CHAPTER 3

THE STUDY AREA

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3.1 Location

3.1.1 Location

The Study area is located in the Southwest of Iran and occupies the upper Karoon river basin. Actual location area is located between Chahar Mahal & Bachtiari and a part of Esfahan and so between Khuzestan and Kohkilooyeh &Boyer Ahmad provinces. This boundary is located from 49°15 ´ to 52° longitude eastern and 30°15 ´ to 32°45 ´ atitude. This basin is limited by Esfahan province in north and east and Khozestan province in west. Area of target basin is about 27,000 km ^{2} and boundary shown as Figure 3-1-1-1.

Share-Kord is convenient as the base-camp for the investigation. It takes about one hour to Share-Kord from Teheran in the air route and it is about eight hours by the car (about 770 km). The airports adjacent to the Study area locate at Isfahan, Share Kord, Ahwaz and Shiraz. The road net in the project region develops comparatively. However, the road condition is not so good in the country area and there are many dirt passes in a high altitude of 3000-4000m, so that 4WD car is required for the investigation.

3.1.2 Topography

Geographical features in Study area is formed with the distribution stratum and the geological structure. It is naturally that, weather condition is greatly influenced. The degree of the invasion is different depending on the generation age of the distribution stratum or geological properties. The geological structure greatly influences the formation of the river and the mountain range. The river and the mountain range of the Study area are explained as follows.

Karoon river is the largest river in Iran. This river flow in western and south west skirt of Zagros range. Zagros is very similar to Alpine mountains and the same giant arc is surrounded from west to southwest of Iran in north of Hormos and their tail that is called Bashagard mountains extends to Sistan and Balochestan province .

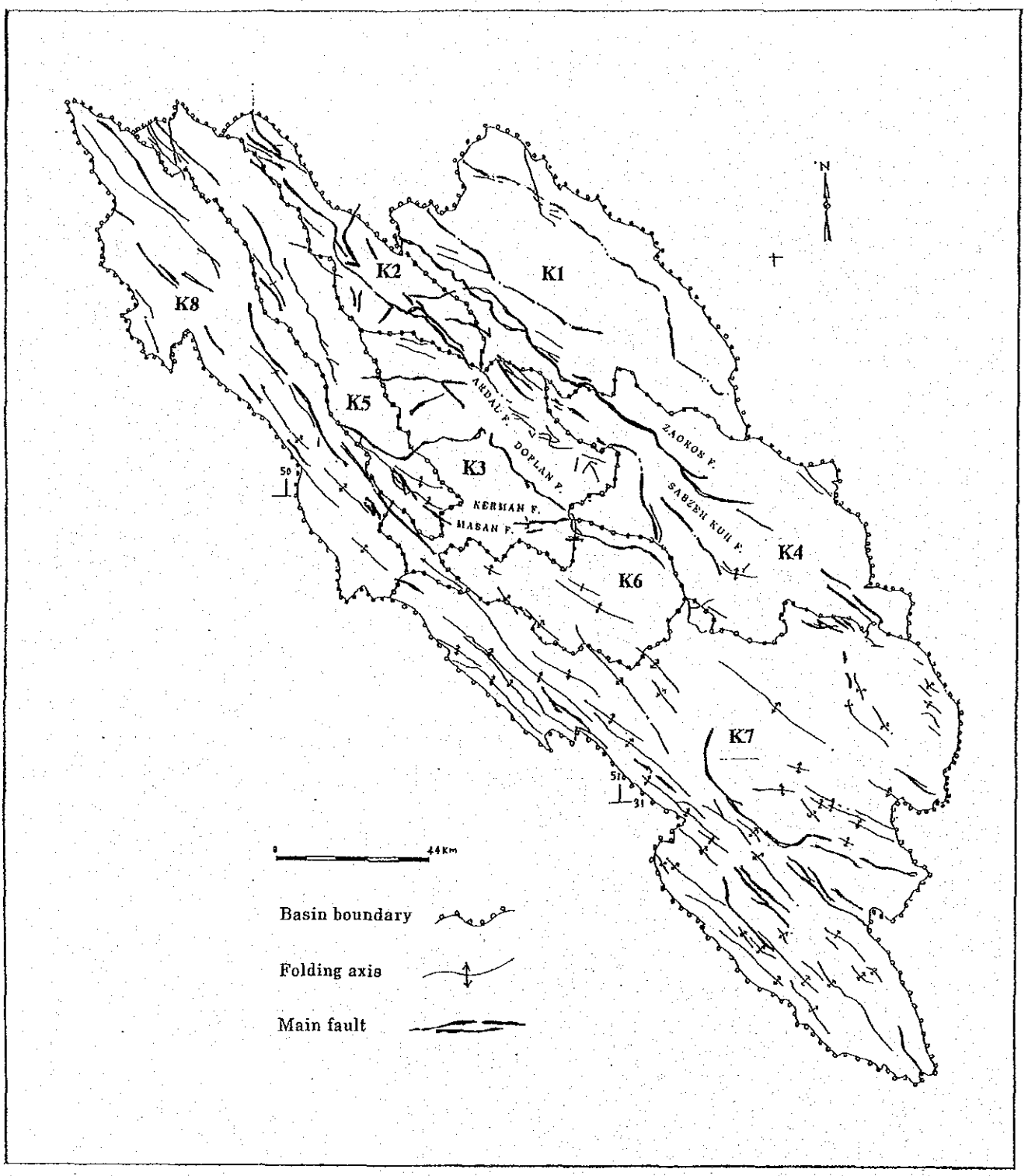


Figure 3-1-1-1 Hydrological Unit and Main Geological Tectonic of Karoon Basin

All the area are divided into six geographical features (A, B, C, D, E and F) by the topographical maps and the aerial photographs and field verification. Classification of geographical features are as follows

a) Mountain area

The area consists of almost consecutive rising or descending slope, generally consists of the bedrock, partly includes talus deposit of the fall thing from the mountain body of the inclination 20-40 degrees

b) Hill area

The area has small ups and downs within difference of elevation 100-300m. It is a gentle area in the whole in geographical features. the ridge or the top part is comparatively smooth and valleys open shallowly. There are a lot of area of a soft stratum eroded smoothly.

