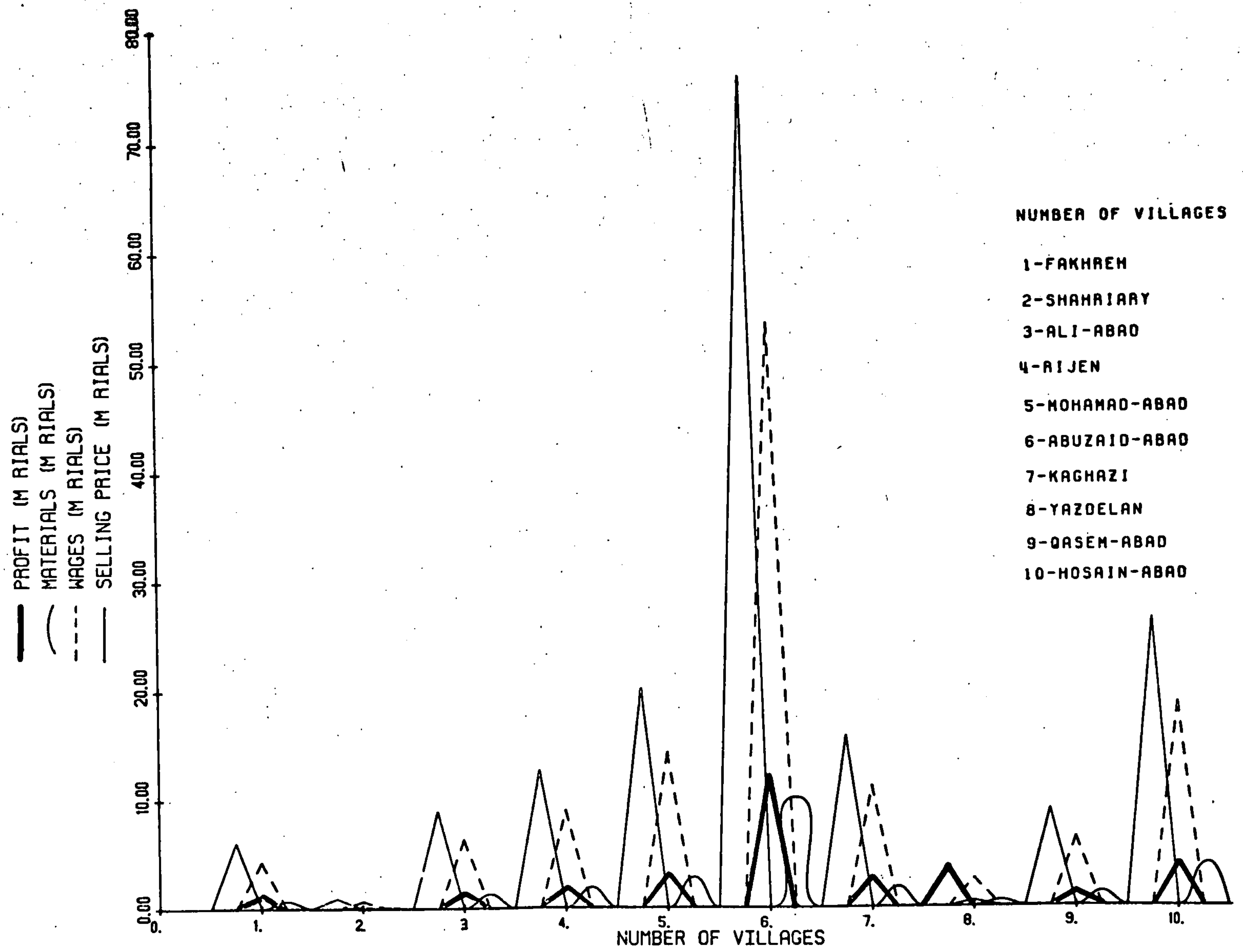


FIG 11.9 SPECIFITION OF CARPET INCOME IN THE ABUZAID-ABAD AREA (1978)



11.4 Marketing

Marketing in the Abuzaid-Abad area includes both agricultural marketing and carpet marketing. The local market has not developed because of the small volume of production and the nearness of the Kashan market. The market for the area is limited to a few shops located in the different village areas, which usually sell the consumer goods. The farmers rarely sell any agricultural produce to the local shopkeepers. Also the residents of the area do not usually buy all their consumer goods from the local shops, because the price of goods is high and good quality commodities are not stocked. The residents usually prefer to buy their consumer goods from the Kashan market. So, in general, the market, and marketing system in the Abuzaid-Abad area, have remained relatively undeveloped. The main reason for this lack of development is the proximity of the area to Kashan City.

In the Abuzaid-Abad area, unlike in most Iranian villages, agricultural produce is not exchanged for consumer goods, but the transactions are often carried out with cash in the local shops. The farmers' production for the markets comprises firstly agricultural commodities, and secondly carpets.

11.4.1 Crops Produce

The agricultural commodities consist of fruit and industrial crops -

a. Industrial crops such as cotton, opium and tobacco, the major part of which are sold at the farmgate. Cotton is usually sold to purchasers who come to the area specially to buy it, at source, of course very cheaply. The opium and tobacco which are controlled by a monopoly are sold to the government by the farmers.

b. Grain is not usually sold in the market because of the low value of production. The majority of farmers sell their surplus wheat and barley to other farmers.

c. Fruit, as we have seen i.e. grapes and pomegranates, is the most important fruits supplied to the market. The grapes in the area ripen very early, because of the climatic conditions, when the selling price is high and there is a great demand for the grapes in the market.

The farmers usually pick and pack the grapes in the evenings. The packed grapes are sent to the Barforushy (the shop of fruit trade) at night when the weather is cool. In the early morning, between 4 - 5.0 a.m., the fresh grapes are supplied to the purchasers by the Barforush(8) - a simple efficient system, but financially unattractive to the producer because of the high commission and handling charges.

In contrast to other parts of Iran, grapes in the Abuzaid-Abad area are merely supplied fresh to the markets. Production of raisins and juice is very rare in the area.

The pomegranate, unlike the grape, is stored for the early winter market. The farmers of the area are skilled in keeping pomegranates in storage. The pomegranate, like the grape, is sent to the Barforushy. If the farmers do not need the money they try to keep it in storage for a long time in order to supply the market when the price is high.

11.4.2 Animal produce

Dairy produce is sold to the shop keepers or the other residents of the area. Sometimes the producers prefer to make purified butter, because they can keep it under normal conditions for a long time. Wool and goats' hair are usually sold to the local merchants,or to purchasers who come to the area. The fattened animals (goats, sheep and cattle) are usually sold in the area. Some dealers buy the animals and when they have between 50 and 70,they send them by lorry to the Tehran meat market. The animals are weighed alive, 50% of the total weight being accounted as the pure meat. They are sold according to the day's price. The production cost is increased by the use of the lorry and the need to feed the animals for 24-48 hours out of doors.

11.4.3 Carpet Market

Carpet selling does not follow a regular method, and carpets are sold in various ways in the area. The more important ways are as follows :

(a) Farsh Forush. There is a big Bazar-e-Farsh (carpet market) in Kashan City. It is one of the most important carpet markets in Iran. In this bazaar there are many Farsh-Farushies (carpet shops) which accept the carpets from the weavers for selling. The Abuzaid-Abad weavers send their carpets to one of these shops whose owners they know and trust. The carpet usually remains there for a few months (maximum 3 months) until it is sold at the owner's suggested price. The customers of these shops are usually the carpet merchants from Tehran, who buy the carpets for export. Also there are some middlemen involved in the buying and selling of carpets at first hand. Householders usually buy the carpet from a middleman or sometimes they attempt to buy directly from Farsh-Farushi.

Then the carpet is sold by the Farsh-Farush , who informs the weaver and pays the carpet price. The commission is 5% of the selling price, which is paid by the owner in cash. Sometimes the owner agrees to receive the carpet price within three months (91 days), when the carpet is sold to a carpet merchant, or in about one year instalments, when the carpet is sold to a householder. In these conditions 10-15% of the selling price is added to the carpet price as interest. Some of the religious people do not expect to receive the interest, because according to Islamic law "interest is Haram" (illegal). In this situation the carpet price is paid in cash by the Farsh-Forush, and he expects to receive the money in 91 days from the carpet merchant, or in instalments from the householder. So the Farsh-Forush can receive about 15-20% of the total carpet price.

(b) Sar-e-Dar Forushi Some carpets are sold before they are finished. Customers in this kind of transaction are usually middlemen or some of the Farsh Forushes. Often they buy the carpet in cash, measuring the carpet by Zār (106 cm). Later, in the market, the carpet is measured by metre (100 cm).

(c) Local market. Local carpet markets have not developed, although there are a few carpet merchants and middlemen involved in carpet buying and selling. The weavers usually prefer to take their carpets to Bazar-e-Kashan. Very few of the weavers sell their carpets to a local merchant. Fig.11.10 shows the system of marketing in the area.

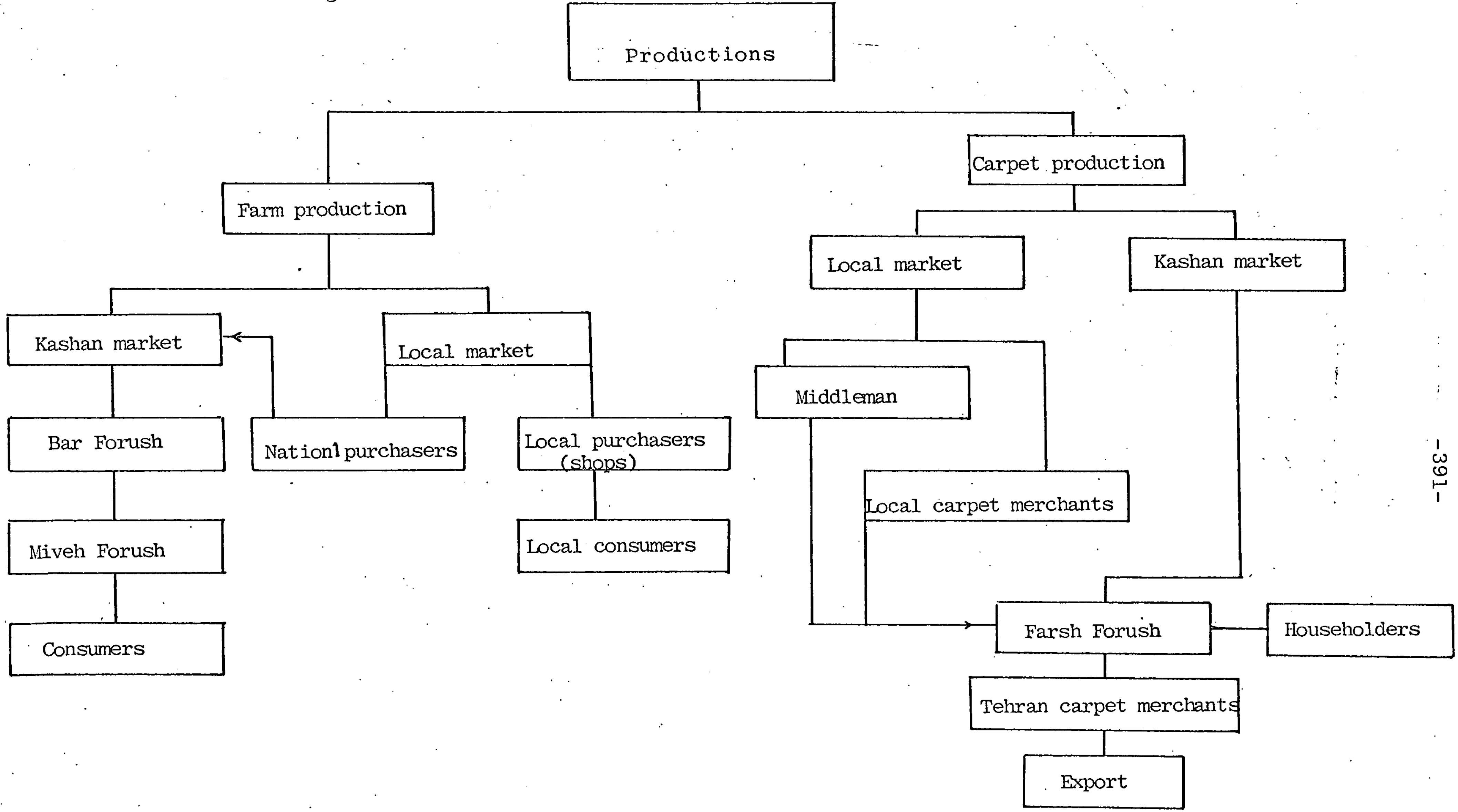
11. 5 Conclusion

Agricultural activities and carpet weaving are the main source of income in the region. There are other sources of income for the people, e.g.government financial assistance, factory or building work and social services etc. but the amounts involved are not considerable. Only 10 people received financial assistance from the government and the number of workers who go to the cities for temporary work is not large, according to an estimate made in 1978. The total number of workers who went in 1978 and worked for part of the year in Kashan, Tehran and other cities was about 250. According to interviews with some of them, the workers' average net income which was brought to the area, was 200 Rials/day. They usually stayed for a maximum of 4-5 months in the cities. Thus we can estimate that approximately 6,750,000 Rials net income was brought into the area by this group. Of the other groups of workers in the social services, agricultural and carpet services, the majority received their wages from within the local rural economy. The total gross income from agricultural activities and carpet weaving was 334,762,120 Rials, of which 46.3% came from agricultural activities and 53.7% from carpet weaving.

The total gross income from agricultural activities can be broken down as 8.7% from annual crops, 10.4% from perennial crops and 27.2% from livestock.

It should be noted that in this study the total net income was accounted as the net profit, plus wages, because

Fig. 11.10 Marketing System in the Abuzaid-Abad area



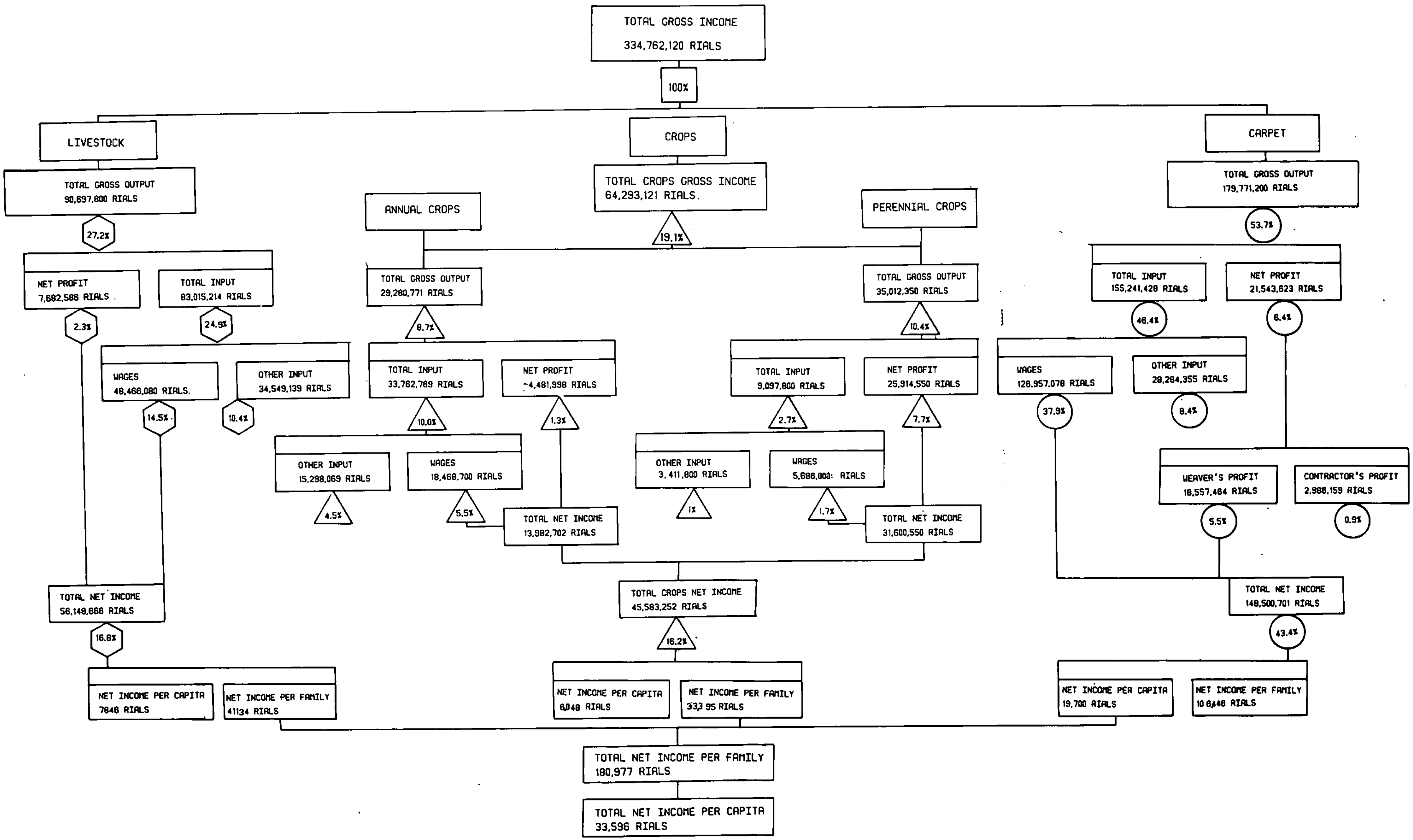
wages often come back to the farmers or weavers themselves.

Thus the per capita net income of the crops production at 6048 Rials was about 81% of the net income from animal husbandry and the per capita net income of agricultural production of 13500 Rials, was about 40% of the carpet weaving net income.

However, the per capita net income in the region from agriculture, carpet weaving and other sources was about 34,100 Rials (£227) according to current prices in 1978. This was only 21.8% of the national per capita income in 1978.[9]

The data from the previous sections have been assessed and the result is illustrated in Figure 11.11.

FIG 11.11 SPECIFICATION OF RURAL ECONOMY IN THE ABUZAID ABAD AREA (1978)



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2. Who have responsibility for care of well's engine.

3. The total income of livestock and the cost of production have been estimated by measuring of income and expenditure of a certain number of varieties of animals in the area. The total number of animals have been known by the questionnaires. It should be noted that the income and expenditure of each variety of animals, approximately are the same in the area.

4. The total wages was 126,956,000 Rials, and the total man-hour per year was 4,885,056.

5. 80 warp strands and 40 knots every 6.5 cm. or about 15 x 15 knots per square inch.

6. See the Population Chapter.

7. See the section 11.2.

8. Middleman of fruit trade.

9. Pars Oil Company (1978) Iran Almanac and book of facts 1978 Seventeenth edition. Echo of Iran, Tehran, p.19.

CHAPTER 12

CONCLUSION

12.1 Introduction

In the previous chapters it has been shown that many traditional villages in the margin of Dasht-e-Kawir were swept away, together with existing cultivated areas and the farming practices which sustained them in a harsh physical environment. Whenever a source of water has appeared, people have gathered around it. In the north west of Dasht-e-Kawir, the basins of Jajrud (Jaj river) and Karaj river, the villages have developed by using river discharge rather than underground water. Close proximity to the Tehran market has been a key factor in the agricultural development of these areas. In the rest of the Dasht-e-Kawir's margin, because of physical conditions, long distances to urban areas, scattered settlements, and little government attention, the villages have remained unchanged and many have been deserted. The residents have migrated to urban areas or to other villages. On the other hand, the socio-economic condition of Iran itself led to rural desertion.

During the 1970's Iran's economy became increasingly dependent on oil. Increasing oil income after 1973 had a deep impact on the nature of economic development and not least on the agricultural progress in Iran, in general, and on the margin of Dasht-e-Kawir in particular.

At the same time the government organized a large number of new projects. But the direct impact of the economic boom was inflation in prices and a rapid growth in levels of wages.

A large number of rural people in the whole of Iran and particularly in less developed agricultural areas like the margin of Dasht-e-Kawir had been attracted to the cities. The high rate of migration had caused the reduction of rural population and desertion of villages (see the Introductory chapter in the case of Goud-e-Jigarh). Of course this situation has occurred mostly in those villages where severity of conditions affected agricultural activities. The condition itself has helped the expansion of the desert. In fact the best protection against desert expansion is provided by the marginal residents of the deset if they have been properly education to use vegetation economically as grazing or for other purposes (Chapter Three).

Accelerating inflation in prices had a direct influence on the carpet prices. As carpet prices increased more rapidly than those for agricultural commodities, carpet making became more profitable than farming. In some areas where carpet weaving was common, e.g. Abuzaid-Abad area, Biabanak, etc.the villagers therefore became interested in increasing carpet production.

Although the increase in oil revenues had no direct impact on the villagers' income in this area, the increase in carpet prices has indirectly changed the condition of the rural economy in some parts of the region. The result of the increase in income in the area has sometimes led to hasty investments in unsuitable agricultural activities.

By increasing income from carpet weaving, the farmers have been able to invest in agricultural activities, mostly in the case of water supply, by digging shallow and deep wells. However by construction of deep wells in unsuitable places and digging shallow wells without any planning and study, a number of farmers have been involved in uneconomical agricultural activities. For example, in the case of the Abuzaid-Abad area, all of the shallow wells (excluding the Sarafrazieh shallow well, which is a qanat-e-motory) cannot operate on full capacity for 24 hours per day and the water discharged from these wells is saline and is unsuitable for irrigation purposes.

However, all these problems have resulted from the imprudence of farmers and carelessness on the part of the government. Well construction is a new phenomenon in the region and the people have no formal experience and knowledge about it. Moreover, the shortage of spare parts of different types of pumps and engines is another critical problem.

Therefore, improving the farming system in irrigated areas is not only a matter of supplying irrigation water, but also requires a full knowledge of other factors such as : (a) increasing knowledge of taking care of water resources, (b) regulation of water for irrigation, (c) water requirements for each crop (d) providing and maintaining good drainage systems and (e) using the irrigation water for soil improvement.

12.2 Rural Economy

The interwoven series of environmental conditions, social, economic and technical factors have an impact on the rural economy of the area. The rural income in Iran in general and in the margin of Dasht-e-Kawir, in particular comprises of the income from cultivation, livestock farming, craft industries and remittances from villagers working in urban areas. In the past agriculture had been the major source of rural income in the whole of the region, and in some parts it still plays a major role.

Agricultural activity has been investigated in three sections in this study : annual crops, perennial crops and livestock. The income from annual crops is insignificant in the region. Only 8.7% of the total gross income resulted from annual crops. Taking into account the wages and other inputs, annual crops caused a loss of about 1.3% of the total gross income in the area. This condition has arisen from severe environmental conditions, and technical factors involved in cultivation. In the whole of the region the methods of cultivation, e.g. ploughing, sowing, irrigation, fertilization and harvesting have remained unchanged. The farmers have not been educated about the use of the new agricultural techniques at all, and so the traditional methods of agriculture with very little modification are dominant in the area. The increase of the farmers' income from carpet weaving has resulted in some investment in agriculture. In most cases attention has been paid to the construction of wells and, as mentioned earlier, there are many failures. On the other hand, the small size of plots does not allow the use of agricultural machinery, and a large number of underemployed farmers is another reason for not using machinery in agriculture. In the Abuzaid-Abad area, unlike the other rural areas of Iran, animals are not used for ploughing and sowing. All agricultural activities are undertaken by simple hand-tools. In the sectors of irrigation, fertilization and pesticide spraying, the traditional methods are applied.

On the other hand perennial crop production in the Abuzaid-Abad area is more important than annual crops. There are three main reasons for this :

(a) expenditures on farm inputs for perennial crops are much lower than for annual crops; profit from perennial crops are therefore higher.

(b) The fruits ripen (especially grapes) in the Abuzaid-Abad area sooner than in other areas in the Kashan region. Therefore, fruit is supplied to the Kashan market while the market is not saturated and the price is high.

(c) The Abuzaid-Abad farmers, unlike those in other parts of the Dasht-e-Kawir's margin are skilful in gardening.

However, total perennial crop net income, taking into account wages which are a return to the farmer, is about 16.2% of the total gross income.

Livestock, the other sector of agriculture, has been limited since 1974, owing to the protection of grazing land in order to prevent desert expansion. About 17,860 ha. or 25.8% of the total area has been protected by the government, and no grazing is allowed in the protected (Qoroq) land. The residents have been upset because of the limitation of grazing land on the one hand, and by the high penalties imposed for disobeying Government regulations on the other.

Therefore, animal husbandry, which has always been the most important source of income in the past, today does not play an important role in the rural income in the area. Cattle for the whole of the year, and sheep and goats for about seven months of the year, are kept in the stables being fed with dried alfalfa, barley and straw. So, bearing in mind the high price of forage, and accounting for wages, profit is insignificant. Thus, the raising of goats and sheep which was the main source of rural income has decreased considerably.Instead cattle keeping, that was uncommon in the area, has increased. Therefore, the total gross income from cattle has reached about 50% of the total livestock gross income. The total net income from livestock was about 16.8% of the total net income in the Abuzaid-Abad area in 1978.