c) River side terrace

Relating to a past change of water surface, geographical features which had been formed in water appeared in surface of the earth by the earth's crust change or climate change. The surface of the earth has a smooth flat plain. There are a lot of cliffs facing rivers. The stratum composition consists of sand ,gravel and clay.

d) Alluvium flat plane

The materials consist of the second deposits in river, lake, basin, and coast part, etc. in new age. Afterwards the area appeared in surface of the earth by descent of water level. These areas are extremely smooth and flat.

e) Large scale fan

Fan deposit consist of sand, gravel and clay coming from the river. Fan is formed with gentle slope within ten degrees and extended to the shape of the fan. This classification includes talus deposit distributed along the valley and partially exists together with B, C, and D.

f) Special geographical features

Arising from geological, topographical and other natural condition (glacier, lake, kar, large-scale landslide or debris flow) and artificial activities(lake, mining ruins etc.)

Topographical classification is summarized as following table.

Table 3-1-2-1 Summary of Topographical Division

Name of Sub-Basin	Area (km2)	Geographical Features						Remarks
		Mountain area A %	Hill area B %	Riverside terrace C %	Alluvium flat plane D %	Large-scale fan E %	Special geographical features F %	
K-1	3,920.2	43.5	11.2	0.2	13.6	31.5		
K-2	1,223.7	83.4	3.2	6.5	0.6	6.3		
K-3	2,509.2	87.7	0.4	0.6	1.4	9.1	0.8	
K-4	3,214.8	61.8	6.8		3.6	27.8		
K-5	2,174.9	96.9	0.5	0.1	0.7	1.8		
K-6	1,474.3	67.1	7.0		7.7	18.2		
K-7	9,021.2	76.9	6.8	1.0	2.0	13.3		
K-8	3,273.2	90.6	1.9	0.7	1.5	4.4	0.9	
Total average	26,811.5	76.0	4.7	1.1	3.9	14.1	0.2	

As a result, the mountains area (A) accounts for 76% on an average of all the basin and it is most dominant. Second dominant is large scale fan area (E) of 14.1 %. Hill area (B) and alluvium flat plane (D) occupy 4.7 -3.9 % at the area. Riverside terrace (C) is 1.1% and special geographical feature (F) is extremely small with 0.2%.

The aerial photographs were used for analysis for landslide and abnormal geographical features and the inventory was made.

Table 3-1-2-2 Aerial Photography of the Project Area

Map	Number	Year taken
DEZFUL	17	1997
SHARE KORD	420	1997
ESFAHAN	55	1991
RAMHORMOZ	299	1993
BROJEN	402	1999
YASUJ	198	1999
TOTAL	**1391**	

3.1.3 Geology

Karoon basin is located in the two different zone of zagros and anandaj-sirjan and has both of tectonics and stratigrapy. Most of the areas belong to zagros zone. The geological feature composition is shown in Table 3-1-3-1 and the main tectonic is shown in Figure 3-1-1-1. The feature of the Study area is the mountain range and the river flow is ruled by the geological structure, and have the flow direction of NW-SE. The stratigraphy in the Study area are shown as Figure 3-1-3-2.

Table 3-1-3-1 Geological Feature Composition

AGE	FORMATION	LITHOLOGY
Upper Pliocene & after	BACHTIARI	Co Conglomerate with sandstone
Upper Miocene – Pliocene	AGHAJARI	Red sandstone and marls
Lower & middle Miocene	MISHAN	Olive green gray sandstone
Lower Miocene	GACHSARAN	Gray ,red marl and gypsum
Oligocene – Miocene	ASMARI	Thick-medium bedded limestone
Paleocene –Miocene	PABDEH	Shale& marls, limestone
Paleocene – Miocene	JAHROM	Thick- medium bedded gray dolomite
Middle-upper Eocene	SHAHBAZAN	Weeding porous thin to medium limestone and dolomite
Paleocene –middle .Eocene	KASHKAN	Red conglomerate with sandstone
Paleocene—Eocene	TALEH ZANG	Thick-medium cream fossil ferrous limestone
Companian	GURPI	Alternation of bluish gray marl and limestone
Santonian –companian	ILAM	Limestone and marl
Turonian-l.santonian	SORGAH	Shale with pyrite
Cenomanian	SARVAK	Massive limestone
Albian l.cenomanian	KAZHDOMI	Gray to brownish limestone
Aptian	DARIAN	Orbitolina limestone
Upper Jurassic	SURMEH	Limestone
Lower Jurassic	NEYRIZ	Limestone
Triassic	KHANEH KAT	Anhydrite & shale & limestone
Permian	DALAN	Limestone
Cambrian	MILA	Sandstone
Cambrian	LALUN	Sandstone
Cambrian	ZAIGUN	Well bedded shale
Infra Cambrian	HORMOZ	Red salty marl with disperse shale sandstone and porphyry