However, the total agricultural income, including animal crops, perennial crops and livestock was under 50% of the total rural gross income in the Abuzaid-Abad area in 1978. The rest of the rural income came from carpet weaving.

Some money is brought into the area by the migrant workers who worked for part of the year in the urban areas. However, it is difficult to calculate the volume of these remittances with any great accuracy but estimates suggest that they represent only a small fraction of income from agriculture and carpet weaving.

Carpet weaving is a very important occupation in the west, south and south east of the Dasht-e-Kawir, but it has not developed in the northern part of the region. For example, the Sar-Kawir area is one of the poorest regions in Iran because of the environmental severity and the lack of carpet weaving, although recently carpet weaving has been started at Trud by the Na'ien carpet merchants.

However, in 1978 in the Abuzaid-Abad area over 50% of the total gross income was from carpet making. This income has been produced mainly by the females as the males make only a small contribution to this output, i.e. the preparation of materials and sales are the duties of men.

The increase in the carpet production has resulted from prevailing suitable conditions in the area, e.g. skilfulness of weavers, the encouragement of carpet merchants and contractors in the past, the demand for those particular carpets in the markets and the limited agricultural income and activities. These factors have contributed to the production of the carpets as much as the high quality of the products.

The increase in the carpet income has directly affected the agricultural activities. Recently, by increasing the villagers' income in the area, sheep and goat fattening as a new occupation has been created. As mentioned in Chapter 4 because of the prohibition of grazing land, animal raising has been restricted. Therefore, many villagers prefer to fatten the sheep and goats for about two or three months during winter. This profitable job needs an initial investment for buying animals and forage, and in many cases it is created by income from carpet weaving.

12.3 Some preliminary thoughts and ideas about spatial aspects of development strategies for rural areas in the margin of Dasht-e-Kawir

As discussed in the previous chapters the rural area in the margin of Dasht-e-Kawir displays interwoven series of environmental, social, economic and technical problems. The solution for these problems in the short-term poses difficulties and in some cases these problems appear insoluble. Also the problems cannot be reduced by solving one or two aspects alone. Thus there must be an interwoven aggregate of solutions to the problems. On the other hand, the density of problems in the margin of Dasht-e-Kawir change from area to area and even from village to village.

Therefore, it is not logical to give the same prescription for these problems. The best way to solve the problems is to investigate the difficulties in each area, even in each village. This is possible by using the opinions of specialists who have made direct observations and completed field research. Any project in the short or long-term should be chosen according to the needs of the villages.

The conditions in the margin of the Dasht-e-Kawir are not suitable for any large projects, e.g. agro-industrial or farm-corporations because experience has shown that the farm corporations in the north west of the Dasht-e-Kawir have not been successful in increasing agricultural output. So agricultural development should be carried out by giving training, capital and credit to the resident farmers in order that they can adapt them to the severe environmental conditions.

However, with regard to organization of agricultural development and social welfare services the following aspects are suggested :

1. <u>Control of desert expansion</u>

   a. The establishment of artificial forests in the most suitable places*

   b. The use of grazing lands, only with respect to their capacity for forage.

   c. The establishment of wind breaks.

   d. The prevention of deserted villages by encouraging the villagers to remain at home.

2. <u>Water supply</u>

   a. The maintenance of operated qanats and revitalization of dried up qanats if they are economical.

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* Artificial forests have been planted in the cultivated land (wrong place) in the Abuzaid-Abad area (Chapter 3).

b. The construction of deep wells, with respect to the underground water quality and quantity.

c. The establishment of a small dam in a suitable area for the conservation of runnoff for irrigation in the dry season, or for using dam qanats.

d. The prevention of well construction in unsuitable areas.

3. <u>Land utilization</u>

a. The reclamation of lands which have been covered by sand and sand dunes.

b. The establishment of drainage channels for the prevention of salt pans.

c. The use of chemical fertilizers and manure to increase soil productivity.

d. The greater awareness of crop rotation.

4. <u>The establishment and development of rural cooperatives</u>

a. The preparation of materials for agriculture, craft, industry and villagers' consumption.

b. The provision of credit on a short-term or long-term basis in order to prevent financial difficulties and to assist agricultural or industrial development.

c. The elimination of the role of middlemen in order to reduce the gap between the producer's selling price and the purchaser's buying price.

5. <u>The development of craft industries</u>

   a. The supervision of carpet weavers, together with the provision of advice as to the best method for weaving and design according to market demand.

   b. The provision of training in carpet weaving in those areas where carpet weaving is not common.

   c. The elimination of the role of contractors by supplying short term capital loans to the weavers.

6. <u>Communications</u>

   a. The construction of roads.

   b. The establishment and development of post offices and the construction of telephone connections between the rural and the urban areas.

7. <u>Village councils</u>

   a. The election of village councils in order to repair qanats, to build or to maintain the bath-house and other public services. Also, the system of rotation, land distribution, water apportionment and any decision about the agricultural activities need to be taken up by village councils.

8. <u>Social welfare services</u>

   a. Health services

   b. Education

   c. Farmer's social security

In the observed villages in the margin of Dasht-e-Kawir some of the organizations and institutions have been established, but unfortunately the results in many cases have been unsatisfactory. The main obstacle to the provision of these basic services for the rural population is the pattern of settlement in the region. The population does not exceed 100 in the majority of these villages. For example, in the Biabanak district merely 10% of the settlements' population exceed 100. In this district there are 152 villages and hamlets (Mazreah) scattered over an area of about 8000 km^2. This pattern of settlement has caused problems for the establishment of service organizations and institutions, especially for the social welfare services.

As mentioned earlier, any suggestion for short-term progress should be proposed and planned very carefully because the possibilities must be assessed with respect to the existence of capabilities in the present situation of Iran. For long-term planning, in the cases of health services and other organizations and institutions, mobile service units can be suggested. The region can be divided into service areas, and several service centres could be established in the best sited settlements. Mobile service units could circulate among peripheral settlements.

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APPENDICES

APPENDIX 1

Cumulative Distribution Function

F = m/n+1 where F is the frequency probability, m is the rank of value and n is the size of sample

The cumulative distribution function has been calculated with 19 year data as follows :

$$F = m/n+1$$

Year	1	2	3	4	5	6	7	8	9	10
10	0.05	0.09	0.14	0.19	0.23	0.28	0.33	0.38	0.42	0.48
10	0.52	0.57	0.61	0.66	0.71	0.76	0.80	0.85	0.90	0.95

On which the values arrayed in order of magnitude are plotted, a straight line is drawn through the points.

APPENDIX 2

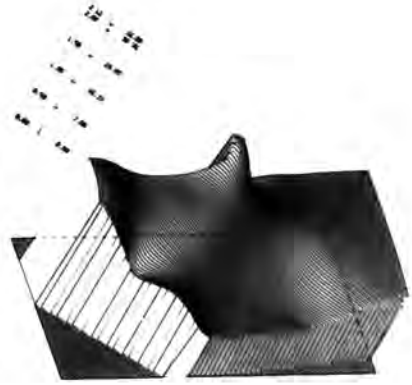
AGROCLIMATOLOGY IN THE MARGIN OF DASHT-e-KAWIR

Table A.2.1 Variability Characteristics of Rainfall for Selected Stations in the margin of Dasht-e-Kawir

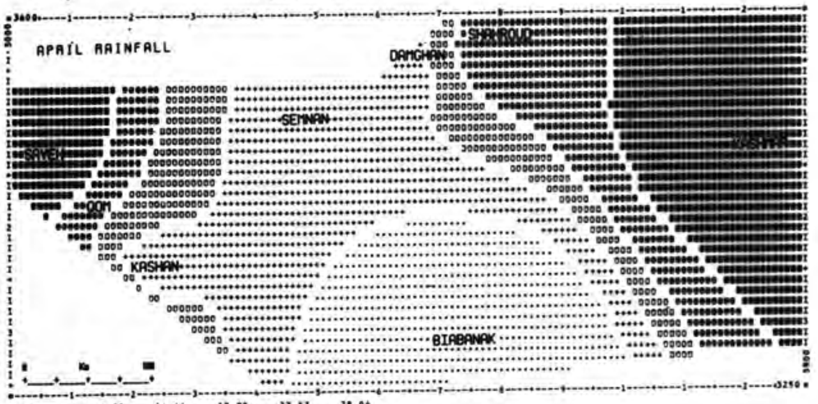
Variables / Station	No.of Observation years	Mean annual rainfall mm	Variance	Standard deviation	Coefficient of variability %	Interannual relative variability %
Kashan	19	139.9	1693.3	41.15	29.2	31.8
Qom	19	130.3	4246.9	65.16	50.0	39.9
Savehe	12	186.2	8390.5	91.6	49.17	47.5
Semnan	11	134.2	4916.8	70.12	52.25	49.2
Damgan	18	92.0	4275.4	65.38	71.06	52.5
Shahrud	25	147.8	4847.7	69.62	47.10	38.8
Kashmar	15	169.5	7211.0	84.9	50.0	45.2
Beiabanak	13	41.46	485.6	27.03	66.0	50.5

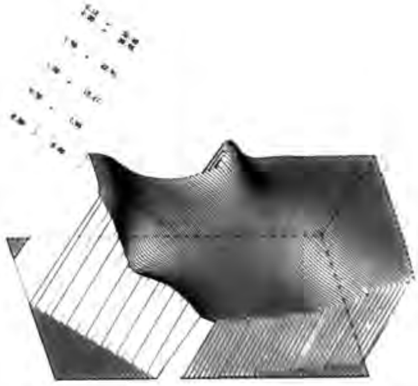
Source : Meteorological Organization of Iran (rainfall data)

FIG A-2-1 SPRING RAINFALL (mm)
IN THE DASHT-E-KAWIR & ITS MARGIN

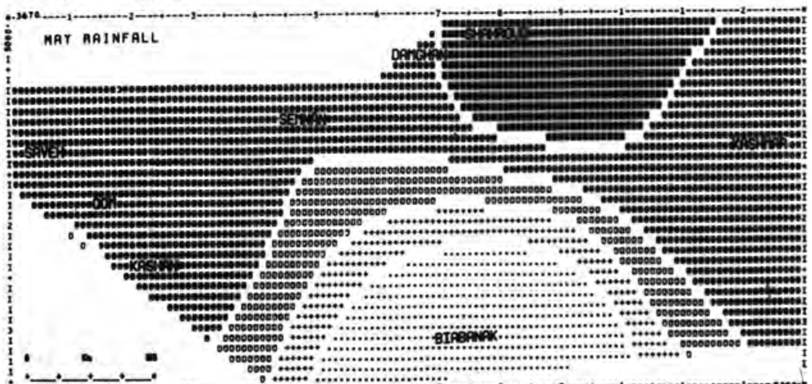


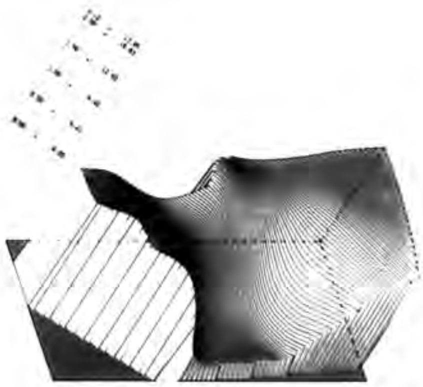
MINIMUM	0.0	6.48	12.96	19.44	25.92
MAXIMUM	6.48	12.96	19.44	25.92	32.40
FREQ.	1	0	1	3	3





MINIMUM	9.90	14.44	18.98	23.52	28.06
MAXIMUM	14.44	18.98	23.52	28.06	32.60
FREQ.	1	3	0	2	2

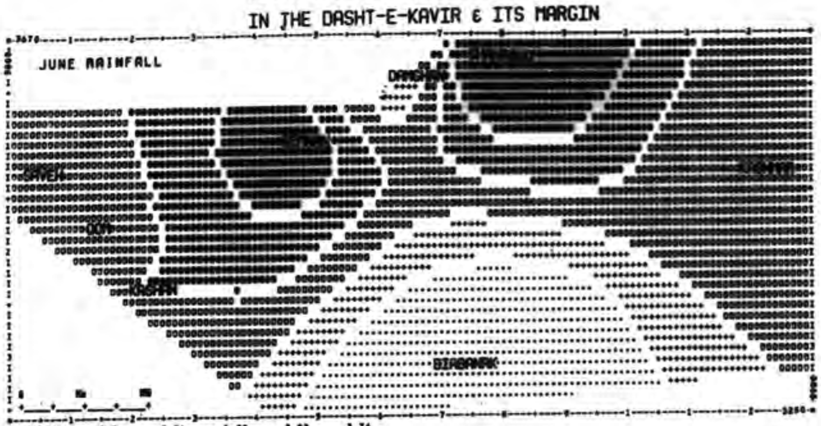


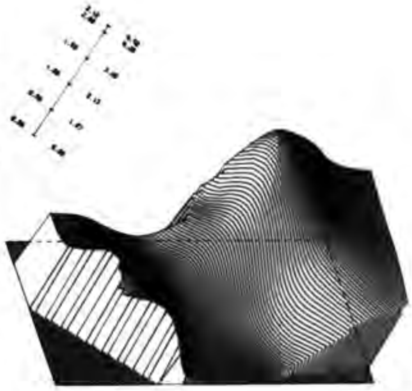


MINIMUM	1.90	5.74	9.58	13.42	17.26
MAXIMUM	5.74	9.58	13.42	17.26	21.10
FREQ.	1	0	1	5	1

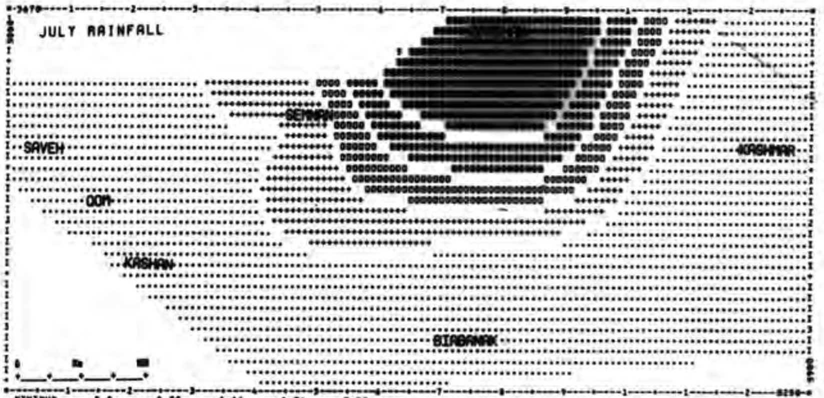
FIG A-2-2 SUMMER RAINFALL (mm)

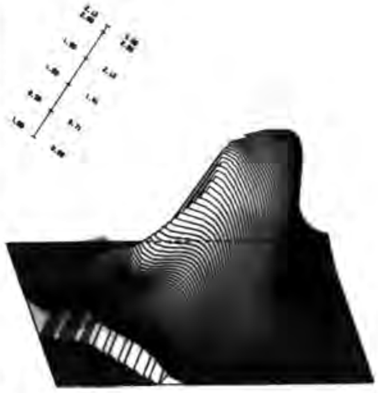
IN THE DASHT-E-KAVIR & ITS MARGIN



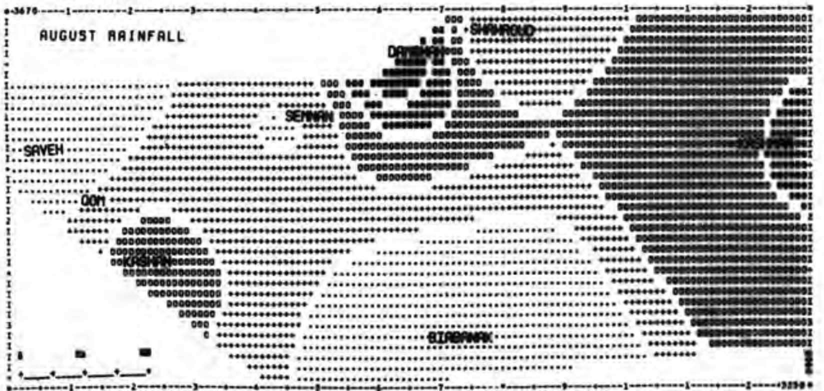


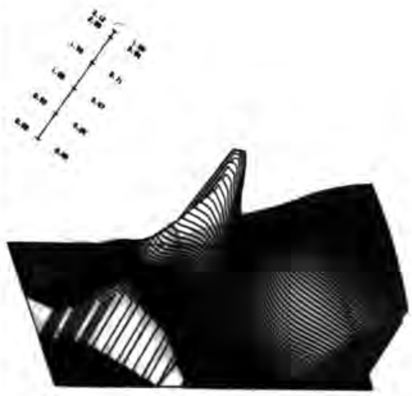
MINIMUM	0.0	0.94	1.88	2.82	3.76
MAXIMUM	0.94	1.88	2.82	3.76	4.70
FREQ.	1	2	3	0	2





MINIMUM	0.0	0.58	1.16	1.74	2.32
MAXIMUM	0.58	1.16	1.74	2.32	2.90
FREQ.	4	2	0	0	2





MINIMUM	0.0	0.20	0.40	0.60	0.80
MAXIMUM	0.20	0.40	0.60	0.80	1.00
FREQ.	2	3	1	1	1

FIG A-2-3 AUTUMN RAINFALL(mm)
IN THE DASHT-E-KAWIR & ITS MAR

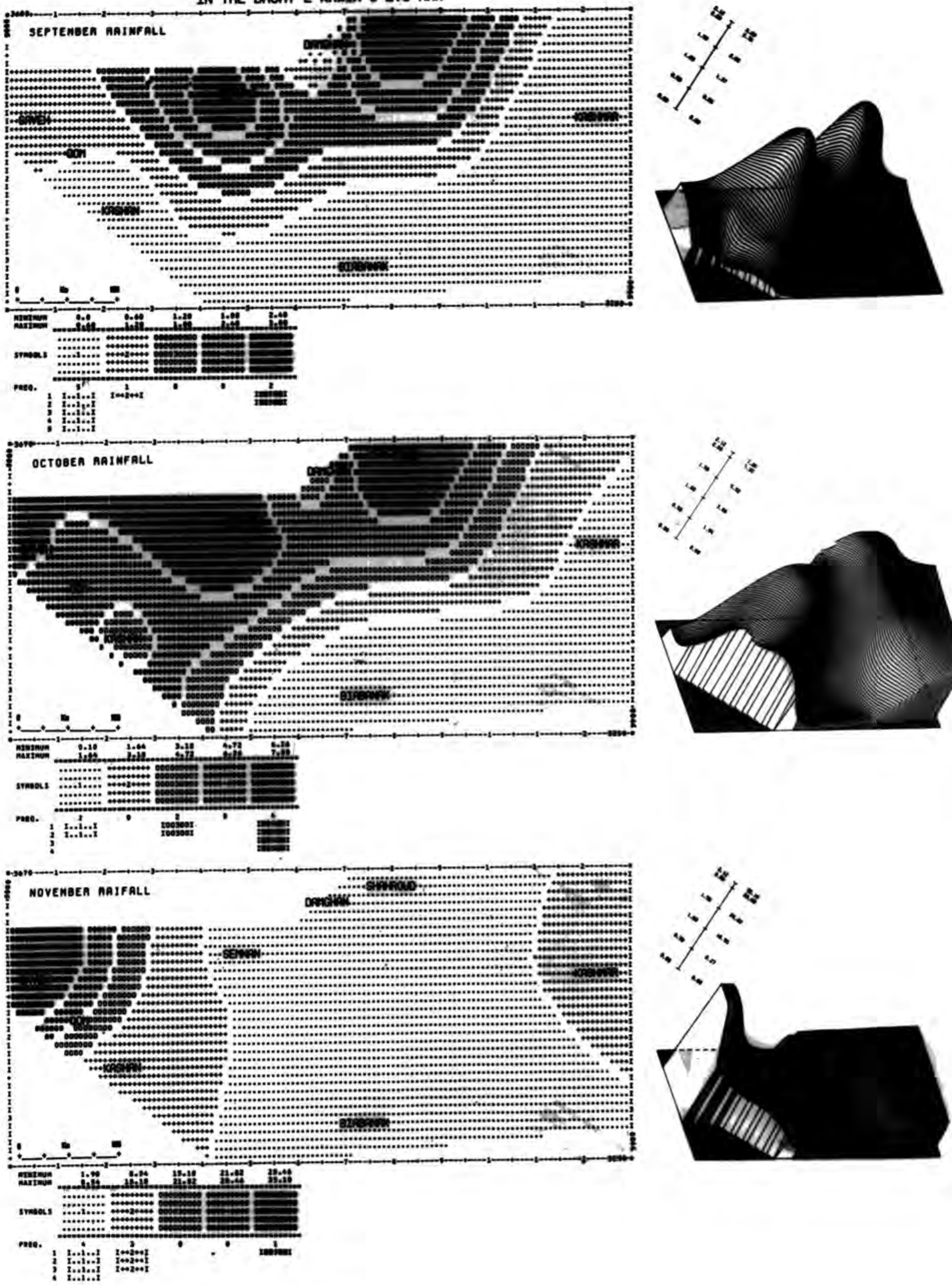
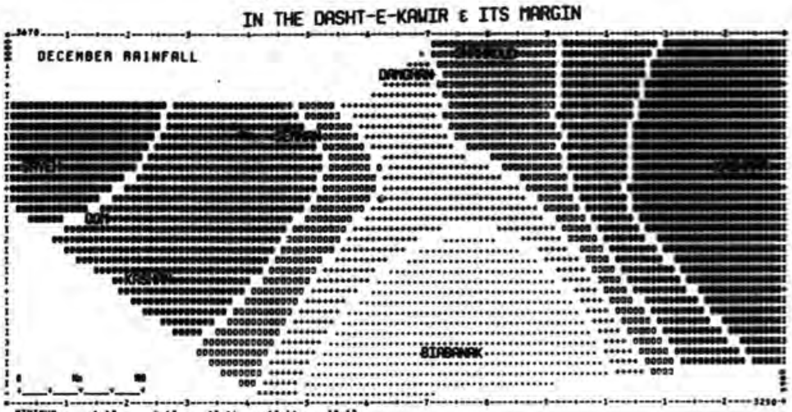
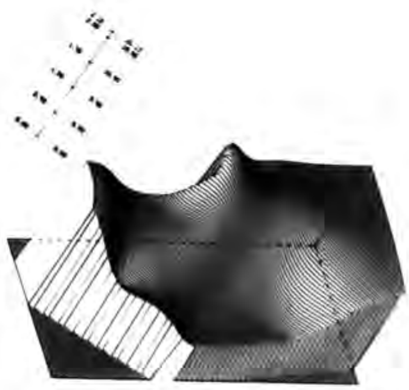
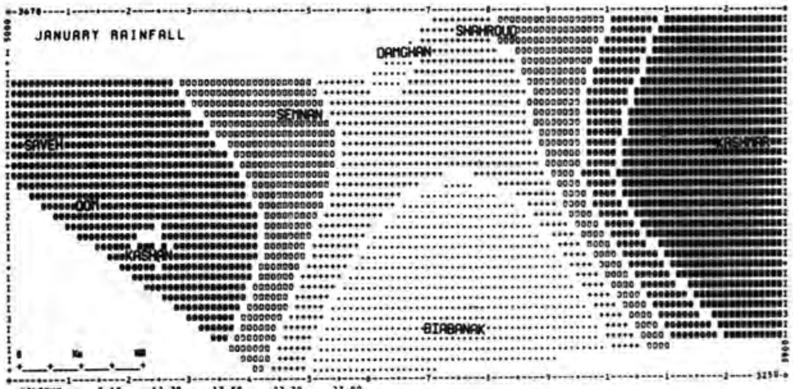


FIG A-2-4 WINTER RAINFALL (mm)
IN THE DASHT-E-KAWIR & ITS MARGIN

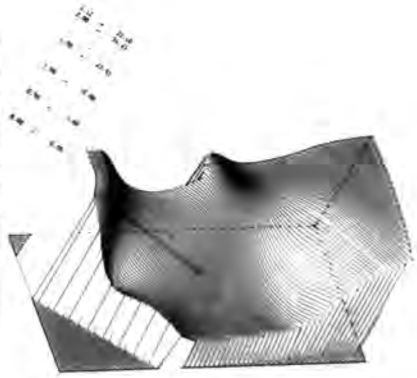


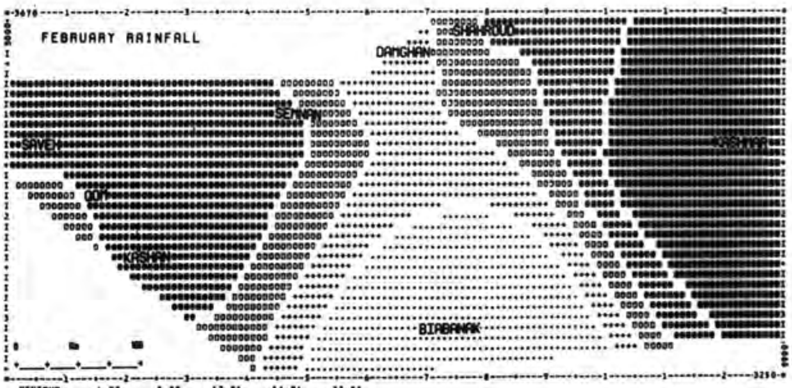
MINIMUM	6.10	9.12	12.14	15.16	18.18
MAXIMUM	9.12	12.14	15.16	18.18	21.20
SYMBOLS	....1....	++++2++++	000030000		
FREQ.	1	1	2	2	2