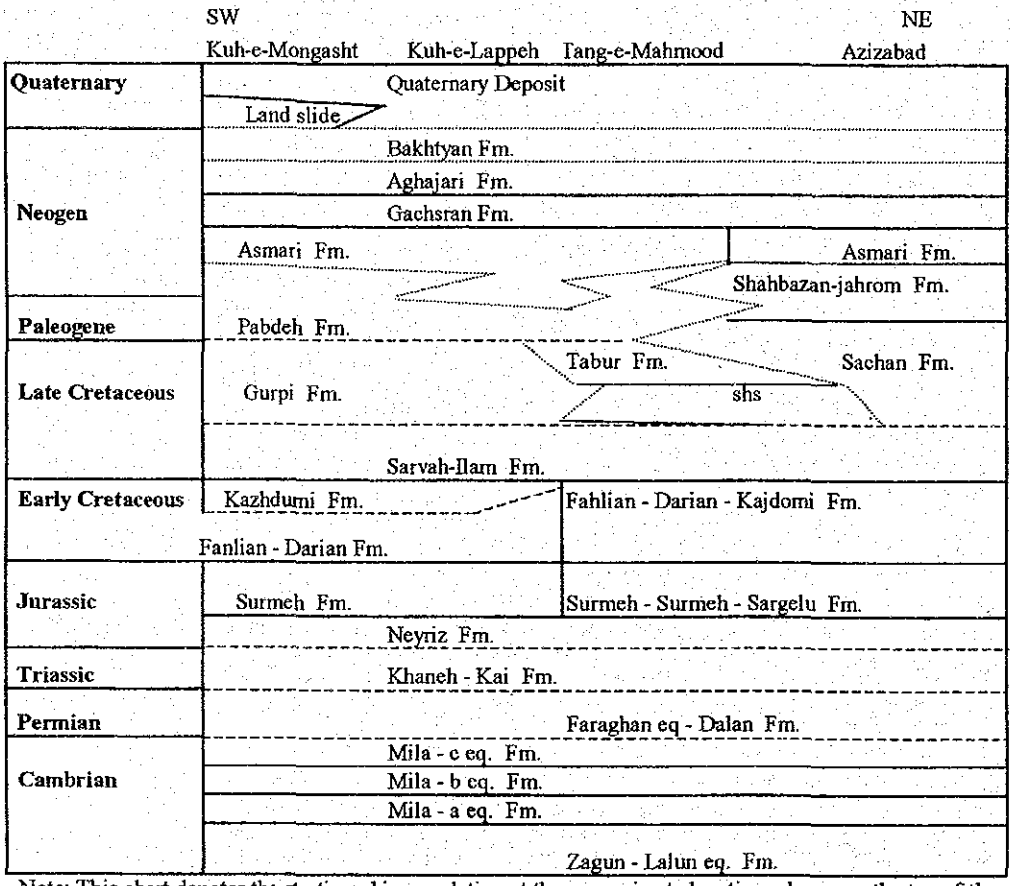
A part of Iran that is located in west of zagros thrust is called zagroos zone. This zone is limited to Minab fault in east. Its characteristics is seen in Arabic neighbour countries. Zagros zone is consist of three separate parts:

1 Khuzestan plain
2 Folded zagros (inner zagros)
3 High zagros

* Khuzestan plain: This part is consist of a big part of binolnahrien plain. Khuzestan plain tectonic is similar to Arabic platform. This plain is covered by quaternary deposits and isn't determinate.

* Folded zagros: This part is located in southwest of Iran and its transverse is about 150-250 km. Probably it has subsidence under zagros thrust. General strike of this area is NW-SE. The paleozoic and Mesozoic and Tertiary are isolate.

* High zagros (inner zagros): Folded zagros is ended to a thrust area in north-east, the genesis a crush zone, that is located between sanandaj – sirjan and folded zagros. This zone is called High zagros because of the highest mountains of zagros.



Note: This chart denotes the stratigraphic correlation at the approximate locations shown on the top of the table. Therefore, exact locations with straight line won't be able to draw.

Figure 3-1-3-2 Stratigraphic Correlation Chart

(1) Stratigraphy of Karoon basin:

In Karoon basin there are kind of different deposits from Cambrian to Quaternary. The sign of the stratum is described as follows;

K-1 (Behesht Abad):
QAL-Q-PI-EV-E-K7-K5-K4-K3-J3-J2-P-P1-E2-E1

K-2 (Kohrang)

Q-PI-OM3-OM2-OM1-EO-K8-K7-K1-JK-J1-E2A-TR-P-E3-E2

K-3 (middle karoon)
Q-P1-AS-OM1-OM2-E-K8-K4-J1-TR-PC-CBS-SP

K-4 (vanak)
Q- BK-F-AS-EO-KS-KM-KI-J-TR-P1-PC-C-CBS

K-5 (BAZOFT)
Q-BK-UF-LF-AS-KS-KM-KI-JK-J1-TR-P1-PC-E3-C

K-6 (LORDEGAN)
BK-UF-LF-E-KS-KM-KI-TR-PC-CBS-SP

K-7 (KHERSAN)
Q-BK-UF-GS-AS-JA-PB.GU-GU-BGP-KGP-NZ-TR-E-SP-e

K-8 (KAROON)
QT-BK-UF-LF-AS-EO-PE-KS-KM-TR-PC-E3-E2

QAL= recent terraces and alluvium deposits
PI or BK= terraces and alluvium
EV= volcanic rocks
E= Kashkan .fm
SV+KZ = Bgp
JK = Kgp = KHAMI .fm
J3 = SURMEH.fm
J2 = N Z= NEYRIZE .fm
J1 = KHANEH KAT.fm
P = DALAN .fm
P1 = PERMINE sandstone
E2 = MILA.fm
E1 = LALUN .fm
OM3, OM2, OM or AS = ASMARI .fm
EO = SHAHBAZAN & JAHRUM & ASMARI .fm
TR = KHANEH KAT.fm
SP = HORMOZ COMPLEX
CBS = BARUT.fm.EQ
C = CARBONIFEROUS deposites
e = ZUGUN & LALUN&MILA fms

(2) Tectonice of Karoon basin:

Studies show that there are several faults (main & minor ones, see Figure 3-1-1-1). Because Folds (anticline & syncline) and joints in this zone is an active zone. Most of the faults have NW - SE trend and a dip toward SW. All of faults have a trend similar to zagros. Anticlines are seen in SW especially in K-7 area. This is probably caused by subsidence of Arabic plate under Iran plate. In this area there are many important faults and some of them are consist of following thrust.