MINIMUM	7.10	12.30	17.50	22.70	27.90
MAXIMUM	12.30	17.50	22.70	27.90	33.10
SYMBOLS	....1....	++++2++++	000030000		
FREQ.	2	1	2	2	1





MINIMUM	4.90	8.88	12.86	16.84	20.82
MAXIMUM	8.88	12.86	16.84	20.82	24.80
SYMBOLS	....1....	++++2++++	000030000		
FREQ.	1	1	2	3	1

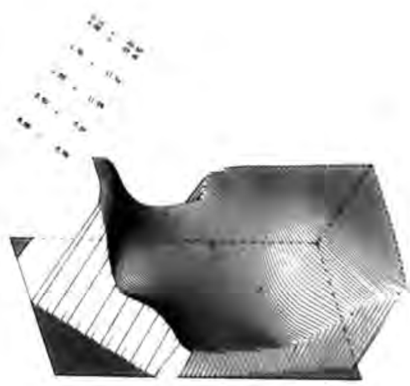
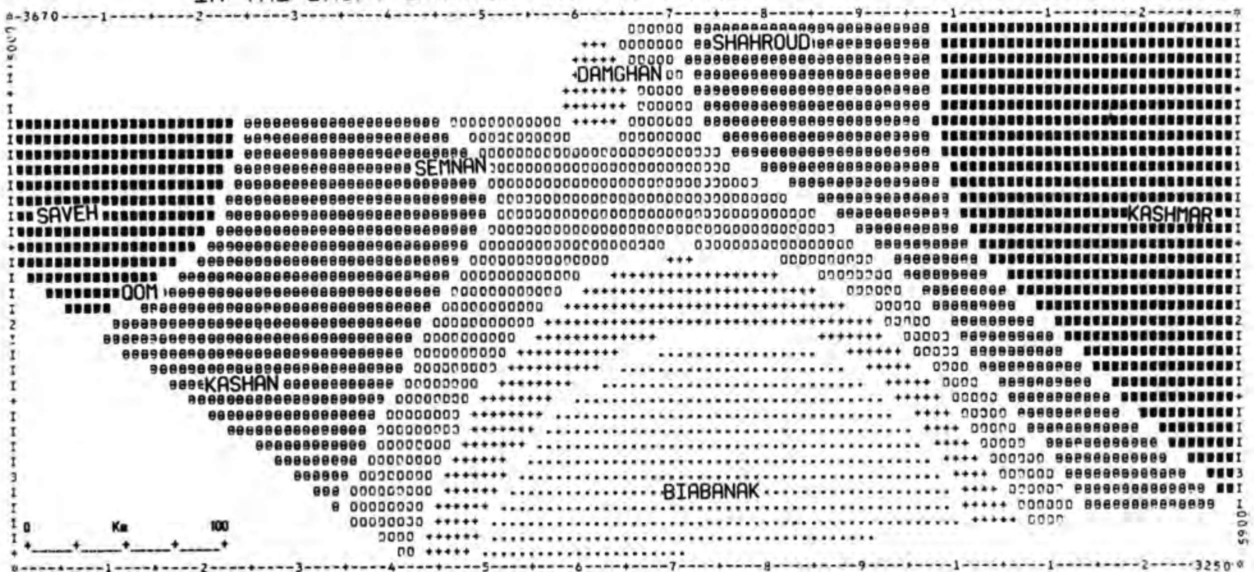


FIG A-2-5 MEAN ANNUAL RAINFALL (MM)

IN THE DASHT-E-KAWIR AND ITS MARGIN



MINIMUM	41.40	70.36	99.32	128.28	157.24
MAXIMUM	70.36	99.32	128.28	157.24	186.20
SYMBOLS	....1....	++++2++++	000030000	@@@@4@@@@	■■■■5■■■■
FREQ.	1	1	0	4	2

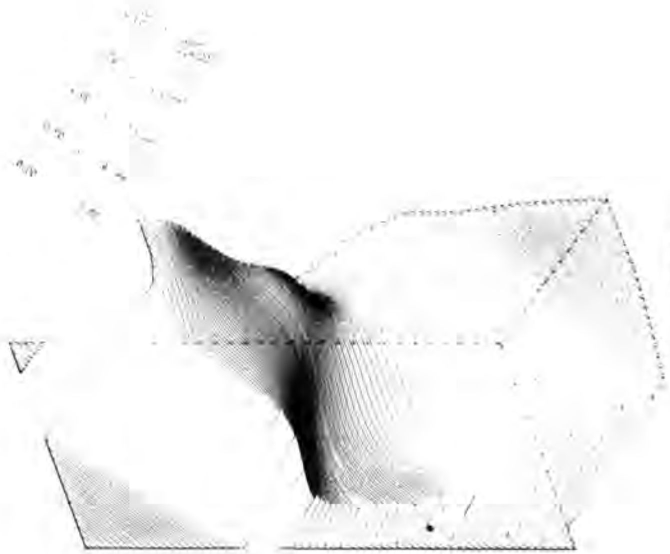
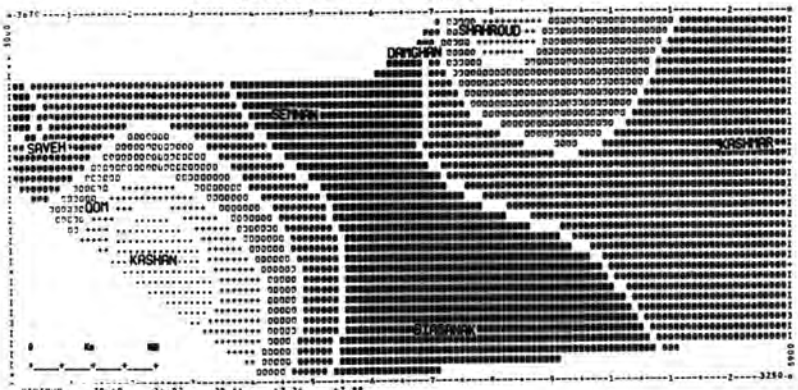
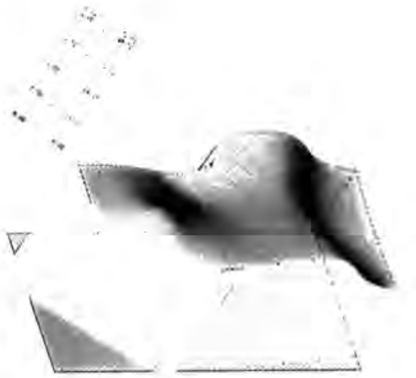


FIG A-2-6 INTERANNUAL RELATIVE OF RAINFALL VARIABILITY (%) IN THE DASHT-E-KAWIR AND ITS MARGIN



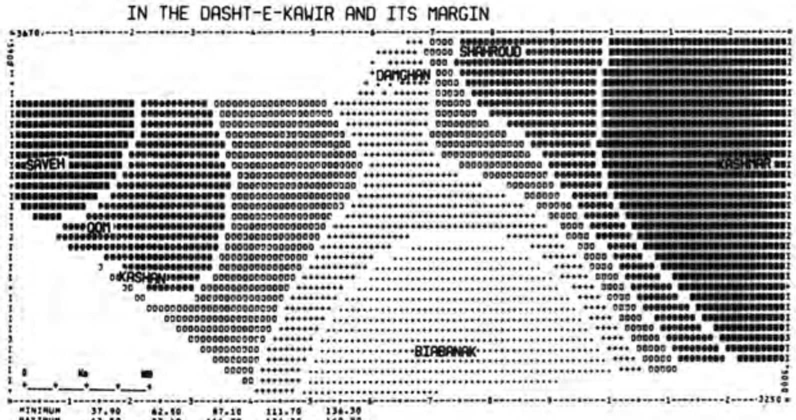


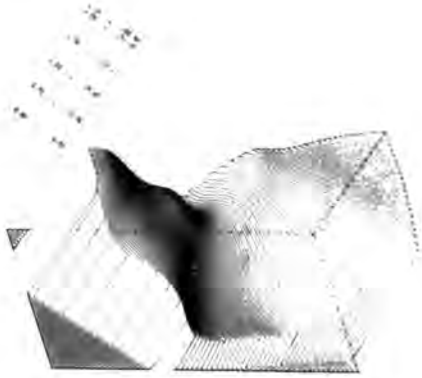
MINIMUM	29.40	34.02	38.64	43.26	47.88
MAXIMUM	34.02	38.64	43.26	47.88	52.50

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
FREQ.	1	0	2	2	3

FIG A-2-7 ANNUAL EFFECTIVE RAINFALL (MM) IN THE DASHT-E-KAWIR AND ITS MARGIN





MINIMUM	37.90	62.50	87.10	111.70	136.30
MAXIMUM	62.50	87.10	111.70	136.30	160.90

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5
FREQ.	2	0	2	2	2

Table A.2.2 Estimate of Confidence Limits for MEAN Annual Rainfall for Selected Stations in the margin of Dasht-e-Kawir

Confidence Level / Station	z = 1 60%	z = 1.26 90%	z = 1.65 95%	z = 1.96 98%	z = 2.33 99%	z = 3.1 99.9%
KASHAN	137.7-142.1	137.1-142.6	136.2-143.5	135.5-144.2	134.7-145.0	133.0-146.7
QOM	126.7-133.9	135.7-134.8	124.3-136.2	123.2-137.3	121.9-138.6	119.1-141.4
SAVEHE	180.6-191.8	179.1-193.2	176.9-195.4	175.2-197.1	173.1-199.2	168.8-203.5
GARMSAR	115.4-124.6	114.2-125.7	112.4-127.5	110.9-129.0	109.2-130.7	105.7-134.2
SEMNAN	137. 141.2	125.3-143.0	122.6-145.7	120.4-147.9	117.8-150.5	112.5-155.9
DAMGHAN	88.2- 95.8	87.2- 96.7	85.7- 98.2	84.5-99.4	83.1-100.8	80.2-103.7
SHAHROUD	144.9-150.7	144.1-151.4	143.0-152.5	142.1-135.4	141.0-154.4	138.8-156.7
KASHMAR	163.6-175.6	162.0-177.1	159.7-179.5	157.8-181.3	155.6-183.5	151.0-188.2
TABAS	75.9- 79.1	75.4- 79.5	74.8- 80.1	74.3- 80.6	73.7- 81.2	72.5- 82.4
BEIABANAK	37.0-46.0	35.8- 47.1	34.0- 48.9	32.6- 50.3	31.0- 51.9	27.5- 55.4

Table A.2.3 Estimate of Confidence Limite for Annual Rainfall for selected Stations in the margin of Dasht-e-Kawir

Confidence Limit / Station	$z = 0.26$ 60%	$z = 0.53$ 70%	$z = 0.84$ 80%	$z = 1.29$ 90%	$z = 1.65$ 95%	$z = 2.33$ 99%
KASHAN	129.2-150.5	118.1-161.6	105.3-174.4	86.8-192.9	72.0-207.7	44.1-235.6
QOM	113.3-147.2	95.7-164.8	75.6-184.9	46.3-214.2	22.8-237.7	0.0-281.9
SAVEHE	162.3-210.0	137.6-234.7	109.2-263.1	68.0-304.3	35.0-337.3	0.0-399.6
GARMSAR	100.7-139.2	80.6-159.3	57.6-182.3	24.2-215.7	0.0-242.4	0.0-292.8
SEMNAN	115.9-152.4	97.0-171.3	75.3-193.0	43.7-224.6	18.5-249.8	0.0-297.5
DAMGHAN	75.0-108.9	57.3-126.6	37.1-146.8	7.7-176.2	0.0-199.7	0.0-244.1
SHAHROUD	129.7-165.8	110.9-184.6	89.3-206.2	58.0-237.5	32.9-262.6	0.0-309.9
KASHMAR	147.4-191.5	124.5-214.4	98.1-240.8	59.9-279.0	29.4-309.5	0.0-367.3
TABAS	70.5- 84.4	63.2- 91.7	54.9-100.0	42.7-112.2	33.1-121.8	14.8-140.1
BEIABANAK	34.3-42.4	27.0- 55.7	18.7- 64.0	6.5- 76.2	0.0- 85.9	0.0-104.3

FIG A-2-8 CONFIDENCE LIMITS OF RAINFALL
IN THE SELACTED STATIONS
IN THE MARGIN OF DASHT-E-KAWIR

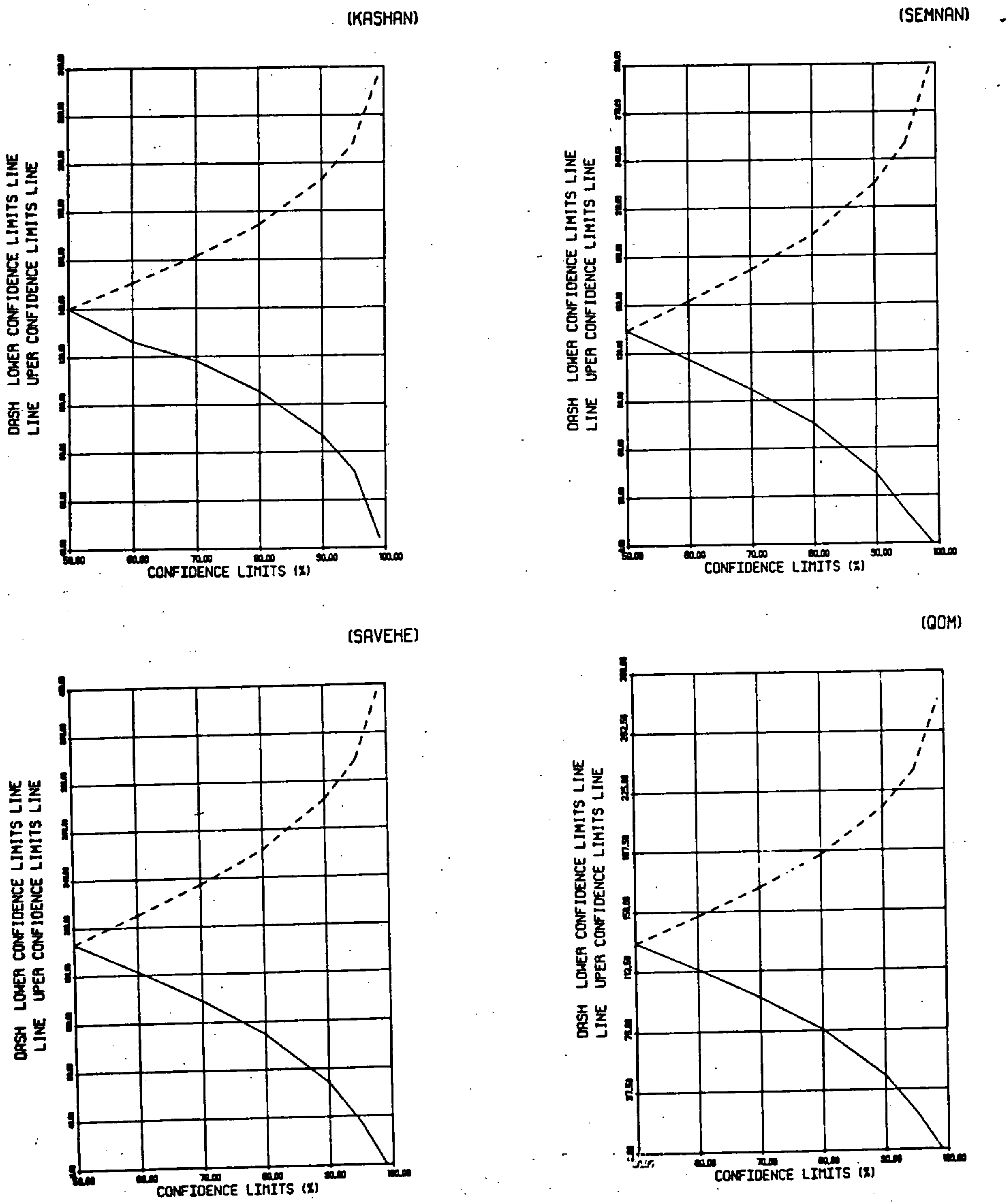
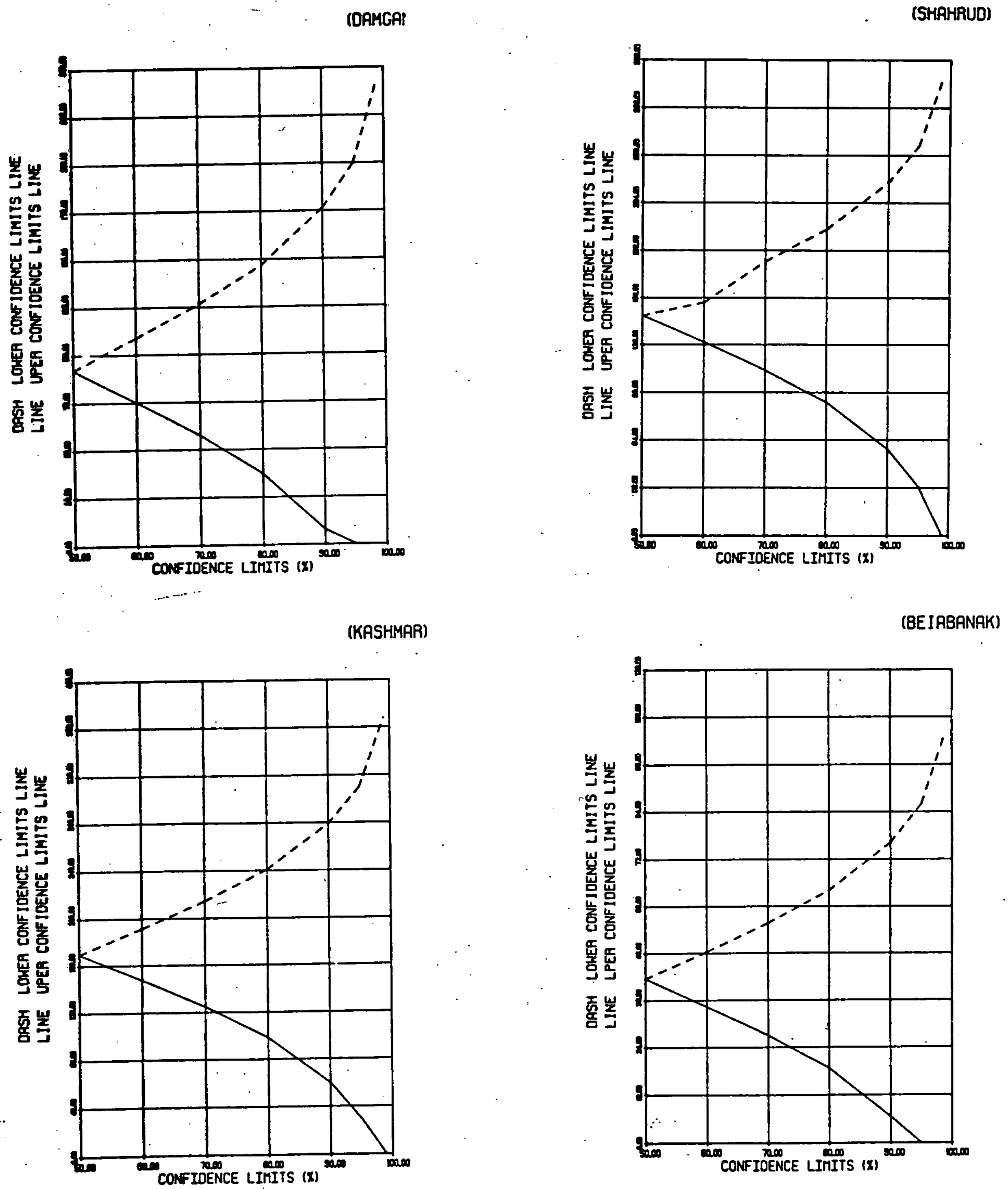


FIG A-2-8 CONFIDENCE LIMITS OF RAINFALL
IN THE SELACTED STATIONS
IN THE MARGIN OF DASHT-E-KAWIR



Estimation of rainfall in the Dasht-e-Kawir and its margins

In the margin of the Dasht-e-Kawir there are, unfortunately, not enough meteorological stations, and some of the stations do not have records for a long number of consecutive years. This makes agroclimatology planning difficult, especially when estimates of rainfall and evapotranspiration are concerned.

In order to estimate rainfall in the region multiple regression equations in valuing altitude, latitude and longitude have been calculated for mean, higher and lower annual rainfall by the author.

We must bear in mind that there are a few dominant factors influencing the rainfall value, in general, and in the region in particular, of which altitude, latitude and the source of moisture are the most important. The source of moisture is the air mass that comes from the Mediterranean Sea which lies some distance to the west of this area, and as the distance the air mass must travel increases, its effect decreases. Beaumont (1976)[1] believes "in general, precipitation totals decline in an easterly and southerly direction away from the Mediterranean Sea". On the other hand, although the Caspian Sea is the source of moisture in the north of Iran, its moisture rarely passes to the central part of Iran from the Alborz mountains.

The statistical characteristics and regression equations have been calculated using the SPSS system by computer, and the

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(1) Beaumont, P.F. et al. (1977) The Middle East, A Geographical Study, John Wiley & Son, Chichester, p.64.

data has been used from 12 meteorological stations' records in the margins of the Dasht-e-Kawir. The results of these calculations have been illustrated in the following tables.

REGRESSION EQUATION INVOLVING: MEAN ANNUAL RAINFALL, ALTITUDE, LATITUDE, LONGITUDE

CASE-N	R	A	L	LO
1	139.5	955.	33.98	51.45
2	100.9	900.	34.70	51.48
3	130.3	928.	33.63	50.88
4	180.3	1167.	35.20	50.35
5	120.1	835.	35.25	52.33
6	134.2	1138.	35.55	53.20
7	92.0	1170.	36.22	54.37
8	147.8	1366.	36.42	55.30
9	169.6	1060.	35.20	58.47
10	77.2	1290.	34.02	58.15
11	77.5	691.	33.60	56.90
12	41.5	680.	33.18	55.03

VARIABLE	MEAN	STANDARD DEV	CASES
R	117.5750	40.9386	12
A	1015.0000	220.9698	12
L	34.7458	1.0624	12
LO	53.9925	2.8258	12

CORRELATION COEFFICIENTS

	R	A	L	LO
R	1.00000	0.47204	0.50956	-0.31418
A	0.47204	1.00000	0.68090	0.13584
L	0.50956	0.68090	1.00000	-0.02390
LO	-0.31418	0.13584	-0.02390	1.00000

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * *   VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE..   R   ANNUAL RAINFALL MILLIMETRE

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
L	LATITUDE OF STATION DEGREE	0.50956	0.25965	0.25965	0.50956	10.56657	0.27420
LO	LONGITUDE OF STATION DEGREE	0.59238	0.35091	0.09125	-0.31418	-5.112455	-0.35299
A	ALTITUDE OF STATION METRE	0.63869	0.40791	0.05700	0.47204	0.6174454E-01	0.33327
(CONSTANT)						-36.20579	

$\boxed{R=10.56657 * L -5.112455 * LO +0.061445 * A -36.20759}$

REGRESSION EQUATION INVOLVING; HIGHER RAINFALL,ALTITUDE,LATITUDE ,LONGITUDE

CASE-N	R	A	L	LO
1	252.0	95.	33.90	51.40
2	225.0	90.	34.70	51.40
3	269.0	92.	33.60	50.80
4	332.0	116.	35.20	50.30
5	393.0	83.	35.20	52.30
6	226.0	113.	35.50	53.20
7	305.0	117.	38.20	54.30
8	359.0	136.	36.40	55.30
9	286.0	106.	35.20	58.40
10	108.0	129.	34.00	58.10
11	113.0	69.	33.60	56.90
12	67.0	68.	33.10	55.00

VARIABLE	MEAN	STANDARD DEV	CASES
R	244.5000	103.0371	12
A	101.1667	22.0200	12
L	34.8833	1.4218	12
LO	53.9500	2.8334	12

CORRELATION COEFFICIENTS

	R	A	L	LO
R	1.00000	0.39098	0.63290	-0.42935
A	0.39098	1.00000	0.60639	0.14556
L	0.63290	0.60639	1.00000	0.00384
LO	-0.42935	0.14556	0.00384	1.00000

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * *

DEPENDENT VARIABLE.. R   HIGHER RAINFALL MILLIMETRE

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
L	LATITUD DEGREE	0.63290	0.40056	0.40056	0.63290	41.03042	0.56618
LO	LONGITUDE DEGREE	0.76615	0.58699	0.18643	-0.42935	-16.28960	-0.44795
A	ALTITUD METRE	0.77122	0.59478	0.00779	0.39098	0.5281142	0.11286
(CONSTANT)						-361.3810	

$\boxed{R=41.03042 * L -16.28960 * LO +0.5291142 * A -361.391C}$

REGRESSION EQUATION INVOLVING, LOWER ANNUAL RAINFALL,ALTITUDE,LATITUDE,LONGITUDE

CASE-N	R	A	L	LO
1	45.0	955.	33.98	51.45
2	51.0	900.	34.70	51.49
3	53.6	928.	33.63	50.88
4	63.0	1167.	35.20	50.35
5	42.5	835.	35.25	52.33
6	60.0	1138.	35.55	53.20
7	29.0	1170.	36.22	54.37
8	69.5	1366.	36.42	55.30
9	82.9	1060.	35.20	58.47
10	17.5	1290.	34.02	58.15
11	22.4	691.	33.60	56.90
12	2.6	680.	33.18	55.03

VARIABLE	MEAN	STANDARD DEV	CASES
R	44.8250	23.2901	12
A	1015.0000	220.9698	12
L	34.7458	1.0624	12
LO	53.9925	2.8258	12

CORRELATION COEFFICIENTS

	R	A	L	LO
R	1.00000	0.44208	0.56685	-0.20061
A	0.44208	1.00000	0.68090	0.13584
L	0.56685	0.68090	1.00000	-0.02390
LO	-0.20061	0.13584	-0.02390	1.00000

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * *

DEPENDENT VARIABLE.. R ANNUAL RAINFALL MILLIMETER

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
L	LATITUDE OF STATION DEGREE	0.56685	0.32132	0.32132	0.56685	9.855754	0.44956
LO	LONGITUDE OF STATION DEGREE	0.59694	0.35633	0.03501	-0.20061	-1.749366	-0.21225
A	ALTITUDE OF STATION METRE	0.60850	0.37027	0.01394	0.44208	0.1736993E-01	0.14480
(CONSTANT)						-220.7992	

$$\boxed{R=9.855754 * L -1.749366 * LO +0.0173699 * A -220.7992}$$

FIG A-2-9 SCATTERGRAM INVOLVING ,MEAN ANNUL RAINFALL
ALTITUDE , LATITUDE & LONITUDE
IN THE DASHT-E-KAWIR & ITS MARGIN

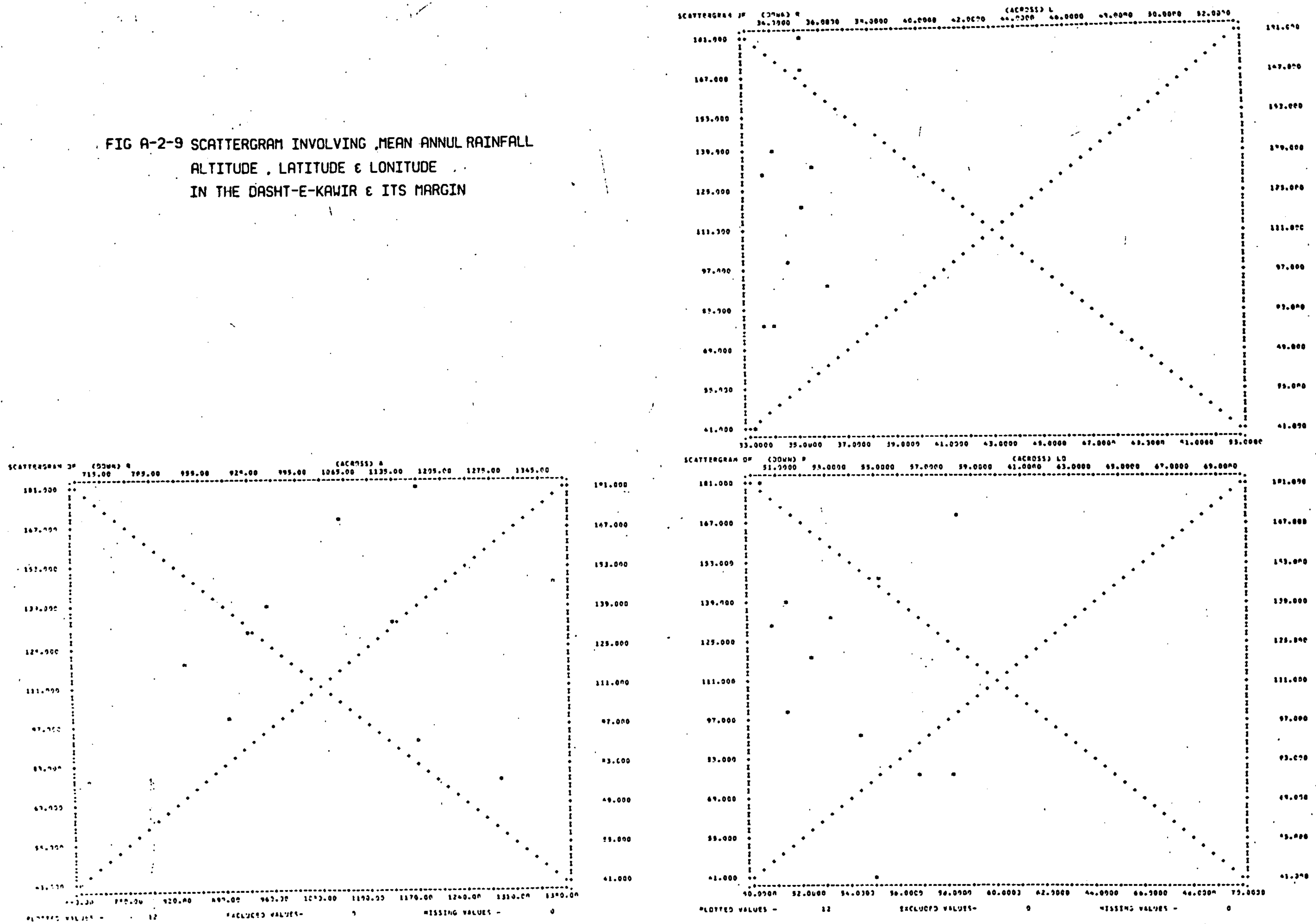
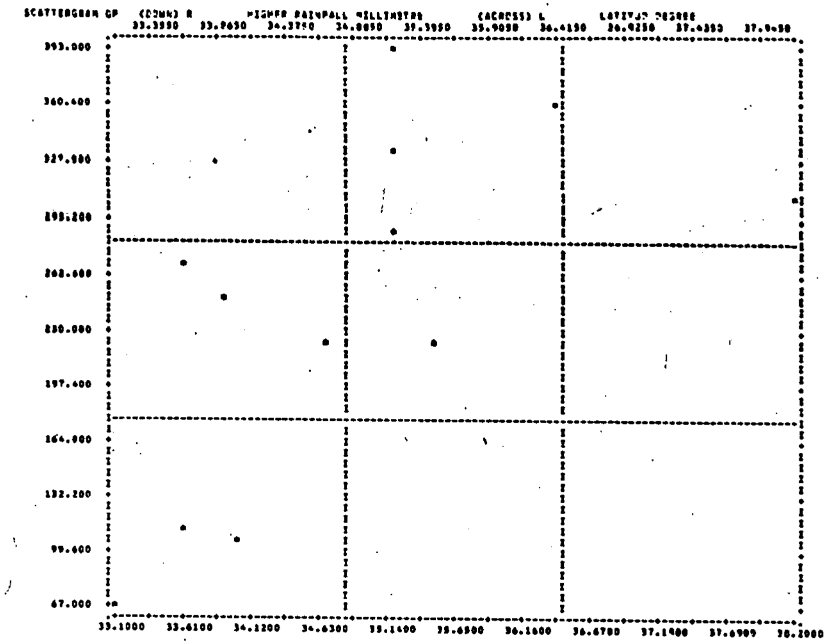
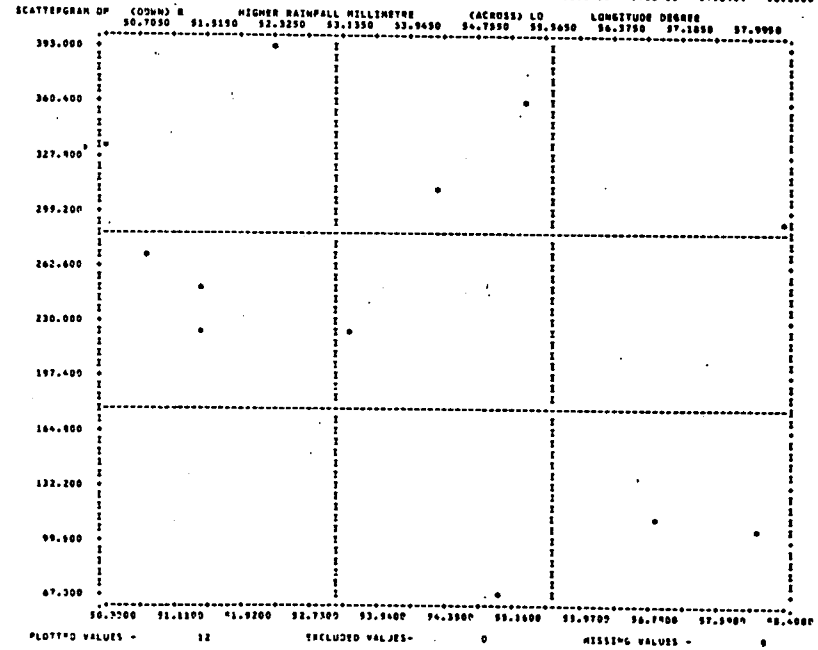


FIG A-2-10-1 SCATTERGRAM INVOLVIN HIGHER RAINFALL
ALTITUDE , LATITUDE & LONITUDE
IN THE DASHT-E-KAWIR & ITS MARGIN





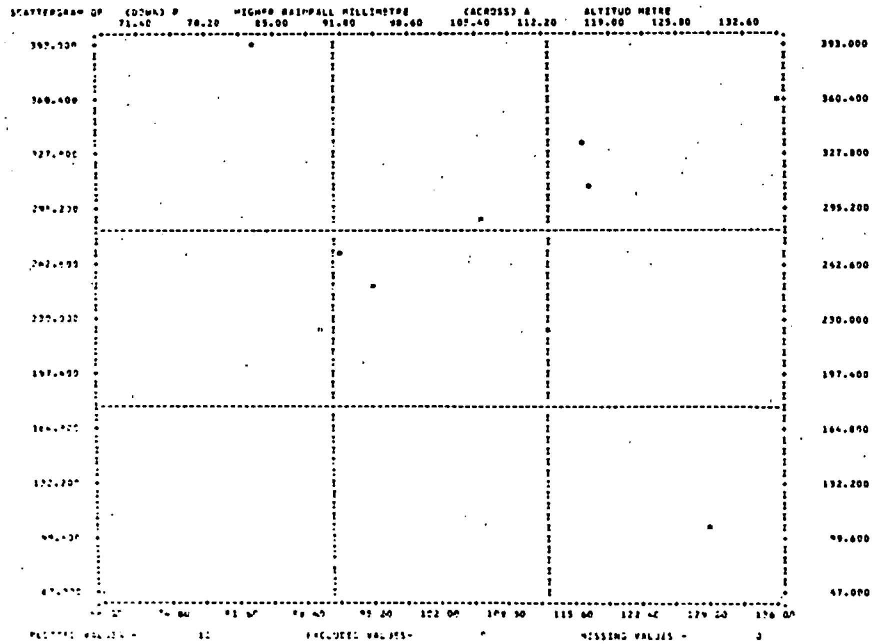
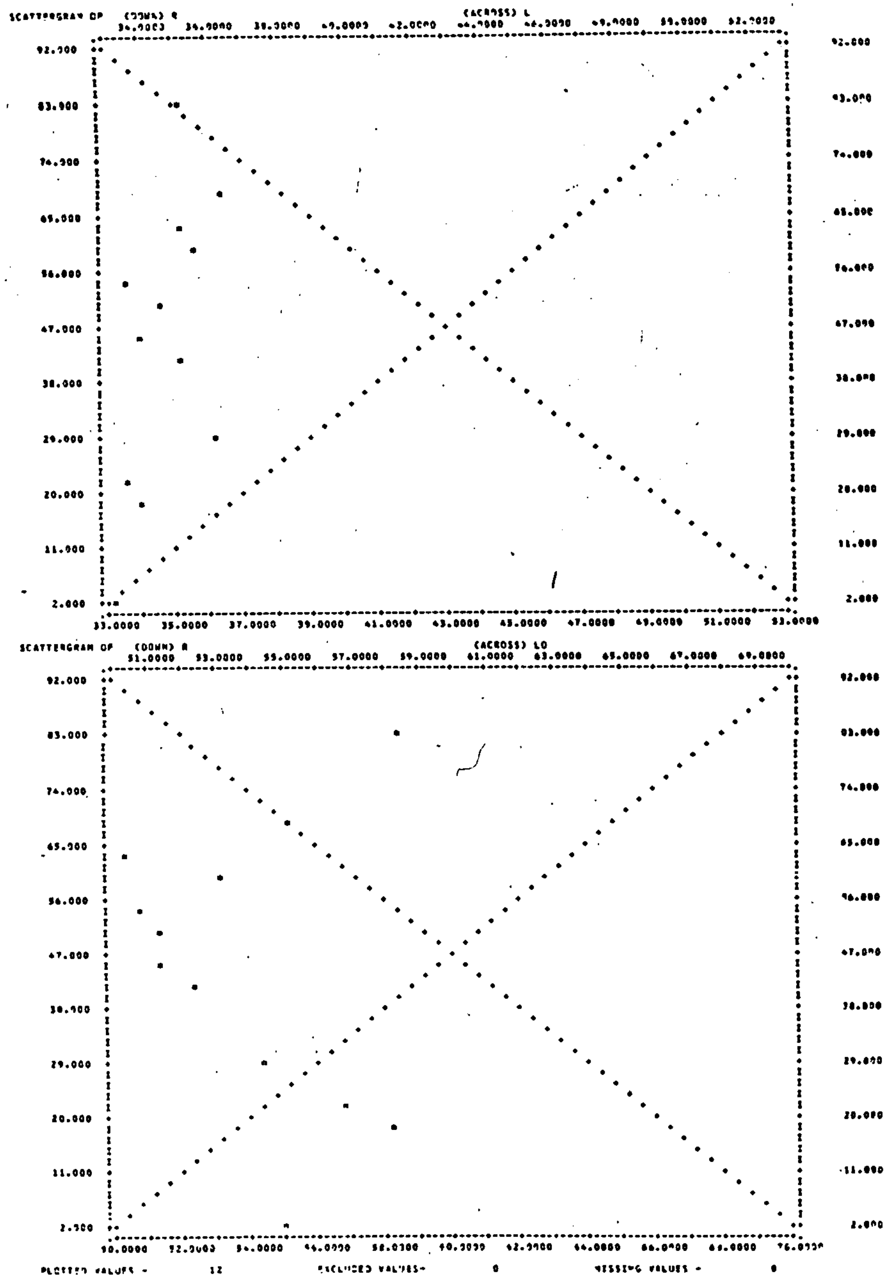


FIG A-2-10 SCATTERGRAM IVOLVING LOWER RAINFALL
ALTITUDE , LATITUDE & LONITUDE
IN THE DASHT-E-KAWIR & ITS MARGIN



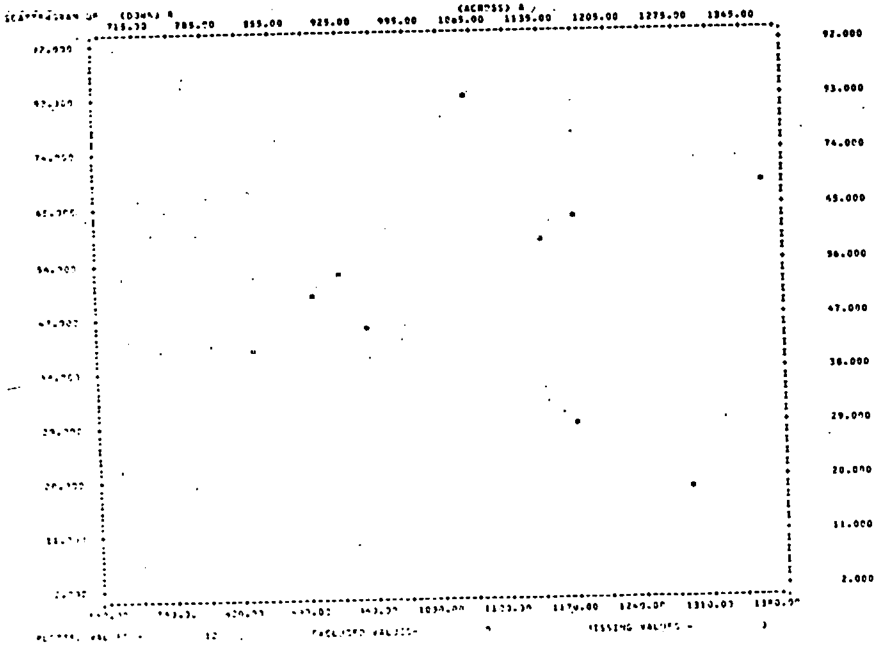


Table A.2.4 Specification of Monthly Temperature for Selected Stations in the margin of Dashe-e-Kawir (°C)

Months	Station DAMGHAN Lati 36 ,13'N Longi 54,22'E Alti 1138 m Ye 1957-1975				Station SHAHROUD Lati 36,25'N Longi 55,2'E Alti 1366 m Ye 1951-1975				Station KASHMAR Lati 35,12'N Longi 58,28' Alti 1060 m Ye 1960-1975			
Months / Temp.	Max	Min	Range	Mean	Max	Min	Range	Mean	Max	Min	Range	Mean
January	6.7	-5.5	12.2	0.6	6.1	-4.7	10.8	0.7	9.3	-0.2	9.5	4.55
February	9.9	-4.3	14.2	2.8	9.2	-2.0	11.2	3.6	11.9	2.1	9.8	7.0
March	15.9	1.5	14.4	8.7	14.3	3.1	11.2	8.7	17.1	4.8	12.3	10.9
April	22.2	7.0	15.2	14.6	20.4	7.4	13.0	13.9	23.9	9.7	14.2	16.8
May	28.0	12.8	15.2	20.4	26.2	12.4	13.8	19.3	30.1	15.3	14.8	22.7
June	32.8	15.2	17.6	24.0	30.5	15.9	14.6	23.2	35.6	19.0	16.6	27.3
July	34.3	15.9	18.4	25.1	32.3	19.1	13.2	25.7	37.0	20.4	16.6	28.7
August	34.2	16.6	17.6	25.4	31.8	18.4	13.4	25.1	36.2	18.4	17.8	27.3
September	30.8	12.8	18.0	21.8	28.3	13.7	14.6	21.0	29.5	16.7	13.4	22.8
October	24.1	8.1	16.0	16.1	22.3	7.9	15.4	15.1	25.4	11.0	14.4	18.2
November	15.5	0.9	14.6	8.2	14.8	2.6	12.2	8.7	17.6	6.0	11.6	11.8
December	9.2	-4.0	13.2	2.6	8.2	-1.4	9.6	3.4	10.7	1.7	15.0	6.2
Ann-Mean	21.9	6.4	15.5	14.19	20.3	7.7	12.6	14.0	23.6	10.3	13.3	17.0

Source : Meteorological organization of Iran.

(Cont.)

Table A.2.4 Specification of monthly temperature for Selected Stations in the margin of Dasht-Kawir (°C)

Month	Station QOM Lati 33,38'N Longi 50,52'E Alti 995 m Ye 1953-1975				Station SAVEH Lati 35,2'N Longi 50,21'E Alti 928 m Ye 1962-1975				Station SEMNAN Lati 35,33'N Longi 53,12'N Alti 835 m Ye 1966-1975			
	Max	Min	Range	Mean	Max	Min	Range	Mean	Max	Min	Range	Mean
January	9.7	-0.1	9.8	4.8	9.4	-1.4	10.8	4.0	8.2	-1.4	9.6	3.4
February	12.8	2.2	10.6	7.5	12.7	0.3	12.4	6.5	10.3	0.9	9.4	5.6
March	18.4	6.0	11.8	12.2	18.7	5.1	13.6	11.9	17.5	5.3	12.2	11.4
April	24.4	10.6	13.8	17.5	23.6	8.4	15.2	16.0	23.3	10.9	12.4	17.1
May	31.3	16.3	15.0	23.8	30.2	14.2	16.0	22.2	30.0	16.4	13.6	23.2
June	36.5	21.1	15.4	28.8	36.0	19.2	17.8	27.6	35.8	21.2	14.8	28.5
July	39.2	23.6	15.6	31.4	38.5	22.1	16.4	27.5	38.1	23.9	14.2	31.0
August	38.3	18.3	20.0	28.3	37.9	20.9	17.0	29.4	36.9	19.9	17.0	28.4
September	34.0	14.8	19.2	24.4	33.3	11.1	11.2	22.2	32.2	13.4	18.8	22.8
October	25.5	13.1	12.4	19.3	27.6	10.6	17.4	18.8	25.7	9.9	15.8	17.8
November	18.0	5.6	12.4	11.8	19.2	4.6	14.6	11.9	17.6	4.4	13.2	11.0
December	11.8	7.2	10.6	6.5	13.1	1.5	11.6	7.3	10.6	-0.2	10.8	5.2
Ann.Mean	24.9	11.0	13.9	17.95	24.9	9.7	15.2	17.3	23.6	10.3	13.5	17.1

(Cont.)