1-Zagros thrust
2-Naghan thrust
3-Ardal thrust
4-Doplan thrust
5-Kerman thrust

6-Mongasht thrust
7- Kuh -e-Sfid thrust

(3) Hazard

Mass movement and land slide are a kind of hazard phenomenon where different geographical and geological factors are involved. These factors consist as follows;

Potential Factor: land slope, kind of material, volume of mass※, climate
Accelerative factors; water, cut and bank, earthquakes, ice
※The extent and thickness of the layer such as marl which is likely to cause landslide.

The most important factor is geological formation. This basin has kinds of marl formation or formation with marl in their composite. Study of aerial photo in this area has shown that the most land slides have occurred in formations of Gurpi, Pabdeh, Sarvak and Kazhdomi. These formations are very sensitive. These formations have usually a kind of clay mineral which absorb water and loose cohesiveness. This property of clay mineral can be flowed different thickness layer that is not sensitive to slide.

3.1.4 Meteorology

(1) General Characteristics

The basin rainfall varies from 250 mm to 1700 mm depending on elevation, slope orientation/exposure. Annual rainfall is about 650 mm on an average in the Study area. In general, upper basins of K5 and K8 have rainfall more than 1,500 mm. And rainfall amount has trend to reduce toward south east in the Study area. The majority of precipitation occurs from Azar to Ordibehesht (from December to May). Especially, heavy precipitation falls from Dey to Esfand (from January to March). The high mountain zone exceeding EL. 2,000 m above mean sea level is covered with snow every year.

In the Study area, winter season is moderate and short, however summer season is long and hot. And temperature reaches its highest point generally in the month of Tir (July) and its lowest point in the Bahman (February). The annual average temperature is about 25 ℃. The monthly maximum temperature in the Study area is about 40℃ and monthly minimum temperature is −14℃. Mean annual evaporation varies from 1,000 mm to 3,000 mm. Distribution of annual evaporation in the Study area has similar characteristics to those of temperature.

(2) Probability and Intensity of Rainfall

Probability of rainfall occurrence has been estimated by graphical method using Weibull plot. The results are summarized as follows.

Table 3-1-4-1 Probability of Maximum Daily Rainfall

Station	Station Code	Sub-basin No.	2 years (mm/day)	5 years (mm/day)	10 years (mm/day)	25 years (mm/day)
Yasouj	341522	K7	72	95	110	130
Hanna	341547	K7	43	57	64	78
Barz	341549	K7	67	85	97	115
Shahre Kord	342559	K1	36	48	57	68
Armand	342607	K3	63	85	100	120
Lordjan	342611	K6	59	75	85	98
Goosheh Pol	342662	K5	110	150	180	220
Behestabad	342820	K1	50	66	77	90
Deh Sheikeh Soosan	343579	K8	88	120	140	170

KWMO has analyzed rainfall intensity at several rainfall gauging stations. These data are shown in following table.

Table 3-1-4-2 Rainfall Intensity in 60 minutes

Station	Station Code	Sub-basin No.	2 years (mm/hour)	5 years (mm/hour)	10 years (mm/hour)	25 years (mm/hour)
Yasouj	341522	K7	10.2	13.7	16.1	19.0
Pataveh	341544	K7	10.0	14.6	17.4	21.3
Share Kord	342083	K1	9.4	16.6	21.3	26.7
Pole Shalu	342578	K8	13.7	17.4	21.7	25.6
Izeh	343069	K8	18.4	28.3	34.7	42.6
Der-Sheiker-Soosan	343579	K8	17.9	30.6	39.4	46.6

3.1.5 Hydrology and River Regime

(1) General Conditions of River Regime

Karoon river is one of the longest river in Iran. The total length of Karoon is about 840 km and its catchment area is about 70,000 km^2. Annual discharge is estimated at 453 m^3/s. Lowest downstream point of the Study area is located at the upstream of Shahid Abass Pour Dam and its catchment area is 27,000 km^2. Original source of Karoon river is Van and Zardkoh springs which formulate Kohrang river. The main source of river originate Zardkuh and Zagross mountains. Main tributaries of Karoon river are listed up as Ab.Vanak, Beheshtabad, Bazoft, Khersan and Monji river.

a) Khersan River(9,070 km^2)

Khersan river flows in the southwest part of Karoon basin. At first, Boshar river is flowing which originates from mountains of north of Ardakan in Fars province. After passing Yasoji city, this river flows in northwest direction and receives some tributaries such as Sepidar, Kabkian and Kariek rivers, which originates in Dena mountins. Then the river joins to Marbor river that originates in north and east parts of Dena moutains. At this point, the river that now is called Khersan, flows in northern west direction and after receiving some small tributaries, junctions to Karoon River. The total length of Khersan River is 225 km.

b) Abe Vanak River (3,490 km^2)

Vanak River originates in the eastern part of Karoon basin from junction of Kasegan and Sulegan River. The river flows west ward and then receives Aghabolagh River that originates in the northern part of K4 sub-basin. The total length of Abe Vanak River is 140 km.

c) Abe Kiar River (3,880 km^2)

Kiar River originates in the western mountainous area which is located near Bourjen. This river flows westward and have junction with Jahanbin river at the 46 km downstream from Bourjen. After junction with Rudeh Sarab, Kiar river changes flow direction to the southwest and joins to Kurang (Middle Karoon) river. The total length of Kiar River is 225 km.

d) Bazoft River (2,180 km^2)

Bazoft River originates in northern west part of Karoon basin. This river has no large tributaries and flow in southern east direction. Total length of the river is 140 km and have junction with Karoon river at the 20 km upstream point from the junction of Karoon and Khersan river.