Table A.2.4 Specifications of monthly temperature for Selected Stations in the Margin of Dastht-Kawir (°C)

Month	Station KASHAN (ABUZAID-ABAD) Lati 33,58' N Longi 51, 27' E Alti 755 m Ye 1960-1979						Station BIEABANK Lati 33,10'N Longi 55 E Alti 680 m Ye 1961-1973			
	Max	Min	Range	Mean	Abs Max	Abs Min	Max	Min	Range	Mean
January	10.0	-0.8	10.8	4.6	19.0	-10.0	13.4	-0.5	13.9	6.4
February	13.3	1.4	11.9	7.2	27.0	-10.0	16.4	2.0	14.4	9.2
March	19.8	6.5	13.3	13.1	32.0	-2.0	22.1	7.3	14.9	14.7
April	26.3	11.0	15.3	18.6	36.0	-1.0	27.1	12.3	14.8	19.7
May	31.4	17.1	24.3	24.3	42.0	11.0	33.6	18.0	15.6	25.8
June	37.7	21.8	15.9	29.7	48.0	15.0	38.7	22.6	16.7	30.6
July	41.2	24.6	16.6	32.9	48.0	19.0	40.0	24.5	15.5	32.2
August	39.46	22.0	17.4	30.7	46.0	17.0	38.8	22.6	16.2	30.7
September	37.1	16.9	20.2	27.0	41.0	11.0	35.1	17.6	17.5	26.3
October	27.9	12.6	15.3	20.2	37.0	7.0	29.5	12.0	17.5	20.7
November	18.4	4.7	13.7	11.6	31.0	-3.0	21.5	5.3	16.5	13.5
December	13.2	1.6	11.6	7.4	21.0	-12.0	15.5	0.2	15.3	7.8
Ann.Mean	26.3	11.6	14.7	18.9			27.6	11.9	15.7	19.8

FIG A-2-11 ANNUAL TEMPERATURE (C) IN THE SELACTED STATIONS
IN THE DASHT-E-KAWIR MARGIN

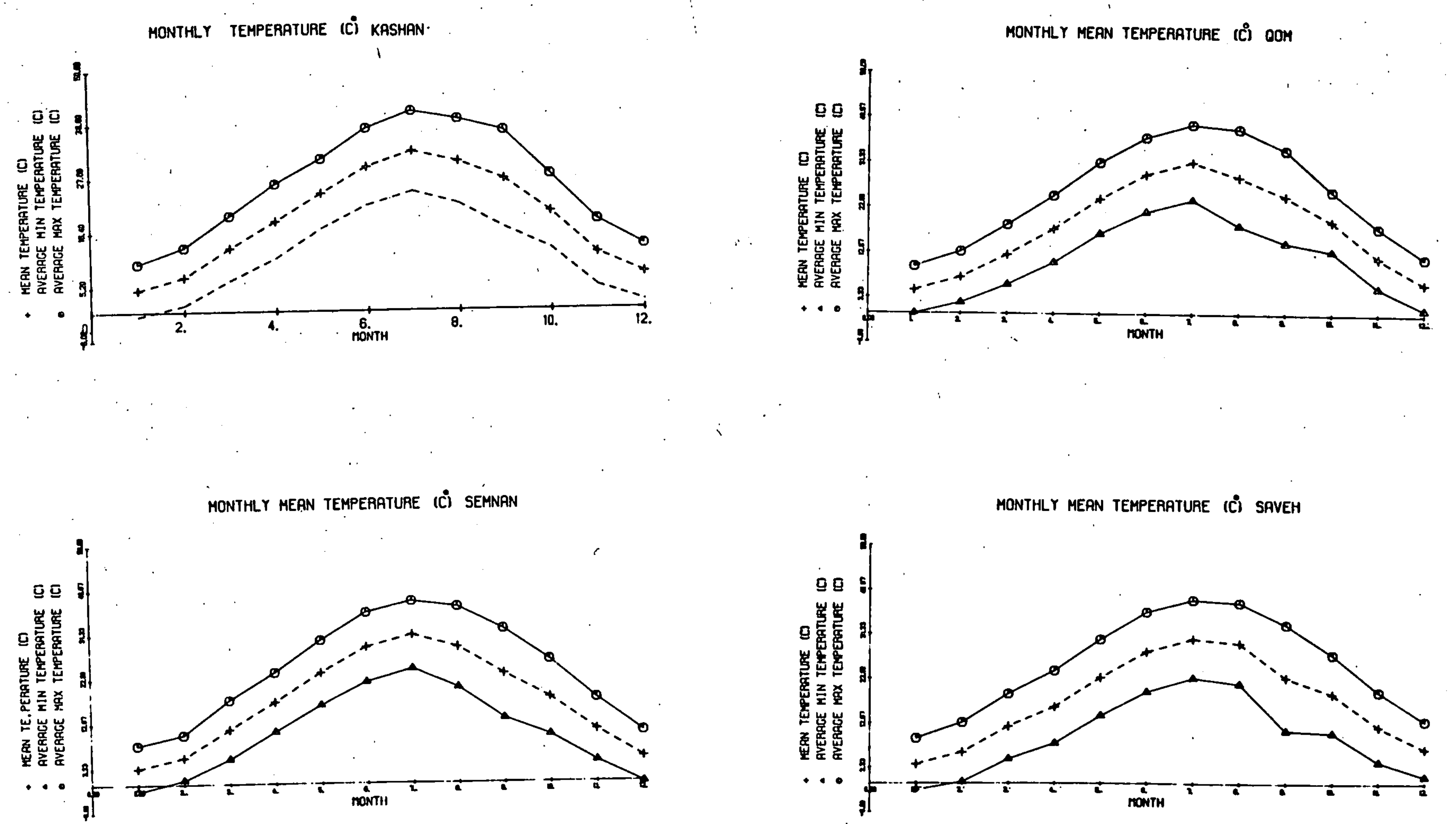


FIG A-2-11 ANNUAL TEMPERATURE (C) IN THE SELACTED STATIONS

IN THE MARGIN OF DASHT-E-KAWIR

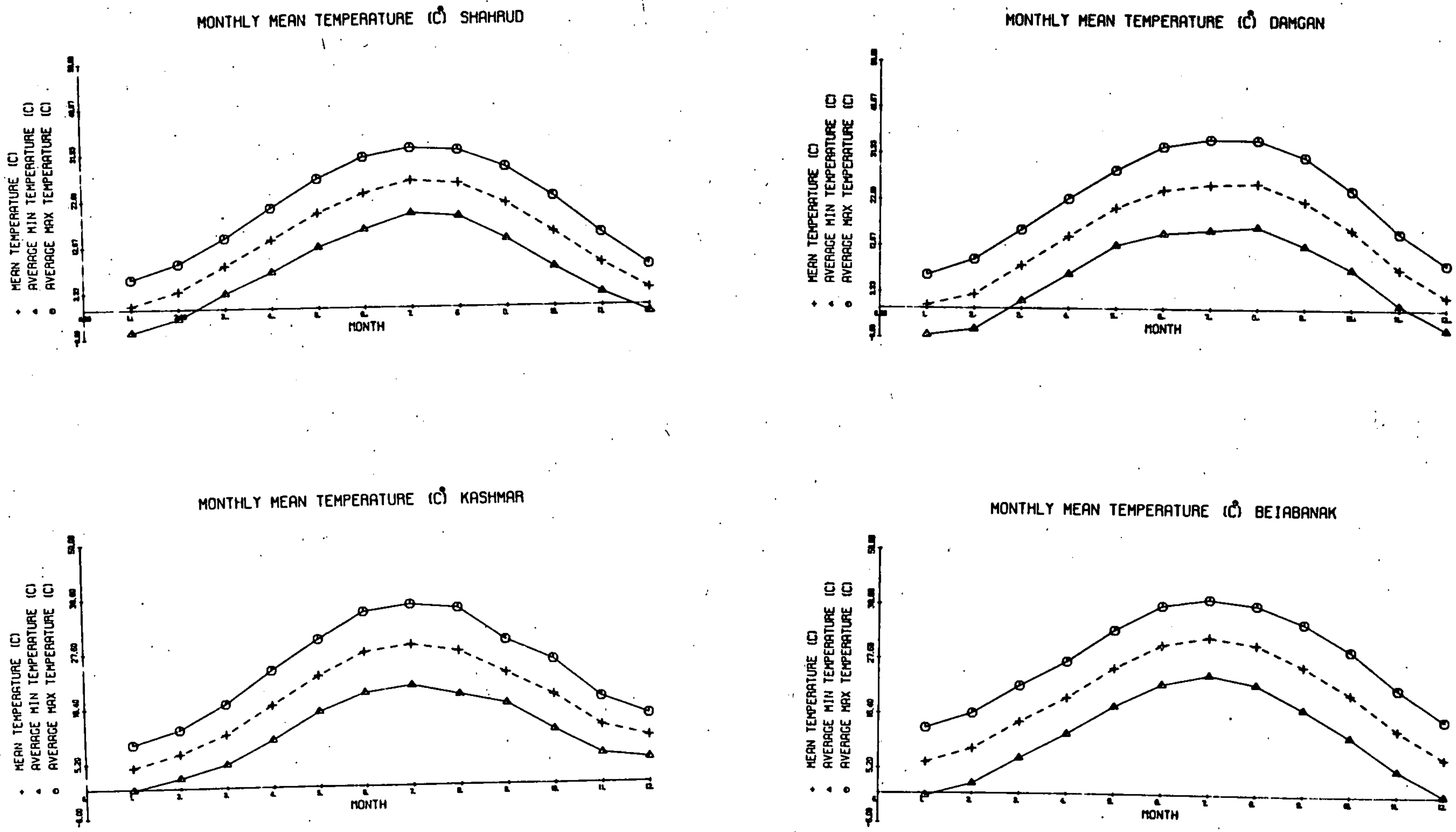


Fig A.2.12 MEAN ANNUAL TEMPERATURE (C)
THE DASHT-E-KAWIR AND ITS MARGIN

MINIMUM	14.00	15.16	16.32	17.48	18.64
MAXIMUM	15.16	16.32	17.48	18.64	19.80
FREQ.	2	0	3	1	2

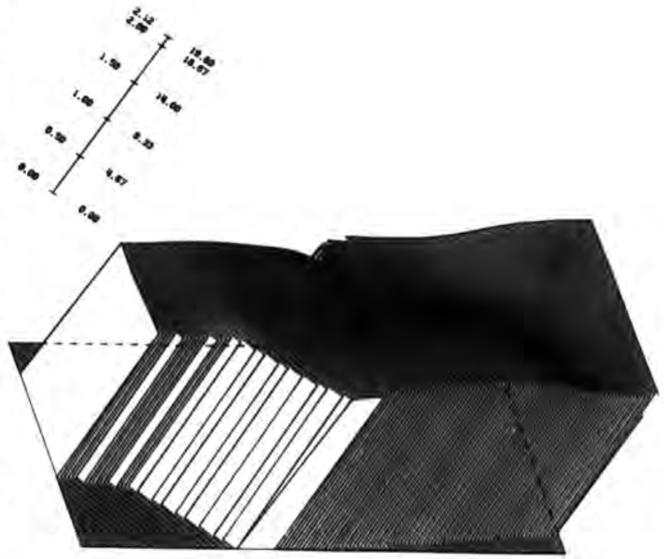
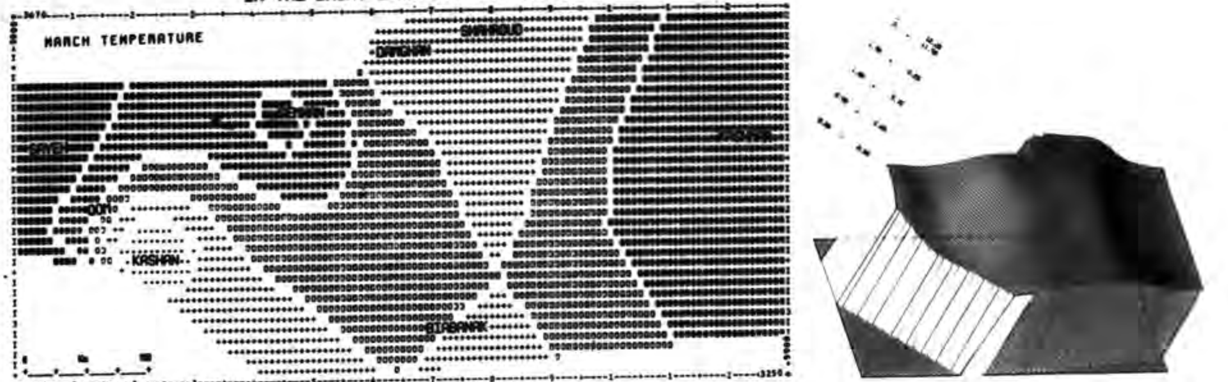
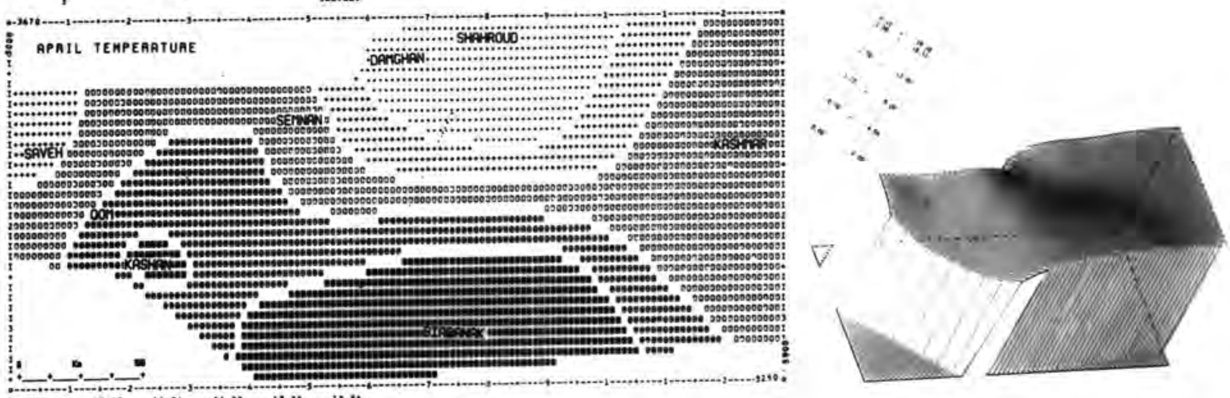


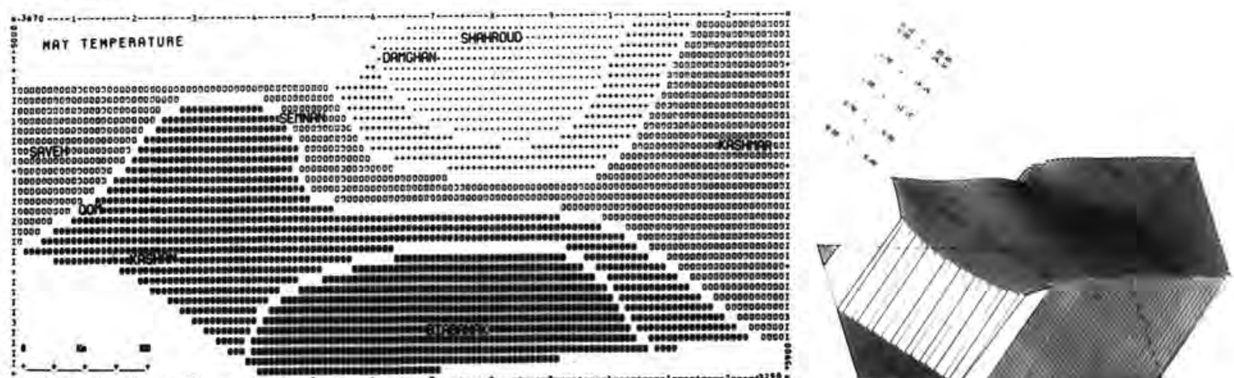
FIG A-2-13 SPRING TEMPERATURE (C°)
IN THE DASHT-E-KAVIR & ITS MARGIN



MINIMUM	7.20	8.20	9.20	10.20	11.20
MAXIMUM	8.20	9.20	10.20	11.20	12.20
FREQ.	1	2	1	1	3

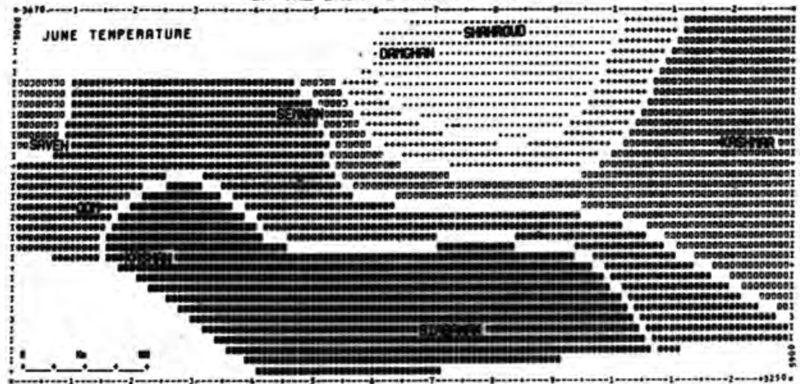


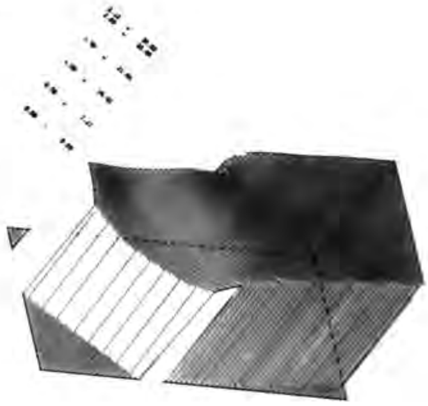
MINIMUM	13.90	15.06	16.22	17.38	18.54
MAXIMUM	15.06	16.22	17.38	18.54	19.70
FREQ.	2	1	2	1	2



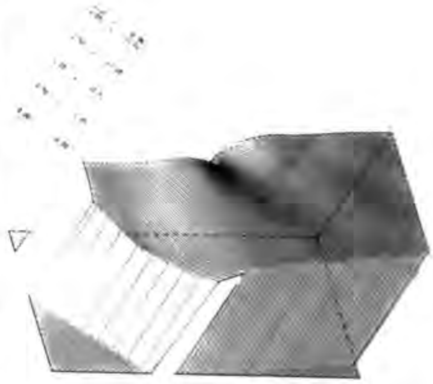
MINIMUM	19.30	20.60	21.90	23.20	24.50
MAXIMUM	20.60	21.90	23.20	24.50	25.80
FREQ.	2	0	2	3	1

FIG A-2-14 SUMMER TEMPERATURE (C°) IN THE DASHT-E-KAWIR & ITS MARGIN

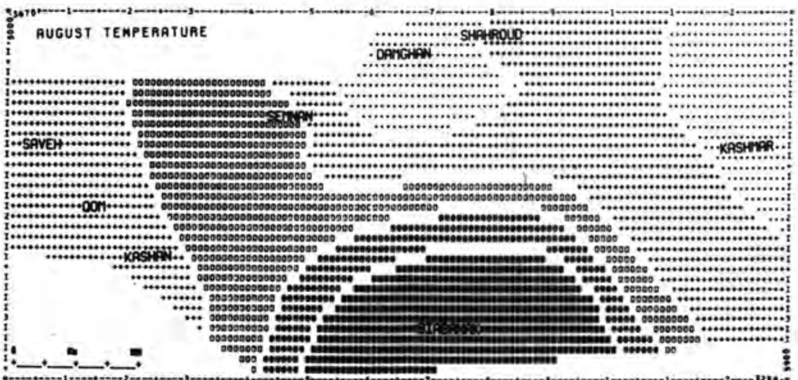


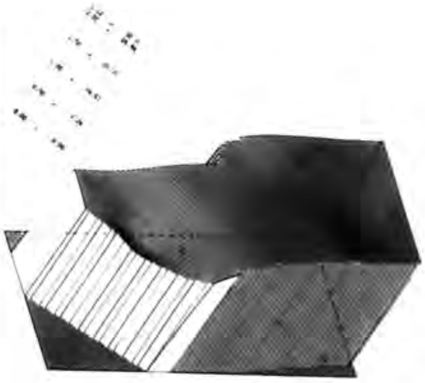


	1	2	3	4	5
MINIMUM	23.20	24.68	26.16	27.64	29.12
MAXIMUM	24.68	26.16	27.64	29.12	30.60
FREQ.	2	0	2	2	2



	1	2	3	4	5
MINIMUM	25.10	26.66	28.22	29.78	31.34
MAXIMUM	26.66	28.22	29.78	31.34	32.90
FREQ.	2	1	1	1	3

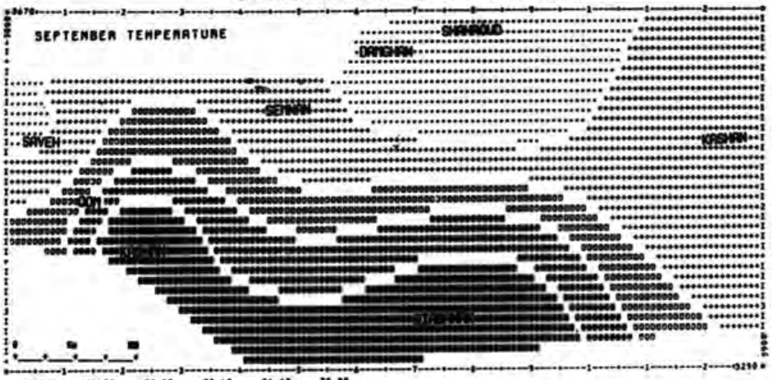




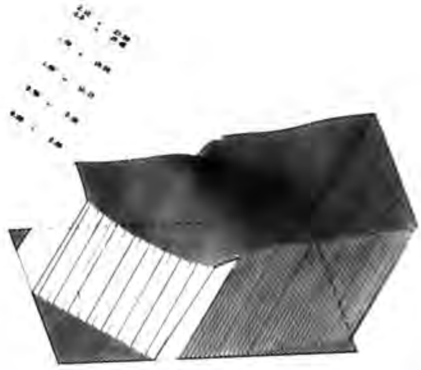
	1	2	3	4	5
MINIMUM	22.00	25.20	28.40	31.60	34.80
MAXIMUM	25.20	28.40	31.60	34.80	38.00
FREQ.	3	3	1	0	1

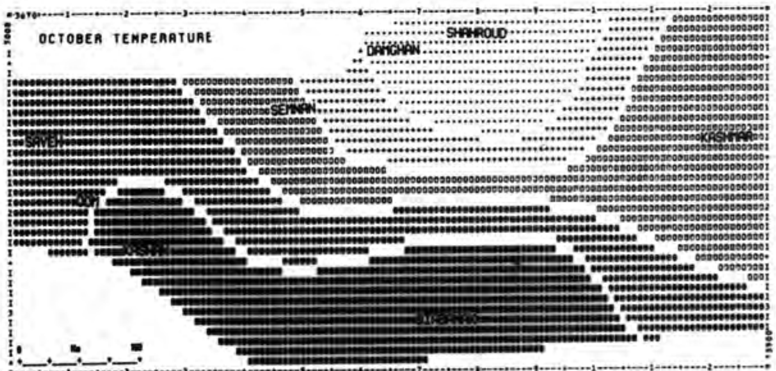
DATA VALUE EXTREMES ARE 22.00 38.09

FIG A-2-15 AUTUMN TMPERATURE (C°)
IN THE DASHT-E-KAWIR & ITS MARGIN

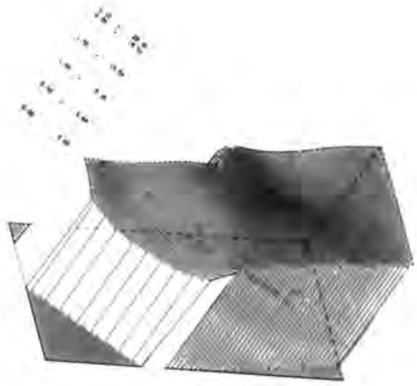


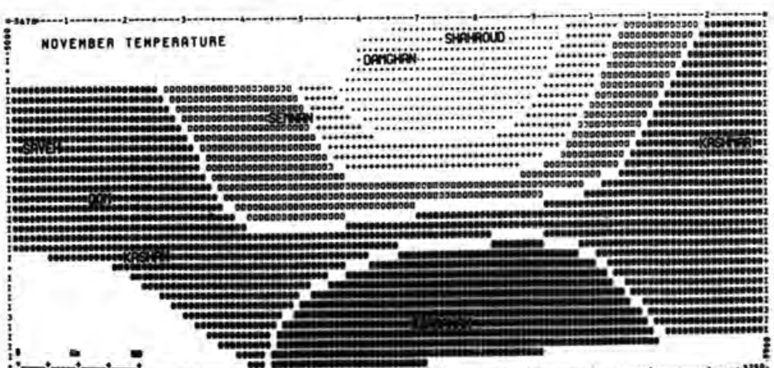
MINIMUM	21.00	22.20	23.40	24.60	25.80
MAXIMUM	22.20	23.40	24.60	25.80	27.00
FREQ.	2	3	1	0	2





MINIMUM	15.10	16.22	17.34	18.46	19.50
MAXIMUM	15.22	17.34	18.46	19.58	20.70
FREQ.	2	0	2	2	2





MINIMUM	8.20	9.26	10.32	11.38	12.44
MAXIMUM	9.26	10.32	11.38	12.44	13.50
FREQ.	2	0	1	4	1

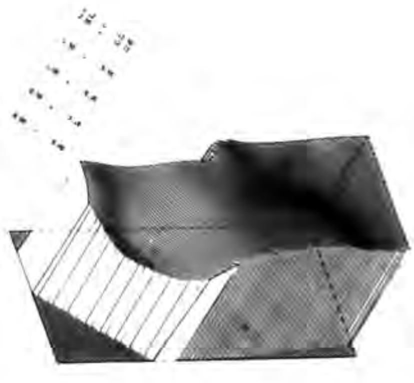
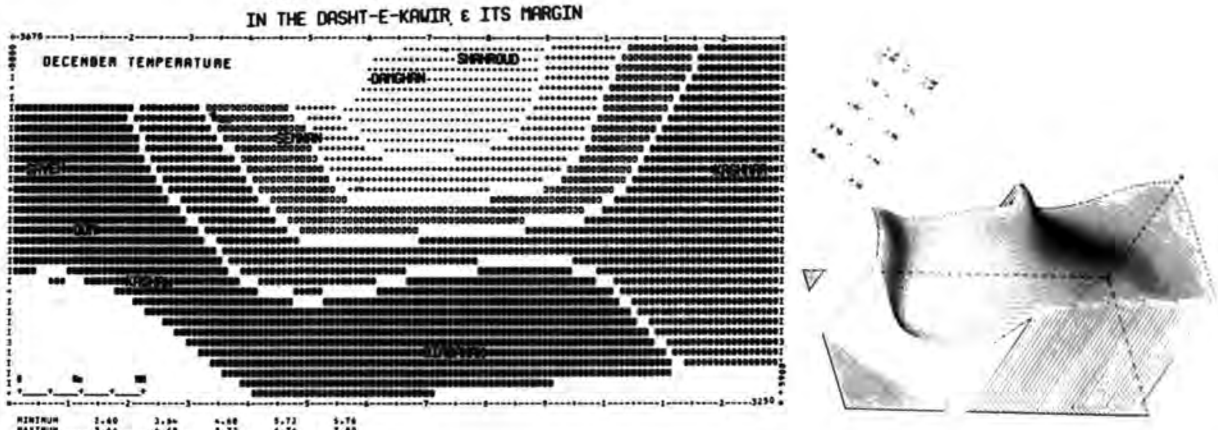
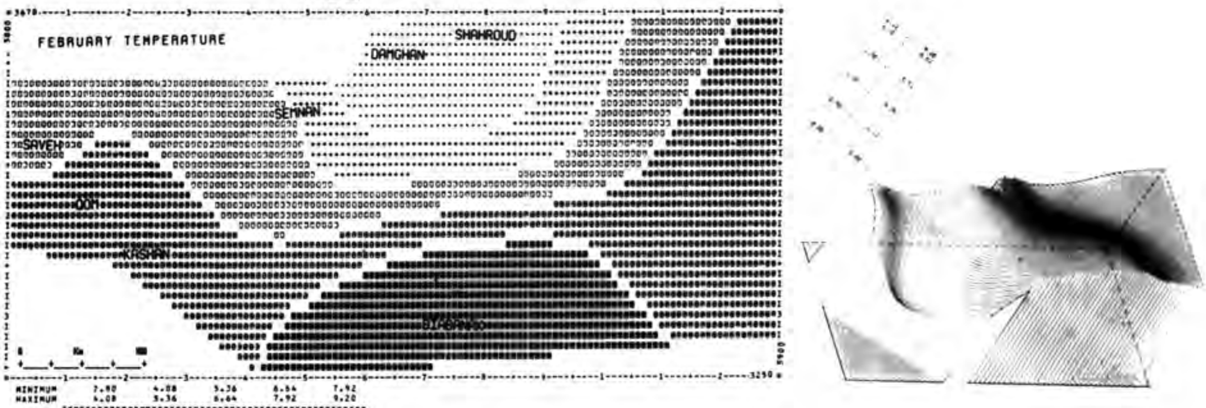