(2) Hydrological Conditions

Average monthly discharge at Karoon I dam site ranges from 190 m^3/s to 710 m^3/s. The highest monthly discharge of Karoon river occurs during Favardin (April) due to snowmelt in the upper sub-basins which altitudes are higher than 2,000 m above sea level. Extreme floods had been observed mainly between Dey and Farvardin (January and April).

Hydrological characteristics of each river in the Study area are shown as following table. From the aspect of specific runoff, it is possible to roughly categorize these rivers into three types.

- Type A (high runoff type) : Bazoft
- Type B (medium runoff type) : Khersan (Kabkian, Marboreh), Kurang, Karoon
- Type C (low runoff type) : Vanak, Kiar, Lordejan

Table 3-1-5-1 Hydrological Characteristics in Each River Basin

Station	Station Code	River Basin	Catchment Area (km^2)	Annual Runoff (m^3/s)	Specific Runoff ($m^3/s/km^2$)
Barzbakhtiari	34121	Khersan	8,900	112.0	0.0126
Sulegan	34213	Vanak	1,992	10.2	0.0051
Behestabad	34216	Kiar	3,825	22.2	0.0058
Armand	34219	Karoon	9,900	100.9	0.0102
Morghak	34221	Bazoft	2,355	71.5	0.0304
Poleshaloo	34222	Karoon	24,210	320.4	0.0132
Dazak	34227	Kurang	563	9.1	0.0162
Botari	34118	Kabkian	885	16.2	0.0183
Lordejan	34210	Lordejan	351	2.2	0.0063
Kata	34113	Marboreh	4015	38.1	0.0095

(3) Probability of Flood

Probability of occurrence of maximum daily discharge has been estimated by graphical method using Weibull plot. The results are summarized as follows.

Table 3-1-5-2 Probablity of Maximum Daily Discharge

Station	Station Code	Sub-basin No.	Catchment Area (km^2)	2 years (m^3/s)	5 years (m^3/s)	10 years (m^3/s)	25 years (m^3/s)
Botari	34118	K7	885	160	300	420	600
Barzbakhtiari	34121	K7	8,900	630	1,150	1,650	2,350
Lordejan	34210	K6	351	2.8	3.2	3.5	3.8
Armand	34219	K3	9,900	500	830	1,100	1,450
Poleshaloo	34222	K8	24,210	1,450	2,200	2,750	3,500
Dazak	34227	K2	563	115	210	300	420
Solegan	34213	K4	1,992	110	225	320	490
Beheshtabad	34216	K1	3,825	145	290	420	630
Morghak	34221	K5	2,355	650	1,000	1,300	1,650
Kata	34113	K7	4,015	210	350	420	520

(4) Sediment

Sediment data are available at sixteen discharge gauging stations, however, they are mainly suspended load data. Judging from these data, it is recognized that specific sediment volumes in K7 sub-basin shows high amount compared to other sub-basin. On the other hand, specific sediment volumes in K1, K3 and K7 show comparatively low value. As for average volume of sediment in unit discharge, sediment amounts at Yasuj, Shahmoktar and Tangzardalou show high value. Specific volume of sediment correlates with catchment area nevertheless sediment depends on many factors such as topographical, geological and hydrological condition.

Table 3-1-5-3 Sediment Data

Basin No.	River Name	Station Name	Catchment Area (km2)	Average Volume of Sediment (kg/m3/s)	Specific Volume of Sediment (ton/km2/year)
K1	Ab Kiar	Behstabad	3,825	0.015	27
K3	Khersan	Barzbakhtiari	8,900	0.003	26
		Armand	9,900	0.003	18
K4	Solegan	Tangzardalou	1,045	0.580	63
		Solegan	1,992	0.020	31
K5	Ab Bazoft	Morghak	2,355	0.003	45
K7	Boshar	Yasuj	803	0.150	121
		Shahmoktar	1,187	0.128	200
		Darshahi	1,609	0.082	66
		Botari	885	0.087	52
		Kerik	128	0.079	304
		Pataveh	2,800	0.004	63
	Marboreh	Khakdaneh	801	0.013	199
		Kata	4,015	0.009	51
K8	Karoon	Poleshaloo	24,210	0.002	12
		Outsadekaro	25,850	0.001	5

note : Here, sediment data implies suspended load data

3.1.6 *Soil*

In the Study Area, major soils are Lithic Leptosols, Gypsic Regosols, Calcaric Regosols, Calcaric Cambisols and Haplic Calcisols. Lithic Leptosols are distributed mainly in higher lands with shallow depth at the foot and slope of mountains. Calcaric Regosols are distributed widely from higher lands to flat lower lands. Gypsic Regosols are found at marly formation and weak to erosion. Calcaric Cambisols and Haplic Calcisols are important and forming fertile flat piedmont plains with a deep depth. Parent material of soils is limestone so that the soils are generally little alkaline (pH = 7.5 – 8). Their distribution is summarized as follows.