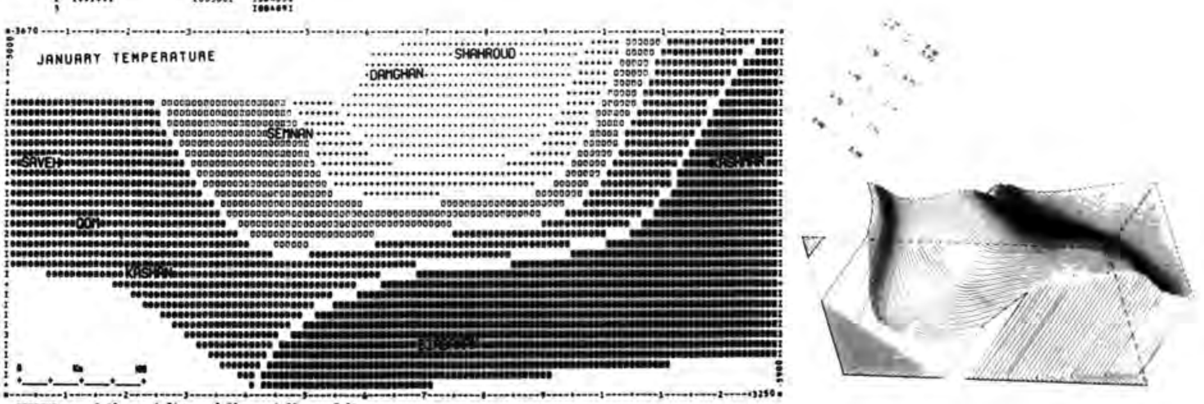
FIG A-2-16 WITER TEMPERATURE (C°)
IN THE DASHT-E-KAWIR & ITS MARGIN



MINIMUM	2.40	3.64	4.68	5.72	5.76
MAXIMUM	3.64	4.68	5.72	6.76	7.80
SYMBOLS	....1....	++++2++++	000030000	####4####	####5####
FREQ.	2	0	1	2	3
1	I..1..I		I003001	I##4##I	I##5##I
2	I..1..I			I##4##I	I##5##I
3					I##5##I



MINIMUM	2.80	4.08	5.36	6.64	7.92
MAXIMUM	4.08	5.36	6.64	7.92	9.20
SYMBOLS	....1....	++++2++++	000030000	####4####	####5####
FREQ.	2	0	2	3	1
1	I..1..I		I003001	I##4##I	I##5##I
2	I..1..I		I003001	I##4##I	
3				I##4##I	



MINIMUM	0.60	1.76	2.92	4.08	5.24
MAXIMUM	1.76	2.92	4.08	5.24	6.40
SYMBOLS	....1....	++++2++++	000030000	####4####	####5####
FREQ.	2	0	1	3	2
1	I..1..I		I003001	I##4##I	I##5##I
2	I..1..I			I##4##I	I##5##I
3				I##4##I	

Table A.2.5 Monthly Potential & Actual Evapotranspiration for the Selected Stations in the Margin of Dasht-Kawir (mm)

STATION	KASHAN		QOM		SAVEHE		SEMNAN		DAMGAN		SHAHRUD		KASHMAR		BEIABANAK	
E / Month	E_{TP}	E_{TA}	E_{TP}	E_{TA}	E_{TP}	E_{TA}	E_{TP}	E_{TA}	E_{TP}	E_{TA}	E_{TA}	E_{TP}	E_{TA}	E_{TP}	E_{TA}	E_{TP}
Jan	2.7	2.3	1.8	1.5	1.8	1.5	1.5	1.2	0.1	0.0	0.2	0.1	3.6	3.1	2.3	1.9
Feb.	7.7	7.0	8.2	7.5	7.3	6.6	5.4	4.9	2.9	2.6	5.1	4.6	10.2	9.3	9.7	8.9
March	29.9	30.8	40.9	42.2	42.7	44.1	31.6	32.6	25.7	26.5	16.0	16.0	29.7	30.6	62.3	64.3
Apr.	66.4	70.0	134.5	139.5	100.8	105.7	86.4	90.6	68.8	74.0	63.9	67.0	84.0	86.7	198.7	215.4
May	124.1	143.7	371.0	433.2	260.7	304.5	184.2	215.2	129.9	151.0	117.8	137.6	173.0	202.1	578.3	676.2
Jun.	192.1	227.1	696.2	823.2	490.2	581.2	306.9	363.9	176.9	210.0	165.8	196.6	269.4	319.4	1136.7	1347.9
July	287.8	337.9	925.9	1082.5	485.0	571.0	378.1	445.2	192.6	227.7	200.6	236.2	303.8	357.4	1390.9	1637.7
Aug.	336.4	382.0	657.0	745.6	588.8	669.7	304.3	346.1	197.0	224.7	192.0	218.4	269.4	306.4	1151.0	1309.8
Sep.	154.4	158.0	402.8	411.5	260.7	265.8	176.5	180.8	147.3	150.8	137.8	141.8	174.8	178.7	624.0	637.5
Oct.	80.0	77.1	185.8	179.6	161.0	155.1	95.5	92.2	82.8	79.5	74.6	69.8	101.8	98.0	241.7	233.1
Nov.	22.7	19.4	36.0	30.6	42.7	36.3	28.9	24.8	22.9	19.5	26.7	22.5	35.9	30.6	44.4	37.9
Dec.	8.1	6.6	5.1	4.1	10.3	8.4	4.5	3.7	2.5	2.0	4.6	3.7	7.2	5.9	5.0	4.1
Total	1312.6	1361.2	3464.8	3901.0	2480.2	2749.8	1603.8	1801.2	1049.4	1168.3	1005.1	1114.3	1462.0	1628.2	5445.5	6170.7

E_{TP} = Potential Evapotranspiration E_{TA} = Actual Potential Evapotranspiration

FIG A-2-17 ANNUAL WATER BALANC IN THE SELACTED STATIONS
IN THE DASHT-E-KAWIR MARGIN

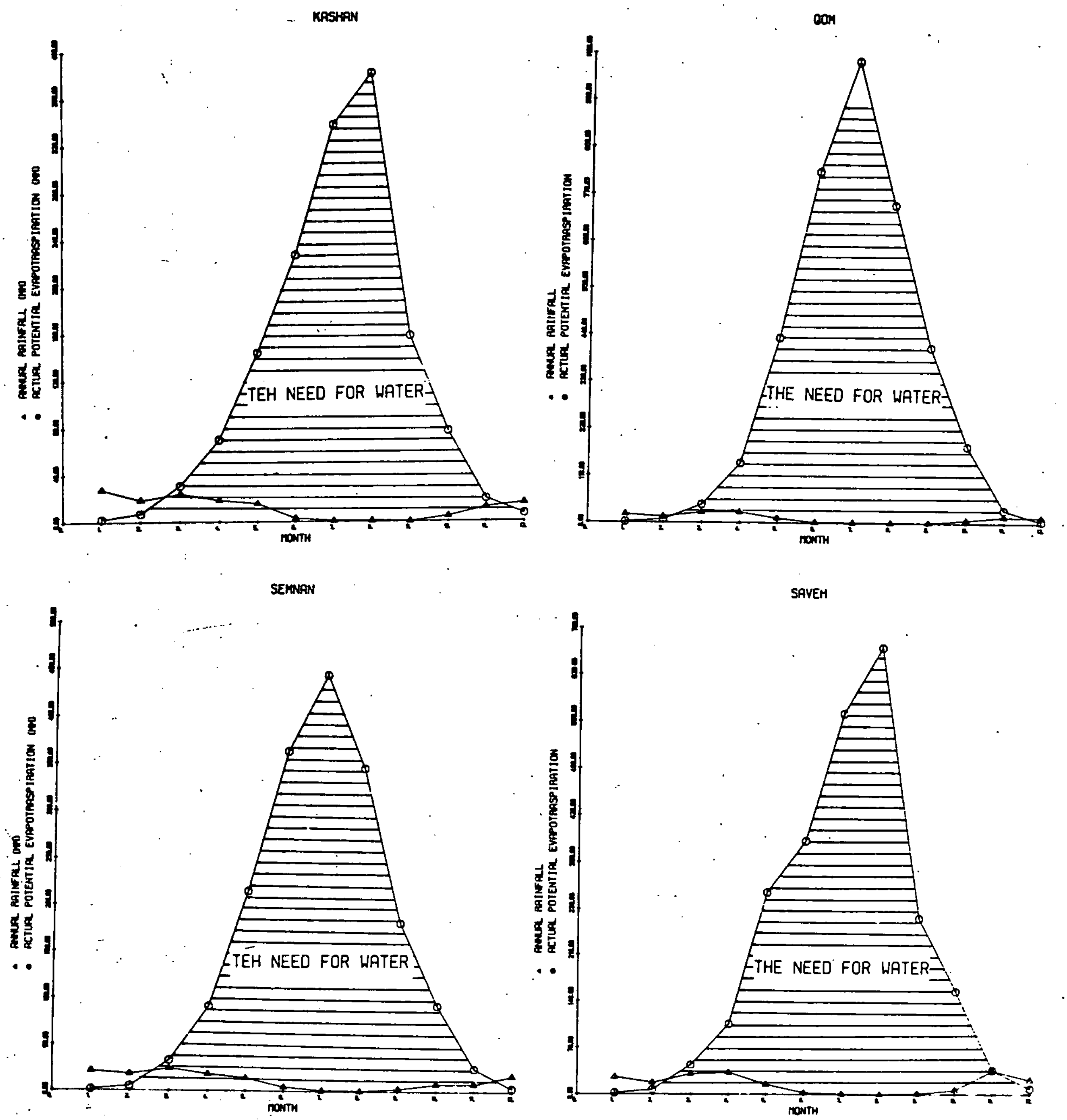


FIG A-2-17 ANNUAL WATER BALANC IN THE SELACTED STATIONS
IN THE MARGIN OF DASHT-E-KAWIR

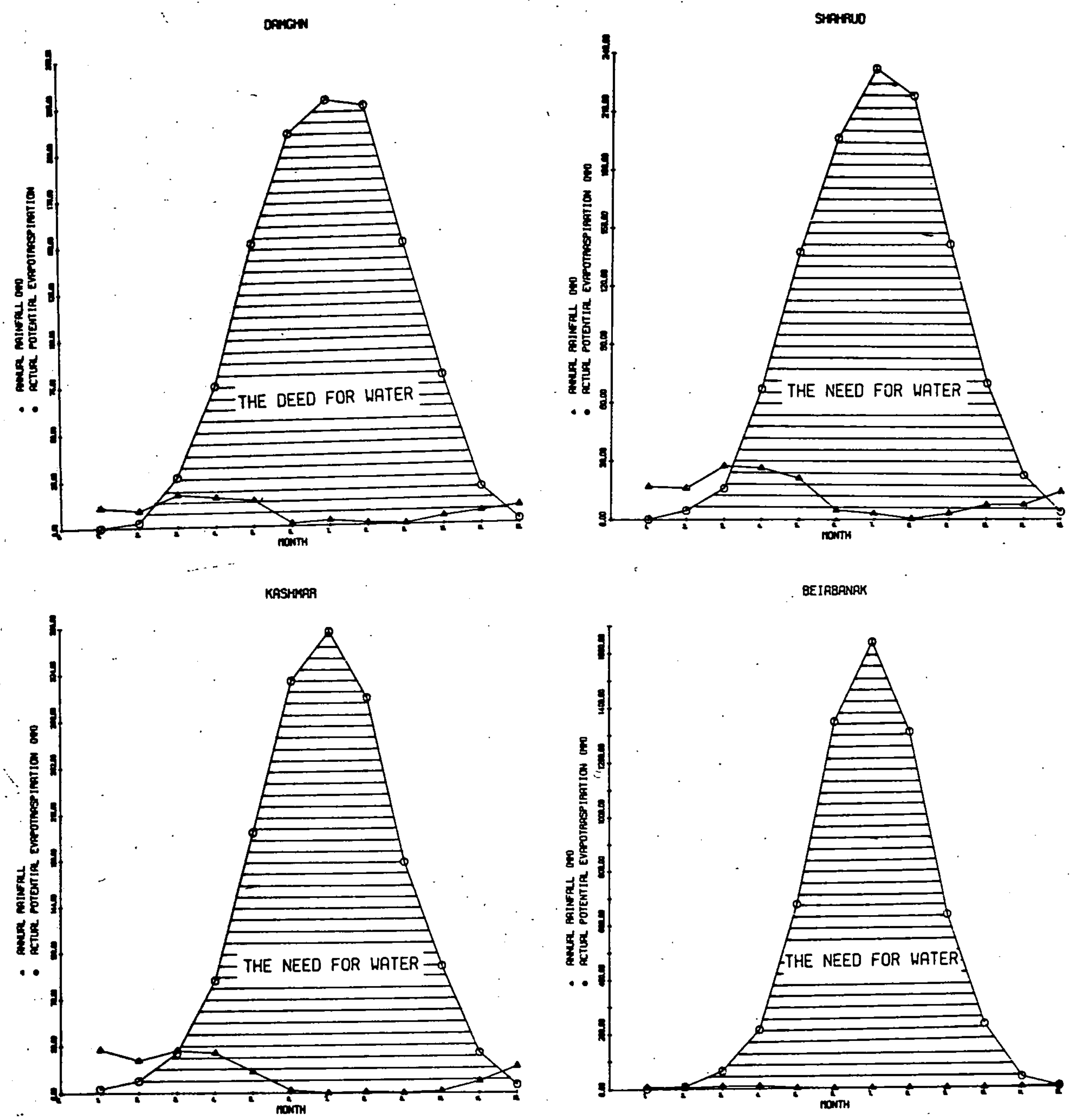
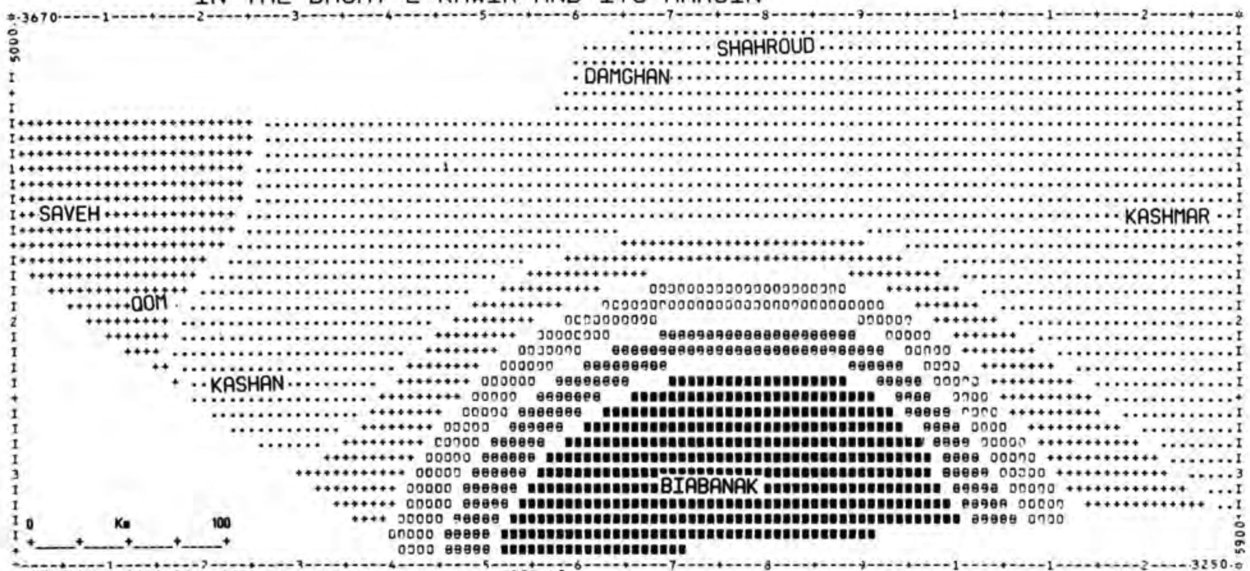


FIG A-2-18 ACTUAL EVAPOTRANSPIRATION (MM)
IN THE DASHT-E-KAWIR AND ITS MARGIN



MINIMUM	1114.30	2125.58	3136.86	4148.14	5159.42
MAXIMUM	2125.58	3136.86	4148.14	5159.42	6170.70
SYMBOLS	....1....	++++2++++	000030000	888848888	■■■■5■■■■
FREQ.	5	1	1	0	1

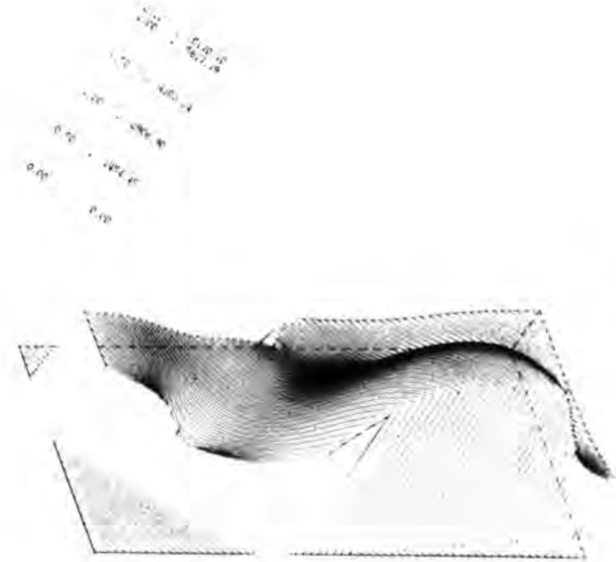


Table A.2.6 Characteristics of Water Balance in the Margin of Dast-e-Kawir (mm)

Station	Evapotrans-piration ET	Rainfall $\bar{p}$	Water Deficit WD	Water Surplus WS *	Effect. Rainfall EF
Abuzaid-Abad	1461.9	139.9	1369.2	46.1	113.1
Qom	3901.0	130.3	380.0	38.0	94.2
Sarehe	2749.8	186.2	2611.0	47.0	160.9
Semnan	1800.8	134.2	1702.3	45.7	106.9
Damghan	1168.3	92	1102.8	24.3	61.9
Shahroud	1114.3	147.8	1016.6	51.3	123.2
Kashmar	1628.2	169.5	1619.4	61.4	157.1
Beiabanak	6170.7	41.4	6142.8	7.3	37.9

* Water surplus occurs during the rainfall season

Table A.2.7 Monthly Water Budget in The Selected Stations in the margin of Dasht-e-Kawir

Water Budget - ABUZAID-Abad

(mm)						100 mm Storage			
Parameter / Month	Evapotranspiration ET	Rainfall P	Water deficit WD	Water Surplus WS	Evap. Loss EL	Ground charge	Ground Storage	Run-off	Effective Rain fall
Jan	2.3	27.6		25.3		25.3	34.5		2.3
Feb.	7.0	18.6		11.6		11.6	56.1		7.0
Mar.	30.8	23.8	7.0			-6.1	50		29.9
Apr.	70.0	18.3	52.7			-50			68.3
May	143.7	15.5	128.2						
June	227.1	2.7	222.4						
Jul.	337.9	0.4	337.5						
Aug.	382.0	0.5	381.5						
Sep.	158.0	0.0	158.0						
Oct.	77.1	4.4	72.7						
Nov.	19.4	12.2	7.2						
Dec.	6.6	15.8		9.2		9.2	9.2		6.6
Total	1461.9	139.9	1369.2	46.1					113.1

RATIOS $\frac{P}{ET} = 0.09$ $\frac{WD}{P} = 9.7$ $\frac{WS}{P} = 0.35$

Thornthwaite's Index $\frac{WS}{ET} = 0.03$ $\frac{WD}{ET} = 0.93$

Table A.2.7 (cont.) Water Budget - SAVEH

Parameter / Month	ET (mm)	P (mm)	WD (mm)	WS (mm)	EL (mm)	Ground Charge (100 mm Storage)	Ground Storage (100 mm Storage)	Run-off (100 mm Storage)	EP (100 mm Storage)
Jan	1.5	25.4		23.9		23.9	35.5		1.5
Feb.	6.6	17.1		10.5		10.5	46.0		6.6
Mar.	44.1	30.7	13.4			-13.4	32.6		44.1
Apr.	105.7	32.6	73.1			-32.6			65.2
May	304.5	14.6	289.9						
June	381.2	2.2	579.0						
Jul.	571.0	0.0	571.0						
Aug.	669.7	0.0	669.7						
Sep.	265.8	0.9	264.9						
Oct.	155.1	6.3	148.8						
Nov.	36.3	35.1	1.2						35.1
Dec	8.4	21.2		12.6		12.6			8.4
Total	2749.8	186.2	2611.0	47.0					160.4

Ratios $\frac{P}{ET} = 0.06$ $\frac{WS}{P} = 0.23$ $\frac{WD}{P} = 14.02$

Thornthwaite's index $\frac{WS}{ET} = 0.01$ $\frac{WD}{ET} = 0.94$

Table A.2.7 (cont.)

Water Budget - QOM

Parameters / Month	mm					100 mm Storage			
	ET	P	WD	WS	EL	Ground change	Ground Storage	RO	EP
Jan	1.5	19.2		17.7		17.7	27.2		1.5
Feb.	7.5	13.3		5.8		5.8	33.0		7.5
Mar.	42.2	24.2	18.0			-18	15.0		42.4
Apr	139.5	24.9	114.6			-15	0		38.9
May	433.2	10.7	422.5						
Jun.	823.2	1.1	822.1						
Jul	1082.5	0.9	1081.6						
Aug.	745.6	0.3	795.3						
Sep.	411.5	0.4	411.1						
Oct.	179.6	6.8	172.8						
Nov.	30.6	14.9	15.7						
Dec.	4.1	13.6		9.5		9.5	9.5		4.1
Total	3901.0	130.3	3803.1	28.0					94.2

RATIOS $\frac{P}{ET} = 0.03$ $\frac{WD}{P} = 29.18$ $\frac{WS}{P} = 0.21$

Thornthwaite's index $\frac{WD}{ET} = 0.97$ $\frac{WS}{ET} = 0.007$

Table A.2.7 (cont.)

Water Budget - SEMNAN

Parameters / Month	ET (mm)	P (mm)	WD (mm)	WS (mm)	EL (mm)	Ground Charge (100 mm Storage)	Ground Storage (100 mm Storage)	Run off RO (100 mm Storage)	EP (100 mm Storage)
Jan.	1.2	20.7		19.5		19.5	32.7		1.2
Feb	4.9	17.9		13.0		13.0	45.7		4.9
March	32.6	23.7	8.9			-8.9	46.8		32.6
Apr.	90.6	17.7	72.9			-46.8	0		64.5
May	215.2	13.5	191.7						
Jun	363.9	4.4	359.5						
Jul.	445.2	0.7	444.5						
Aug.	346.1	0.2	345.9						
Sep.	180.8	2.8	178.0						
Oct.	92.0	7.8	84.2						
Nov.	24.6	7.9	16.7						
Dec.	3.7	16.9		13.2		13.2	13.2		3.7
Total	1800.8	134.2	1702.3	45.7					106.9

RATIOS $\frac{P}{ET} = 0.04$ $\frac{WD}{P} = 20.49$ $\frac{WS}{P} = 0.3$

Thornthwaite's $\frac{WD}{ET} = 0.96$ $\frac{WS}{ET} = 0.01$

Table A.2.7 (Cont.)