Table 3-1-6-1 Major Soils and Distribution in the Study Area

Land Type		Lithic Leptosols	Gypsic Regosols	Calcaric Regosols	Calcaric Cambisols	Haplic Calcisols	Calcaric Kastanozem	Eutric Cambisols	Calcaric Fluvisols	Haplic Kastanozem	Area Ratio
Mountains	1.1	O									66.7%
	1.2	O		O							
	1.3	O		O							
	1.4		O								
	1.5			O							
	1.6				O						
Hills	2.1	O									9.9%
	2.2			O							
	2.3		O								
	2.4		O	O							
	2.5			O							
	2.6						O				
Plateaus and Upper Terraces	3.1			O							12.0%
	3.2				O						
	3.3			O							
	3.4		O	O							
	3.5			O							
	3.8					O					
Piedmont Plains	4.1				O	O					3.1%
	4.2				O	O					
Elluvial Plains	4/5							O			0.6%
Lowlands	6.1								O		0.7%
Gravelly Colluvial Fans	8.1			O							3.2%
	8.2			O							
	8.5									O	
Gravelly River Fans	9.1			O							0.5%
	9.2			O							
Others											3.3%

(note) Referring to "volume 23 Soil and Resources Evaluation and Land Capability in the Upper Karoon Basin" YEKOM, MOA 1999

(1) Soils in the Mountains

Mountains form the highest region of the area, and are mostly bare with hard rocks. Soils are distributed at the slope and foot of the mountains mostly with shallow to semishallow depth. The major soils of mountains are Lithic Leptosols and Calcaric Cambisols. Soils contain large quantity of gravel as 35% to 75%. Concentration of calcium carbonate (CaCO3) is high as more or less 30% - 40% and soils are alkaline with pH of about 7.5 – 8. Soil texture is relatively heavy at most places.

Electric conductivity (EC) of saturated soil is less than 1.0 mmho/cm so that no salinity problem is suffered. Concentration of organic carbonate is moderate (about 0.5-1.0%) to relatively high (0.8-1.5%). Fertility of nutrients is rich to relatively rich at most location, but limitations are steep slope, shallow soil depth and high concentration of gravel.

(2) Soils in the Hills

Hills are forming higher regions adjacent to the mountains. Major soils of hills are Calcaric Regosols and Gypsic Regosols. Soils are generally shallow and semi deep to deep by the locations. Soil texture is generally heavy to very heavy but light to moderate at some places. Soils contain relatively large quantity of gravel at about 35% to 75% in steep hills and 15% to 35% in gentle hills. Concentration of calcium carbonate is 30 to 40% as same as in mountains, and pH is 7.5 to 8. Electric conductivity of saturated soil is less than 1.0 mmho/cm, and there is no harm of salinity. Concentration of organic carbonate is moderate to relatively high as same as mountains. Fertility of nutrients is rich.

(3) Soils in Plateaus and Upper Terraces

Plateaus and upper terraces are located along hills and mountains especially in K1, K4 and K7 River Basins. Said three river basins share 88% of total plateaus and upper terraces. Major soils of plateaus and upper terraces are Calcaric Regosols, Gypsic Regosols, Calcaric Cambisols and Haplic Calcisols. Soils are extensively deposited with relatively deep to deep depth in plateaus and upper terraces. Gravel concentration is about 15 to 35% that is lower than in hills. Calcium carbonate is contained at 20-30% to 30-40% at surface, and pH is 7.5-8. Soil texture is heavy to very heavy due to concentration of clayey soil. Electric conductivity of saturated soil is less than 1.0 mmho/cm so that there is no harm of salinity. Concentration of organic carbonate is low to relatively high and fertility of nutrients is rich.

(4) Soils in Piedmont Plains

Piedmont plains share only 3.1% of total area of the basin, but piedmont plains are very important from aspects of agricultural productivity. Piedmont plains are mainly extending in K1, K6 and K7 River Basins, that share 88% of total piedmont plains. Major soils of piedmont plains are Calcaric Cambisols and Haplic Calcisols. Soils are deposited extensively and deeply in piedmont plains. Soil texture is heavy to very heavy with less concentration of gravel. Electric conductivity of saturated soil is less than 1.0 mmho/cm so that no salinity problems will arise. Concentration of organic carbonate is low to moderate and fertility of nutrients is rich.

(5) Soils in Elluvial Plains

Elluvial plains have high productivity in agriculture as same as piedmont plains, but the area of elluvial plains is only 0.6%. Most elluvial plains are concentrated in K1 River Basin. Major soil of elluvial plains is Eutric Cambisols. The plains have deep to very deep soils with very heavy texture. Electric conductivity of saturated soil is less than 1.0 mmho/cm so that no salinity problems will arise.

Concentration of organic carbonate is low as 0.4-0.7% but fertility of nutrients is rich.

(6) Soils in Lowlands

Lowlands are extending along rivers surrounded by piedmont plains. Major soil of lowlands is Calcaric Fluvisols. Soils are deposited deep to very deep without gravel, and texture is heavy to very heavy. Calcium carbonate is concentrated at about 30-40% in surface and pH is 7.5-8.5. Electric conductivity of saturated soil is less than 1.0 mmho/cm so that salinity is not problem at present. Concentration of organic carbonate is moderate at 0.7-1.0% but fertility of nutrients is relatively poor.

(7) Soils in Gravelly Colluvial Fans

Gravelly colluvial fans are located at the foot of mountains mainly in K1 and K7 River Basins. Major soils of gravelly colluvial fans are Calcaric Regosols and Haplic Kastanozem. Gravel concentration is high as 35 to 75%, and soil depth and texture is varied by locations. In upper location nearby mountains, soil depth is shallow and texture is light to moderate. In lower location, soil depth is relatively deep and texture is heavy to very heavy. Calcium carbonate is concentrated at about 30-40% in surface and pH is 7.5-8. Electric conductivity of saturated soil is less than 1.0 mmho/cm so that no salinity problems will arise. Concentration of organic carbonate is low to relatively high and fertility of nutrients is rich.

(8) Soils in Gravelly River Fans

Gravelly river fans are located at the foot of hills mainly in K1 and K6, but total area of gravelly river fans is only 0.5% of the area. Major soil of gravelly river fans is Calcaric Regosols. Soils are deposited semi deep to very deep, and texture varies from moderate to very heavy. Gravel is contained relatively high as 15% to 35%. Calcium carbonate is concentrated at about 30-40% in surface and pH is 7.5-8.5. Electric conductivity of saturated soil is less than 1.0 mmho/cm so that no salinity problems will arise. Concentration of organic carbonate is low to moderate and fertility of nutrients is rich.

3.2 Land Use and Vegetation

3.2.1 Concept of Land Use Plan

Of the land classifications above, the most important factors in determining land use are the natural conditions, particularly topographic conditions. Besides topography, such natural conditions as geology, climate, soil and vegetation as shown in Figure 3-2-1-1 are also important. The second factor in land classification in this chart is the conditions of transportation. This is because transportation is the most important factor in economic conditions which control the land use, and in the Karoon River Basin particularly, it is thought to be one of the critical conditions. The third factor is the current land use. As materials detailing the current land use in this basin, there are some land use maps that were

drawn based on studies in 1990s.

The site classification is a classification by land use potential from natural, technical, socio-economic and political point based on the above land classifications. In this basin, it is particularly important to develop land conservation, to improve water supply, and construction and/or improvements of access roads.

In summary of the above, the land classification shows the current state of the land, while the site classification is a classification by the potential use of the land. The results of the study on the land classification of this basin are described in the following sections by item.

(1) Natural conditions

a) Topography and land use

As mentioned above, topographical factors play the most important role in land use in the Study area. The topographical factors include elevations, degrees of inclinations, directions of slopes, etc., and among them, particular factors of elevations and inclinations are closely connected with land use. In reference to the above, Figure F-1-1 & F-1-2 in Annex F show the gradation of elevations and inclinations using a 1 km^2 mesh method on a topographical map drawn to 1/500,000 scale. As seen in the Figure 3-2-1-2, the Study area can be divided into two major landscapes. They are ①plateau area, and ②valley area, which are of widely different land use. The details are as follows.

Plateau area: This area occupies the northeastern part of the Study area (K1, the eastern half of K3, K4 and the eastern half of K7) and consists of wide, flat or gently sloping areas at elevations of about 2000 m, with some isolated rocky mountains. The former are Cenozoic deposits and are used for cropping fields, orchards, man-made forests, etc., as stated below. The latter are mountains with Mesozoic sediment rock located universally in valley area as mentioned below. They are often dissected into monadnocks having poor vegetation, as well as being used for rangeland .