Water Budget - DAMGHAN

Parameters / Month	mm					100 mm Storage			
	ET	P	WD	WS	EL	Ground Charge	Ground Storage	RO	EP
Jan	0.0	10.8		10.8		10.8	18.0		0.0
Feb.	2.6	8.9		6.3		6.3	24.3		2.6
Mar.	26.5	17.3	9.2			-9.2	15.2		26.5
Apr.	75.0	15.6	60.6			-15.2	0.0		30.8
May	151.0	13.9	137.1						
June	210.0	1.3	208.7						
July	227.7	2.7	225.0						
Aug.	224.7	1.0	223.7						
Sep.	150.8	0.4	150.4						
Oct.	79.5	4.2	75.3						
Nov.	19.5	6.7	12.8						
Dec.	2.0	9.2		7.2		7.2	7.2		2.0
Total	1168.3	92	1102.8	24.3					61.9

RATIOS $\frac{P}{ET} = 0.07$ $\frac{WD}{P} = 11.9$ $\frac{WS}{P} = 0.26$

Thornthwaite's Index $\frac{WS}{ET} = 0.02$ $\frac{WD}{ET} = 0.94$

Table A.2.7 (cont.)

Water Budget - SHAHRUD

Parameter / Month	mm					100 mm Storage			
	ET	P	WD	WS	EL	Ground Charge	Ground Storage	RO	EP
Jan	0.1	16.9		16.8		16.8	28.4		0.1
Feb.	4.6	16.1		11.5		11.5	39.9		4.6
Mar	16.0	27.4		11.5		11.4	51.3		16.0
Apr.	67.0	26.4	40.6			-40.6	10.7		67.0
May	137.6	21.1	116.5			-10.7	0.0		31.8
Jun.	196.6	4.7	191.9						
Jul	236.2	2.9	233.3						
Aug.	218.4	0.3	218.1						
Sep.	141.8	3.0	138.8						
Oct.	69.8	7.4	62.4						
Nov.	22.5	7.5	15.0						
Dec.	3.7	14.1		11.6		11.6	11.6		8.7
Total	1114.3	147.8	1016.6	51.3					123.2

RATIOS $\frac{P}{ET} = 0.13$ $\frac{WD}{P} = 6.87$ $\frac{WS}{P} = 0.34$

Thornthwaite's Index $\frac{WS}{ET} = 0.04$ $\frac{WD}{ET} = 0.91$

Table A.2.7 (cont.)

Water Budget - KASHMAR

Parameter / Month	mm					100 mm Storage			
	ET	P	WD	WS	EL	Ground charge	Ground Storage	RO	EP
Jan.	3.1	33.1		30.0		30.0	44.1		3.1
Feb.	9.3	24.8		15.5		15.5	59.6		9.3
Mar.	30.6	32.4		1.8		1.8	61.4		30.6
Apr.	86.7	30.6	56.1			-56.1	5.3		86.7
May	202.1	16.2	285.9			- 5.3			21.5
Jun.	319.4	2.2	316.2						
Jul.	357.4	0.0	357.3						
Aug.	306.4	0.6	305.8						
Sep.	178.7	0.0	178.7						
Oct.	98.0	1.4	96.6						
Nov.	30.6	8.8	21.8						
Dec.	5.9	20		14.1		14.1	14.1		5.9
Total	1628.2	169.5	1619.4	61.4					157.1

RATIOS $\frac{P}{ET} = 0.1$ $\frac{WD}{P} = 9.5$ $\frac{WS}{P} = 0.36$

Thornthwaite's Index $\frac{WS}{ET} = 0.03$ $\frac{WD}{ET} = 0.99$

Table A.2.7 (cont.)

Water Budget - BEIABANAK

Parameter / Month	ET	P	WD	WS	EL	Ground Charge	Ground Storage	RO	EP
	mm					100 mm Storage			
Jan	1.9	7.1		5.2		5.2	7.3		1.9
Feb.	8.9	4.9	3.8			-3.8	3.5		8.7
Mar.	64.3	9.7	55.0			-3.5	0.0		13.2
Apr.	215.4	9.9	205.7						
May	676.2	1.9	674.3						
June	1347.9	0.0	1347.9						
Jul	1637.7	0.0	1637.7						
Aug.	1309.8	0.0	1309.8						
Sept.	637.5	0.0	637.5						
Oct.	233.1	6.1	233.0						
Nov.	37.9	1.9	36.0						
Dec.	4.1	6.1		2.1		2.1	2.1		4.1
Total	6170.7	41.4	6142.8	7.3					37.9

RATIOS $\frac{P}{ET} = 0.007$ $\frac{WD}{P} = 130.5$ $\frac{WS}{P} = 0.14$

Thornthwaite's Index $\frac{WS}{ET} = 0.001$ $\frac{WD}{ET} = 0.99$

FIG A-2-19 ANNUAL WATER SURPLUS
IN THE DASHT-E-KAWIR AND ITS MARGIN

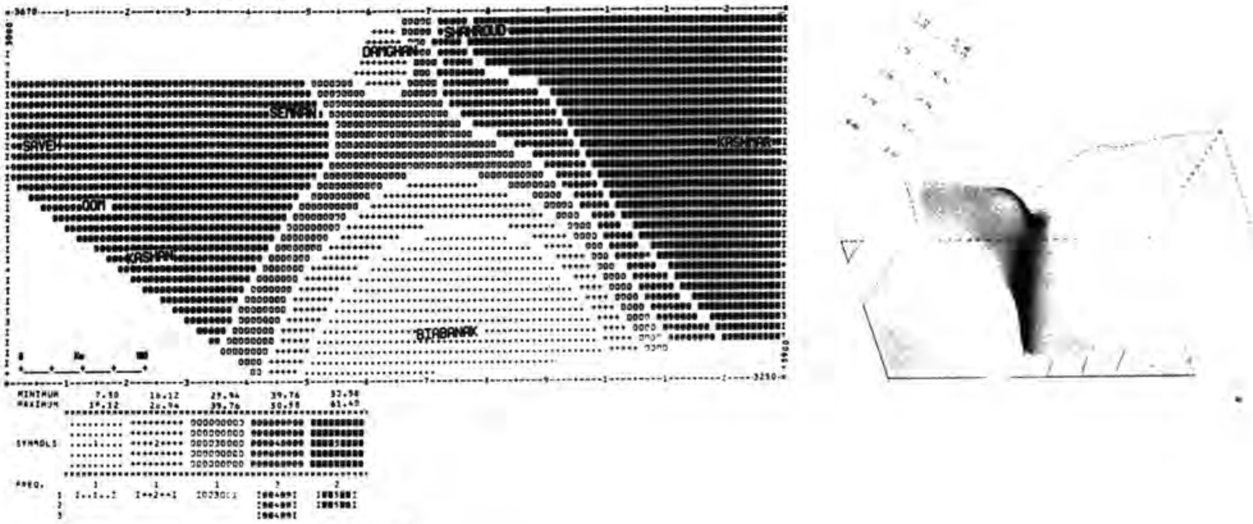


FIG A-2-20 ANNUL WATER DEFICIT (MM)
IN THE DASHT-E-KAWIR AND ITS MARGIN

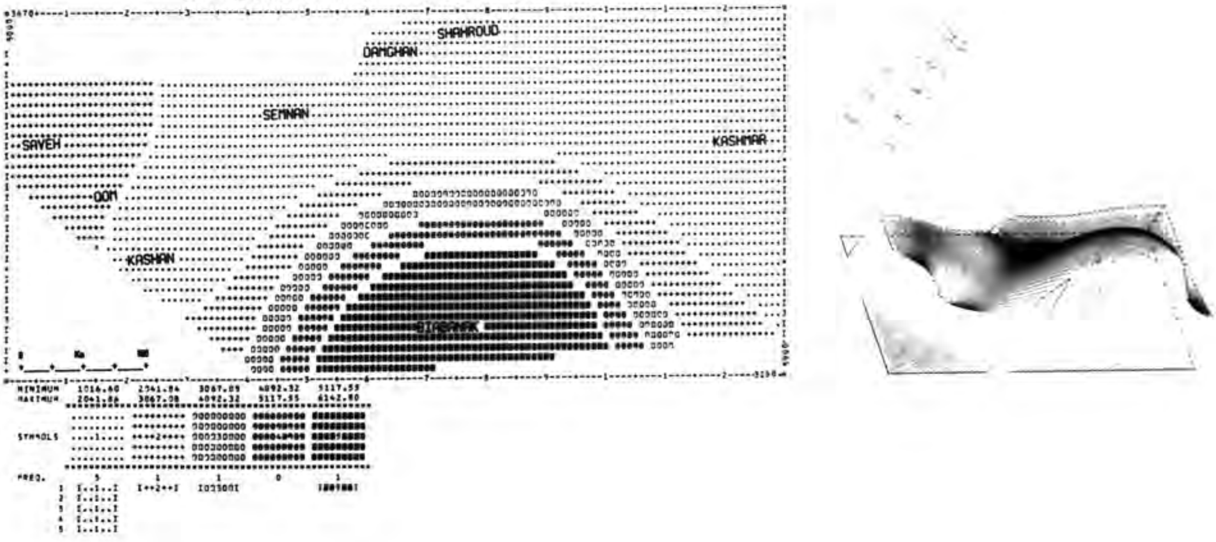
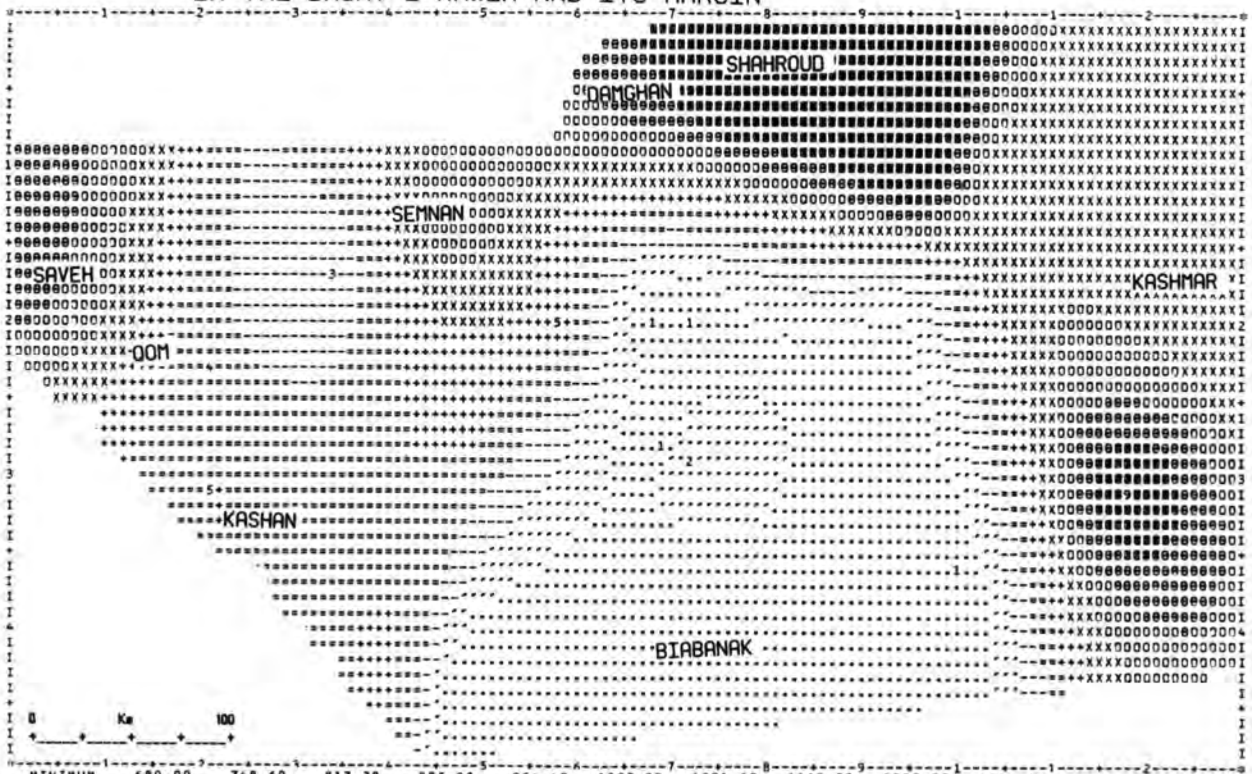
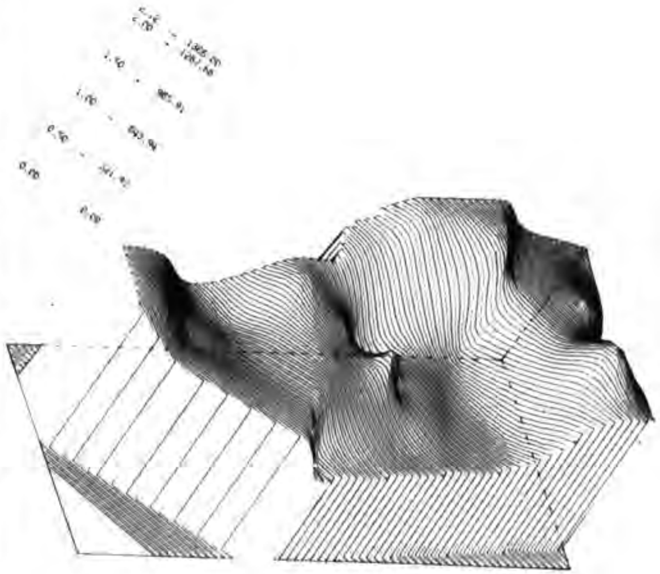


FIG A-2-21 ALTITUDES (M)

IN THE DASHT-E-KAWIR AND ITS MARGIN



MINIMUM	680.00	748.60	817.20	885.80	954.40	1023.00	1091.60	1160.20	1228.80	1297.40
MAXIMUM	748.60	817.20	885.80	954.40	1023.00	1091.60	1160.20	1229.80	1297.40	1366.00
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	0000700000	88888889888	88889888	8888 8888
FREQ.	5	1	1	2	3	1	1	2	1	1



APPENDIX 3

Actual Method for Construction of a Qanat

In this section the process of construction of a qanat is described in the way that it is actually achieved by Moganis (a class of professional digger). In order to be as accurate as possible, the information about this was obtained by interviewing some Moganis and closely observing their work as much as possible, during my field studies in the Abuzaid-Abad area and other parts of Iran.

According to the information derived, planning for digging a qanat is divided into six stages as follows:

The first stage is to select a suitable field for agriculture (irrigated cultivation). In the second stage, the owner must acquire enough capital. The third stage is the search for underground water. The fourth stage involves the digging of test wells. Measuring the slope is the fifth stage and the sixth stage is the actual digging of the qanat.

The owner, or owners, come to a conclusion after the first and second stages, and based on this decision, the Moqanis are hired. The Moqanis, or the chief of the Moqanis (Mamar) are responsible for the last four stages.

(a) Suitable field. The principal aim of digging a qanat is to provide water supply for irrigation which is needed to make the land suitable for agriculture. Sometimes even though the water supply is potentially adequate, either there are not enough fields for agriculture, or the land is not suitable. There is a good example of this situation in the Abuzaid-Abad area, although in this case the example is a deep well (Mazreah-Zahraieh).

(b) Capital. There are many qanats in Iran which are not yet finished or have been finished by their second or third owners. This is a result of the original owner's incorrect estimation of the capital necessary for constructing a qanat, and so they lacked enough money for the digging of the qanats.

(c) Search for underground water. The search for underground water is based entirely on information supplied by the Moqanis, although recently the opinion of natural scientists have been used in the construction and maintenance of qanats.

The majority of Moqanis take into account three factors, topography, basic material of foothill or mountains (area) and vegetation.

1. Topography. First of all, the qanat under construction must have the correct slope to bring the water to the field where it is required. Secondly, the best place for digging a qanat is in the foothills of ranges of mountains, not on the slopes of a single mountain. Thirdly, the width of the mountains is important because the qanat receives more water from the wider mountains, as these receive more moisture than a single mountain.

2. Basic material of mountains or foothill. Usually the Moqani use their experience in their search for underground water. They believe that if a mountain consists of dark or white-coloured rock (usually igneous rocks have these colours), it is unlikely that there will be water. Also a foothill is best for the construction of a qanat because there is more soil than rock. In general, the best aquifers are the coarse-grained, saturated portion of the unconsolidate.(1) Moqanis believe that in mountain regions where the rocks are reddish, and in the plain where there is more soil than rock, are located the most suitable places for digging a qanat. (In the mountainous area reddish colour in the rocks usually occurs in the calcareous formation).

3. Vegetation. The Moqani can detect underground water from some particular kinds of plants, which usually have vertical roots. As the result of the existence of underground water, these kinds of plants can survive in the hot and long dry summer.

4. Digging of test well. The Moqani starts to dig the <u>Chah-e-Gamaneh</u> (experimental wells) to find out the level of the water table and to understand the structure of the ground and availability of underground water. The location of the first experimental well is usually determined from the gradient of the area. The test wells are usually located at three points along the route of the qanats. The first <u>gomanehe</u> is dug in the <u>Khosh-kan</u> (dry section) of the qanat. The third <u>gomanehe</u> is dug in the <u>Ab-deh</u> (water-bearing strata) and the second <u>gomanehe</u> is located between the first

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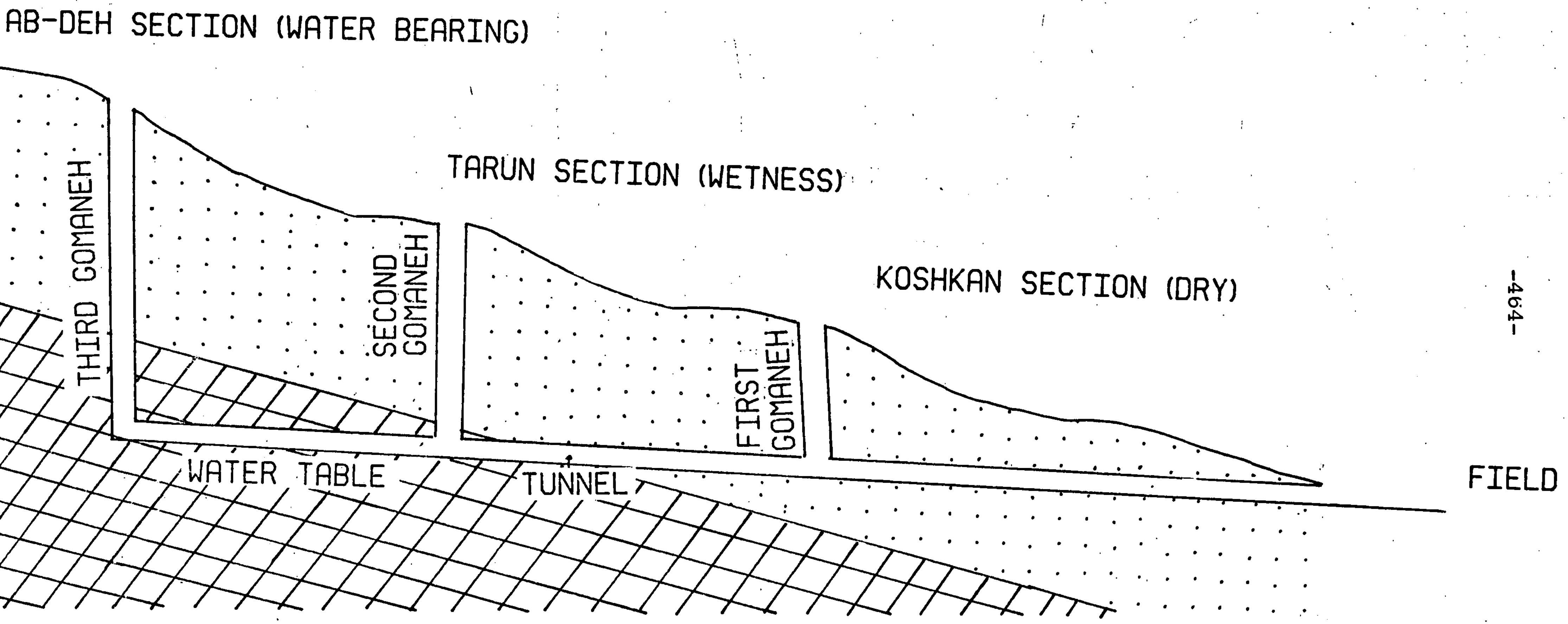
1. U.S. Department of the Interior, Bureau of Reclamation (1977) <u>Ground Water Manual</u>, Washington, p.7.

FIG A.3.1 LOCATION OF TEST WEL



and third wells, and is called Taran (wetness). If the difference in elevation between the field and the mouth of the third gomaneh is more than the depth of the well, it is successful, because the water-table level is higher than the field, and water can flow to the field by gravity force. Figure A.3.1 shows the situation of the Chaheh Gomanehs.

5. Direction of qanat. To determine the direction of a qanat, the Moqani finds the direction of ground water flow from the test wells, and the tunnel of the qanat is dug along the route of the ground water flow in the water-bearing section. Its direction can be changed toward the field in the dry section.

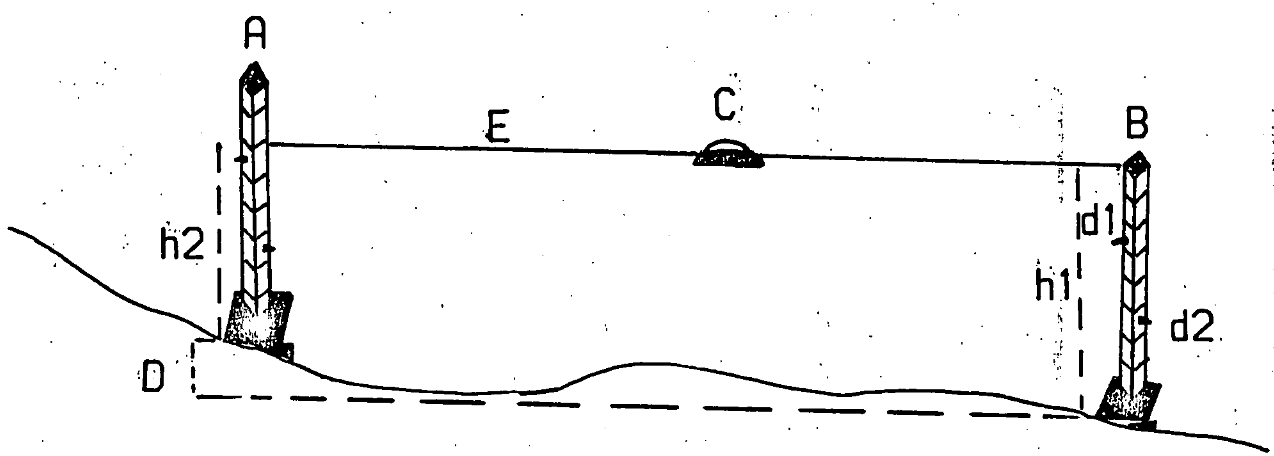
6. Measuring the gradient.

(a) Traditional method for estimating the qanat gradient

Measuring the gradient is crucial for the successful construction of a qanat. A mistake in measuring the slope can cause a major problem in the construction of a qanat because it affects the force of gravity to the determined field. Therefore, the Moqani tries very carefully to carry out this job with accuracy and failure is very rare. This notwithstanding, unfortunately there is a badly measured qanat in the Abuzaid-Abad area (Mazreah-Zahraieh). This question of the correct sloping will be discussed in the mathematical method for estimation of the qanat gradient.

The apparatus for measuring the gradient used by the Moqani is simple. (Fig. A.3.2&3).It is the basis of levelling in surveying - the levelling goes from the field to the first experimental well, and from the first test well to the second,

FIG A-3-2 MEASURING THE SLOP OF QANAT



A & B, two wooden poles are fixed on a flat wooden base (each 1.5 m long).

d1 and d2, two slots, a moving piece of wood suspended inside each slot, for keeping the poles vertical (if the poles are not exactly vertical these pieces of wood come out of the slots.

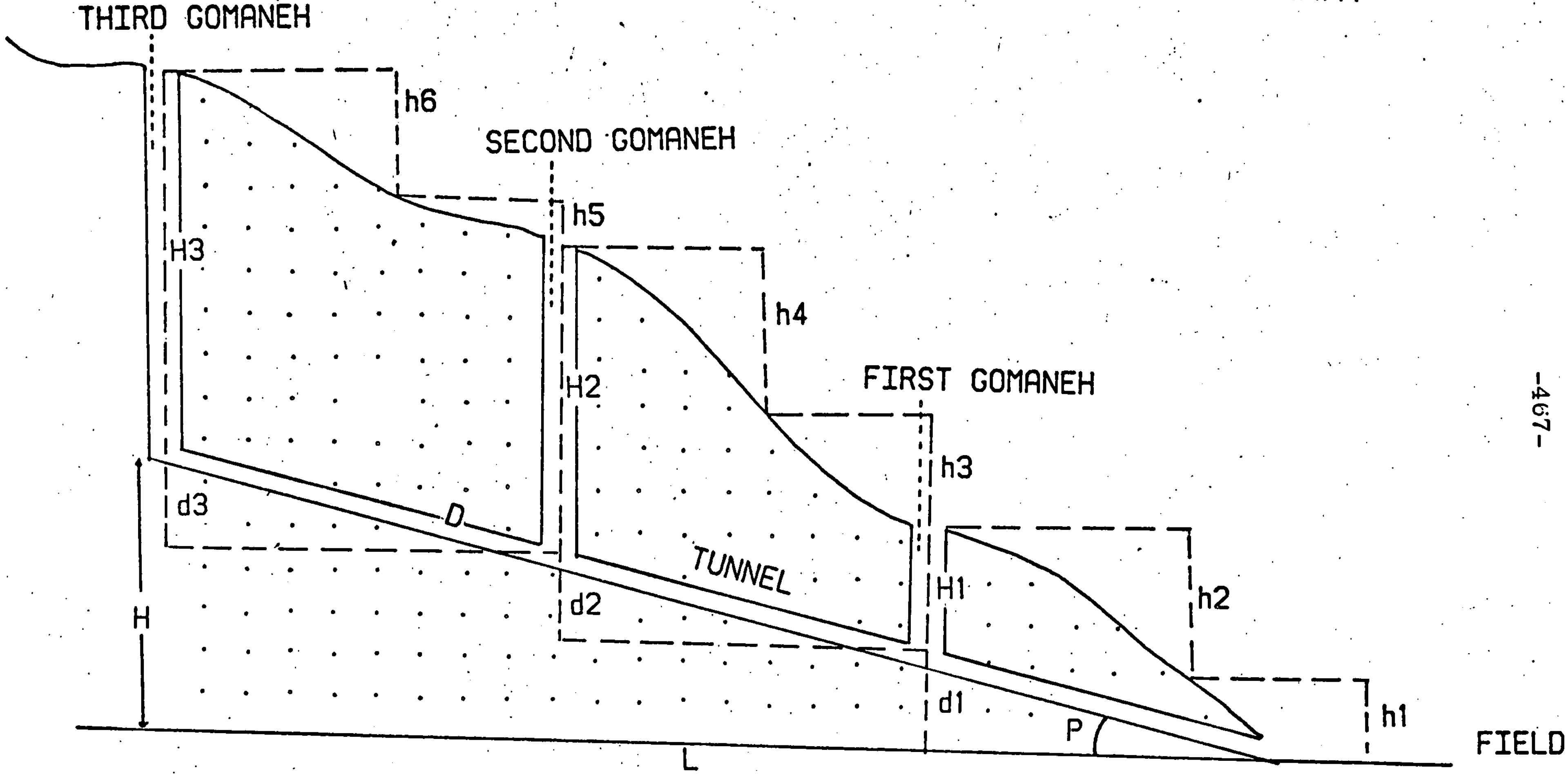
C, spirit-level (is called "Traz")

E, a piece of string 20 m long

Difference of elevation between two poles is

$$D = h_1 - h_2$$

FIG A-3-3 MEASURING THE SLOP OF QANAT



$(h1+h2)-H1=d1$

$H1+(h3+h4)-H2=d2$

$H2+(h5+h6)-H3=d3$

$H=d1+d2+d3$

$P=H/\sqrt{D^2-H^2}$

and from the second to the third.

Particular attention must be paid to the slope from the bottom of the experimental wells to the surface of the field which must have a particular gradient determined by the Memar (Moqani).

In studies about qanats, research workers paid little attention to the gradient of qanats. Some researchers were not interested in the slope, or they satisfied themselves with a description of the quality of the slopes, without noting the quantity. Other groups have paid attention to this basic factor of qanat slope, but some of them have determined constant values for slopes of all qanats. Although these values may have been obtained by measuring one or more qanat gradients, they are not acceptable for all qanat gradients, for example :

..."The maximum gradient in a short qanat is approximately 1:1000 or 1:1500, in a long qanat the tunnel is nearly horizontal" (English 1968) (1)

..."and consists of a gently sloping tunnel." (Beaumont 1971)(2)

..."This (slope) is normally 10-30 cm in 100 m, (1:1000 to 1:3000" (Honary 1980) (3)

..."The maximum gradient in a qanat is 1:1000" (Ministry of Water and Power of Iran 1971)

..."at a gradient of 1 in 2500 or 1 in 1500 in the direction of spring." (Noel 1944).(4)

(1) English, P.W. (1968) The origin and spread of qanats in the Old World, <u>Proc.Amer.PhilSoc</u>., p.173.

(2) Beaumont, P. (1971) Qanat System in Iran, <u>Bulletin of the International Association of Scientific Hydrology</u>, XVI 1,3, p.39.

(3) Honary, M.(1980) <u>Qanats and Human Ecosystems in Iran</u>, Unpublished thesis, Edinburgh, p.145.

(4) Noel,E(1944) Qanats, <u>Journal of the Royal Central Asian Society</u> 31, p.193.

In fact the slope of a qanat depends on the length, topography and water table level, and all these factors must be taken into consideration.

(b) Mathematical Method for estimating qanat gradient

As stated, the slope of a qanat is usually measured by the Moqani using simple apparatus allied to experience and skill.

However, mathematically, the qanat gradient can be shown by the following formula :

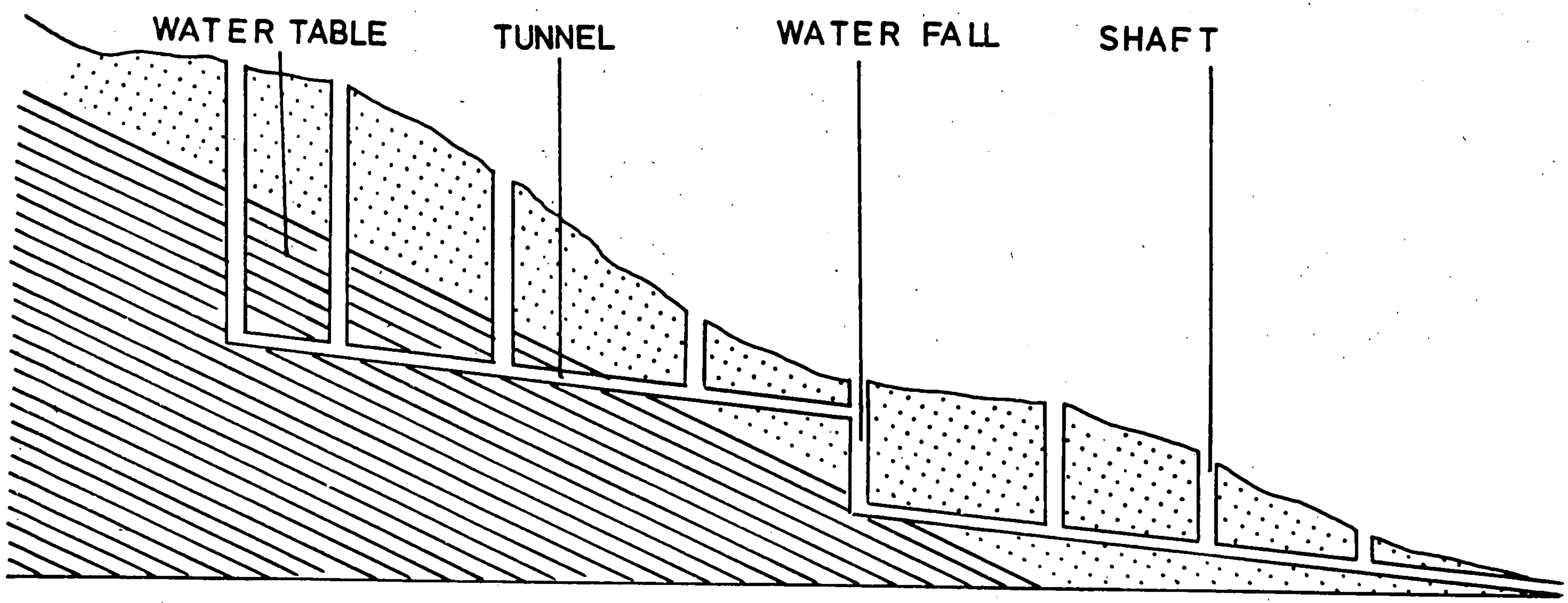
$$P = \frac{D}{L} \cdot 1000$$

where P is the gradient of the tunnel in per thousand, D is the difference in elevation between the field and the bottom of the main well or [D = (altitude of mouth of main well - Altitude of field) - depth of main well] and L is the horizontal distance.

Although sometimes the water bearing strata is too high in relation to the level of the field, the water may come to the surface for a short distance. There are reasons, however, why it is better to continue underground. In this situation if the tunnel is dug too steep, the water rushing down the tunnel will erode the walls and soon destroy them, so the Moqani makes a water fall in a suitable place. Qanat Mohamad-Abad is a good example of this case Fig. A.3.4.

The author has studied the construction of 30 qanats in the Kashan region at various locations to determine a logical relationship between the length of tunnel, depth of main well and H (difference in elevation between the field

FIG A.3.4 WATERFALL IN QANAT SYSTEM



and the bottom of the main well).

The gradient of the 30 qanats have been measured in the field. Table A.3.1 shows the specification of the qanats. According to this calculation, 25 per cent of the qanat gradients are less than 4 per thousand, 45 per cent of them 4-8 perthousand, 25 per cent of qanat slopes are 8-12 per thousand and 5 per cent of the rest are 12-15 per thousand.

To establish a logical relationship between the length of the qanat (L), its gradient (P), the depth of the main well (Z) and the difference between the field and the bottom of the main well (H), a coefficient of correlation has been calculated by computer between these factors, two by two for the 30 qanats in the region (Table A.3.1). The coefficient of correlation between the slope and the length of a qanat is $r_{P,L} = -0.54842$. This negative figure shows that there is a negative correlation between the length and the gradient of a qanat.

The multiple regression equation has been calculated between the factors which have an impact on qanat gradient, and it is shown as follows:

1) $P = 6.37 - 0.69\ L - 0.01\ H - 0.14\ z + 0.14\ HD$

2) $H = -3.81 + 1.04\ HD - 0.90\ z - 0.33\ L - 0.47\ P$

3) $HD = 1.81 + 0.882 + 0.77\ H + 0.79\ 1 + 0.47\ P$

4) $z = 0.38 + 1.04\ HD - 0.78\ H - 0.78\ L - 0.56\ P$

As regression equation 1 suggests, the gradient decreases 0.69/1000, 0.01/1000 and 0.14/1000 per kilometre in length, per metre in different elevations at the bottom of the main able A.3.1 AN SPSS REGRESSION EQATION FOR SPECIFICATIONS OF QANATS :

CASE-N	L	Z	HD	H	P
1	11.250	45.000	110.000	65.000	5.50
2	6.250	90.000	120.000	65.000	4.80
3	10.500	43.000	50.000	7.000	4.00
4	10.000	35.000	40.000	5.000	5.00
5	10.500	41.000	50.000	9.000	0.90
6	2.500	64.000	80.000	16.000	6.40
7	3.000	34.000	60.000	26.000	8.60
8	1.000	18.000	30.000	12.000	12.00
9	1.100	34.000	45.000	11.000	10.00
10	2.500	12.000	50.000	38.000	15.20
11	9.000	40.000	55.000	15.000	1.60
12	9.500	22.000	40.000	18.000	1.80
13	12.000	35.000	75.000	40.000	3.30
14	6.250	16.000	30.000	14.000	2.20
15	3.000	20.000	45.000	25.000	8.30
16	7.000	34.000	55.000	11.000	2.90
17	12.000	38.000	90.000	52.000	4.30
18	8.000	80.000	95.000	15.000	1.30
19	2.000	50.000	60.000	10.000	4.90
20	11.250	40.000	95.000	55.000	4.80
21	6.500	45.000	75.000	30.000	6.90
22	7.000	40.000	50.000	10.000	1.30
23	3.000	80.000	100.000	20.000	6.60
24	1.300	10.000	25.000	15.000	10.00
25	2.750	12.000	50.000	38.000	13.80
26	2.000	22.000	40.000	18.000	9.00
27	6.000	20.000	65.000	45.000	4.10
28	2.000	55.000	70.000	15.000	7.50
29	6.000	44.000	75.000	31.000	5.10
30	5.500	30.000	55.000	15.000	4.50

L,LENGHT OF QANATS KM.
Z,DEPTH OF MAIN WELL.M
HD, DIFF ELAVATION MONTH OF MAIN WELL & FIELD.M
H,DIFF ELAVATION BOTTOM OF MAIN WELL & FIELD. M
P,GRADIENT PER 1000.

VARIABLE	MEAN	STANDARD DEV
L	6.8175	3.7175
Z	35.9500	17.8782
HD	69.0000	27.8492
H	33.7500	18.7051
P	5.7700	3.1008

CORRELATION COEFFICIENTS

	L	Z	HD	H	P
L	1.00000	0.10363	0.50280	0.62310	-0.54842
Z	0.10363	1.00000	0.72928	0.10808	-0.16712
HD	0.50280	0.72928	1.00000	0.75443	0.02194
H	0.62310	0.10808	0.75443	1.00000	0.20585
P	-0.54842	-0.16712	0.02194	0.20585	1.00000

well of the field and depth of the main well, respectively and increases 0.14/1000 per metre in different elevations to the mouth of the main well and field.

According to the above explanation we can analyse equations 2,3, and 4. Figure A.3.5 shows the scattergram of P(Slope) with Z, L, H and DH.

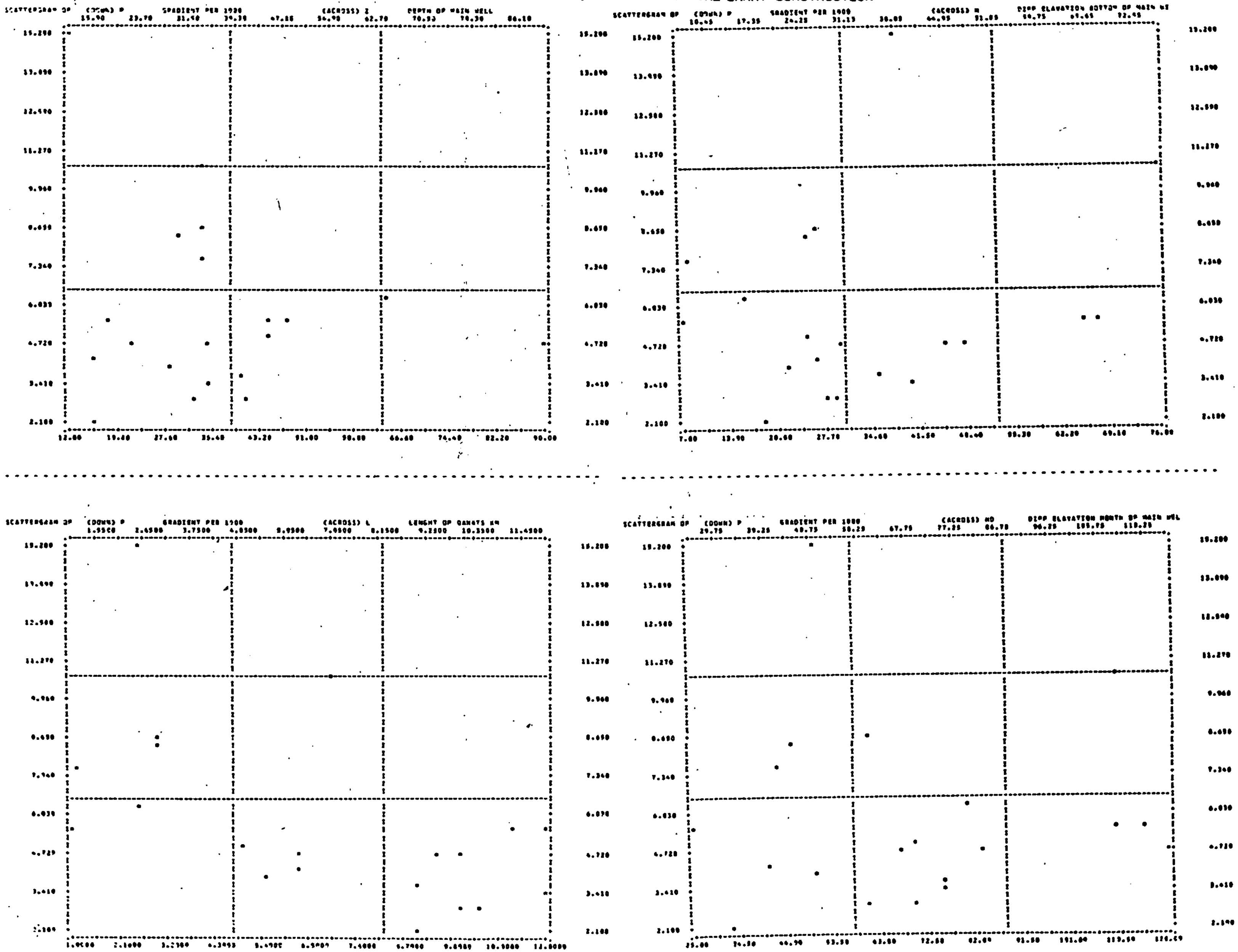
Digging the Qanat

According to interviews with some Mamar (technical experts in qanat construction) and from individual observations, this author asserts that digging starts at the first Gomaneh. The bottom of the first Gomaneh is the tunnel floor and from this point the tunnel is dug to the field and to the second Gomaneh.

From the first Gomaneh toward the field is the khoshkān (dry section) of the qanat. One group can dig the tunnel from the first Gomaneh to the field, while another group can dig the shaft connected to the tunnel, which provides ventilation and through which the soil is removed. Another group starts to dig from the field beginning with an open ditch, called "Joy", until it reaches a depth of some 2 to 3 metres.

The next section of a qanat is called Tarun (wetness). This section is usually located between the first and second Gomaneh. To dig the tarun section, one group starts to dig the tunnel from the base of the first Gomaneh towards the second Gomaneh and another group digs the shafts. The last section of a tunnel is called Ab-deh (water bearing).

FIG A-3-5 SCATTERGRAM OF FACTORS, INVOLVING IN THE QANAT CONSTRUCTION



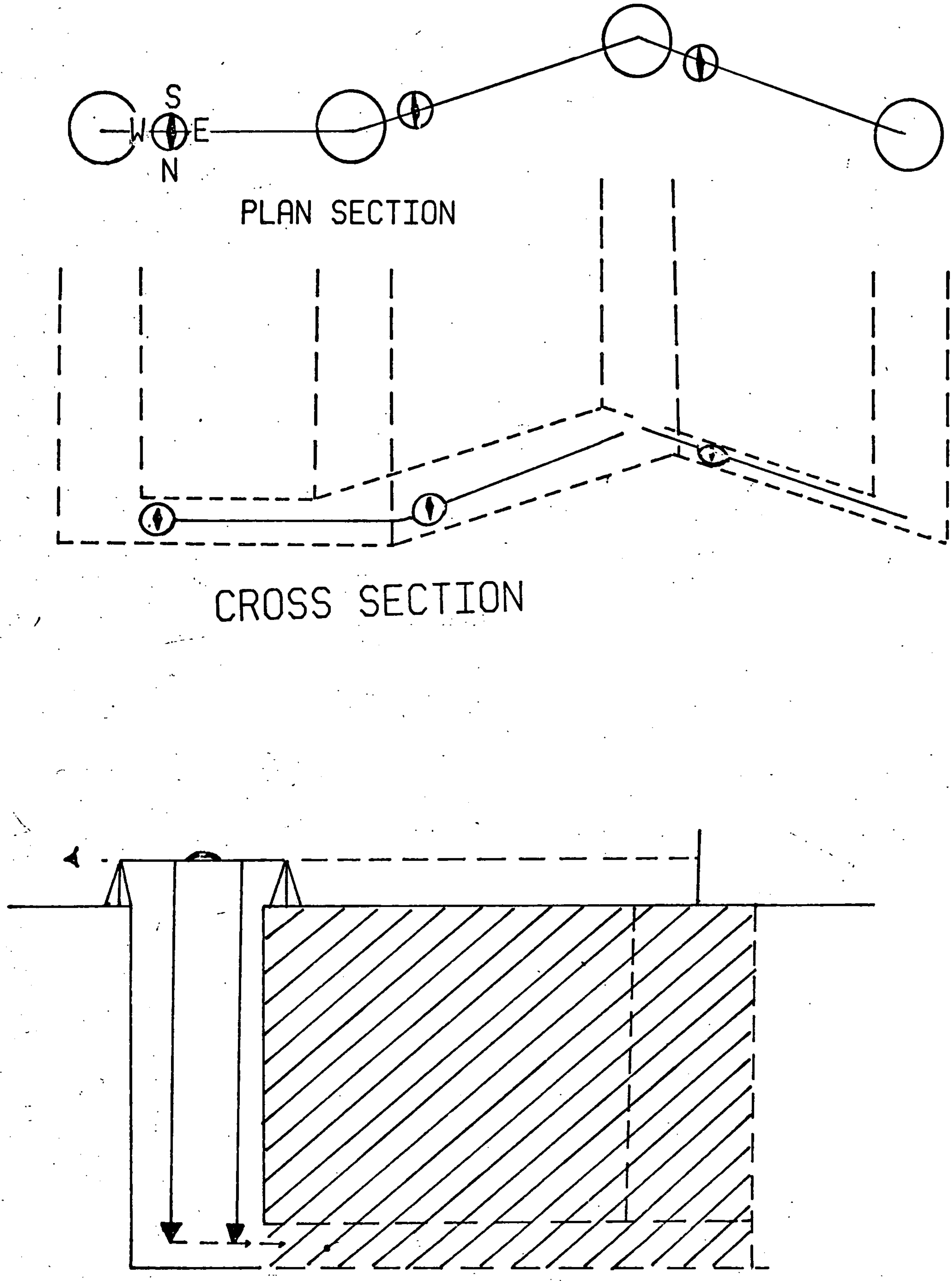
The Ab-deh section is located inside the watertable. In this section water seeps from all sides. Thus, in order to make the water run gently down the sides and prevent it dripping, it is necessary to make the roof steeply ridged.

Sometimes the third Gomaneh is the main or mother well and is called Madar-chah, but occasionally the mother well is dug a few wells after the third Gomaneh. The third Gomaneh or main well is dug as deep as the upper layer of the water-table, though the term 'mother well' is misleading because water is not removed from the qanat at this point alone.

In order to determine the direction in which the tunnel has to be dug from the bottom of the tunnel, two methods are used. First, two plumb-lines are hung from the mouth of the well into the well, thus indicating the direction of the next well. Secondly, a compass is used at the top of the well. According to the Moqani's plan, the compass direction of the next well is read, then the compass is taken to the tunnel and it is dug in the same direction until the next shaft (Fig. A.3.6).

A good deal of skill is required in the surveying, and all the available instruments are used in order to bring the water from the water bearing layer to the surface. But there are many difficulties and problems in qanat digging, the most important of which are as follows: levelling and measuring of the slope, determination of the direction of the well, lack of air at the bottom of deep well, or in the tunnel,accumulation of natural gases, lack of light for working at the bottom of deep wells or in the tunnel, lack of sufficiently large space

FIG A.3.6 DETERMINATION OF QANAT DIRECTION



for digging, and digging a shaft or a tunnel through hard soil or rocks or unstable soil. Furthermore dealing with sand and stones which fall down the wells, and with the danger of a falling bucket or rock, descending and ascending the deep wells, sending messages from the group of workers outside the qanat to the workers inside, and vice versa, working in wet areas for a long time and other problems which occur in special conditions cause difficulties.

But the skilful Moqanis know how to solve many of the problems by simple but effective techniques.

Although the method of constructing qanats is the same in all parts of Iran, in principle, the geographical and social conditions vary and the skill of the Moqani lies in adopting the basic methods to suit these conditions.

Recently, use has been made of machines for digging and removing the water, soil and mud, of hydrologists for determining the underground water and of surveyors for levelling and measuring the slope in the digging of some of the qanats. In spite of this, however, the Moqanis are still the main planners in the construction of qanats.

APPENDIX 4

CONSTRUCTION OF DEEP WELL

The following is the basic information needed before undertaking the design of a well :

(a) Thickness, character and sequence of materials above the water table or at the top of a confined aquifer.

(b) Thickness, character and sequence of the aquifer's permeability, and the degree of confinement of the aquifer.

(c) Size and gradation of aquifer materials.

(d) Transmissibility of the aquifer.

(e) Water level condition.

(f) Quality of water.

Deep wells are constructed by a variety of methods as factors of cost, depth, formation to be penetrated and purpose of the well have an important bearing on the type of well required.

Methods of construction are by cable tool or by various forms of rotary drilling. All of the deep wells in the area have been constructed by the hydraulic rotary method as follows.

A hollow rotating bit loosens, while a mixture of clay and water (drilling mud) forced down through the drill rod carries the cuttings upward in the rising mud. The mud serves the additional purpose of forming a clay lining on the wall of the well, thereby preventing caving and making casing unnecessary during drilling. The drill rod is turned by a rotating table which permits the rod to slide downward as the hole deepens mud is generated. Drilling mud emerging from the hole is pumped and emptied into a pit. After drilling or perforation, casing process takes place by lowering the case into the hole and the clay lining loose particles are washed down from the wall by injecting water down the drill rod.[1]

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(1) Walton, W.C. (1970) Ground water Resource Evaluation McGraw-Hill Book Company, New York, pp.291-293.