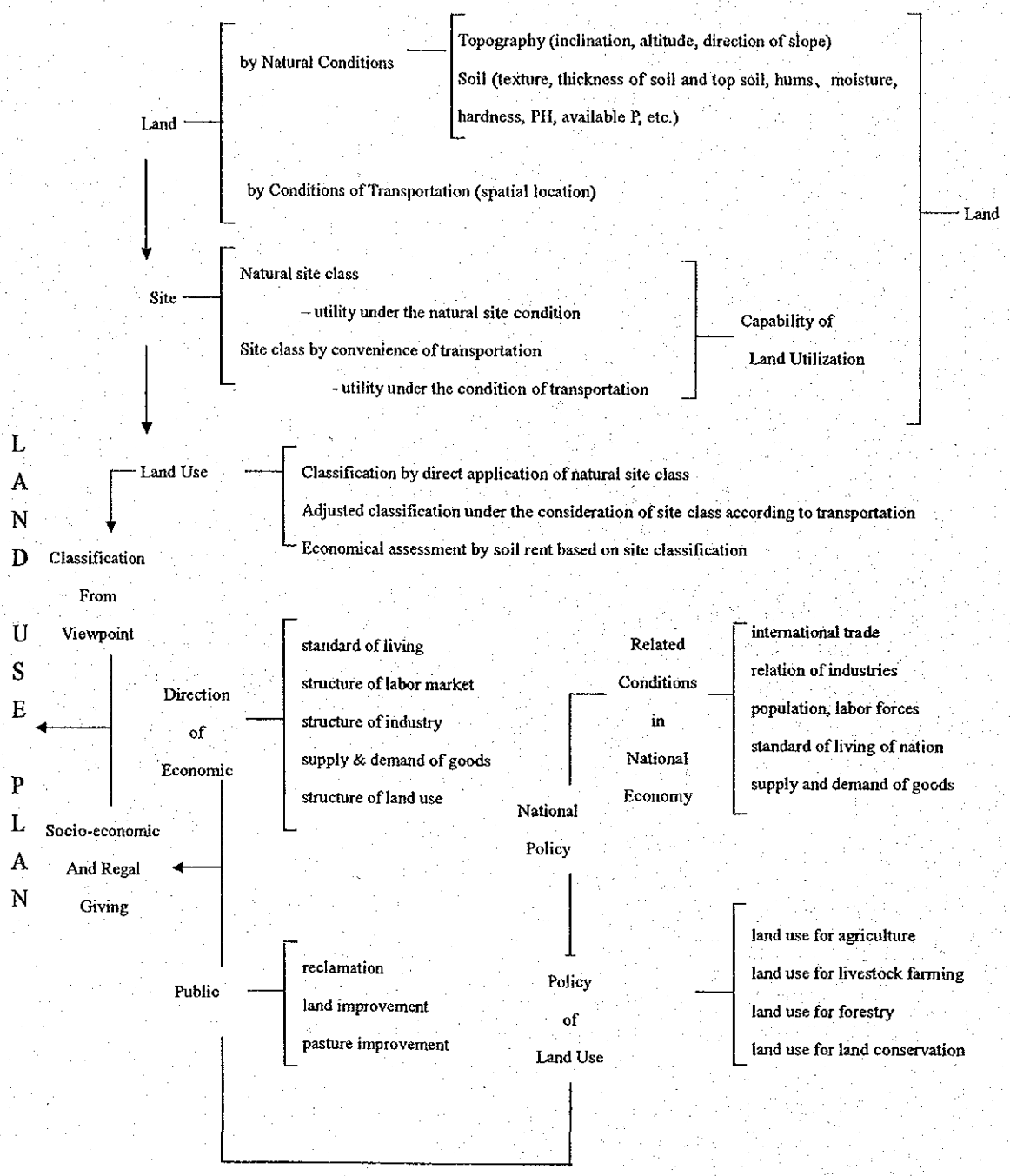


Figure 3-2-1-1 Chart of Land Use Planning (based on manual by "Ministry of Agriculture & Forestry")

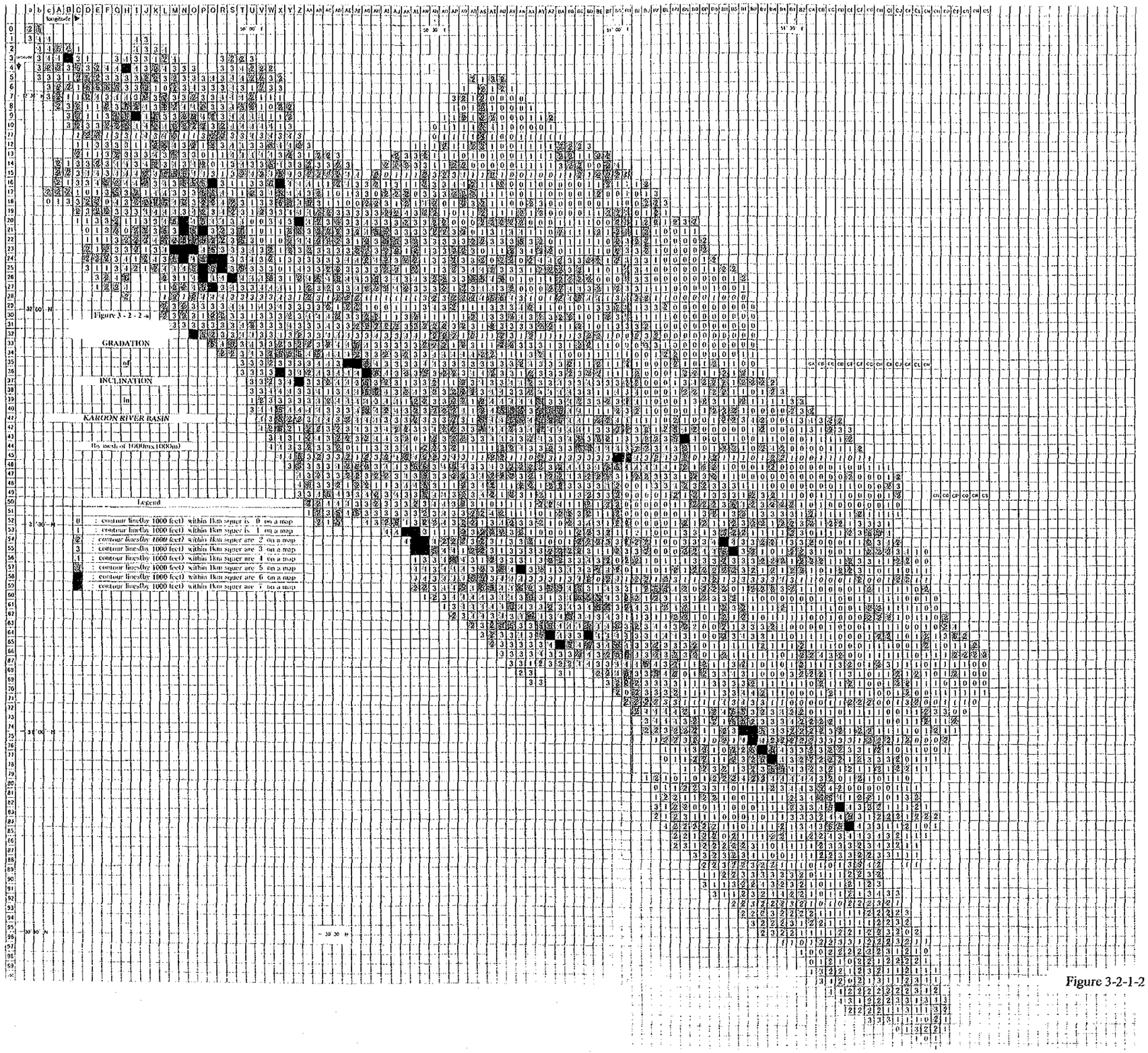


Figure 3-2-1-2 (1) Gradation of Inclination in Karoon River Basin

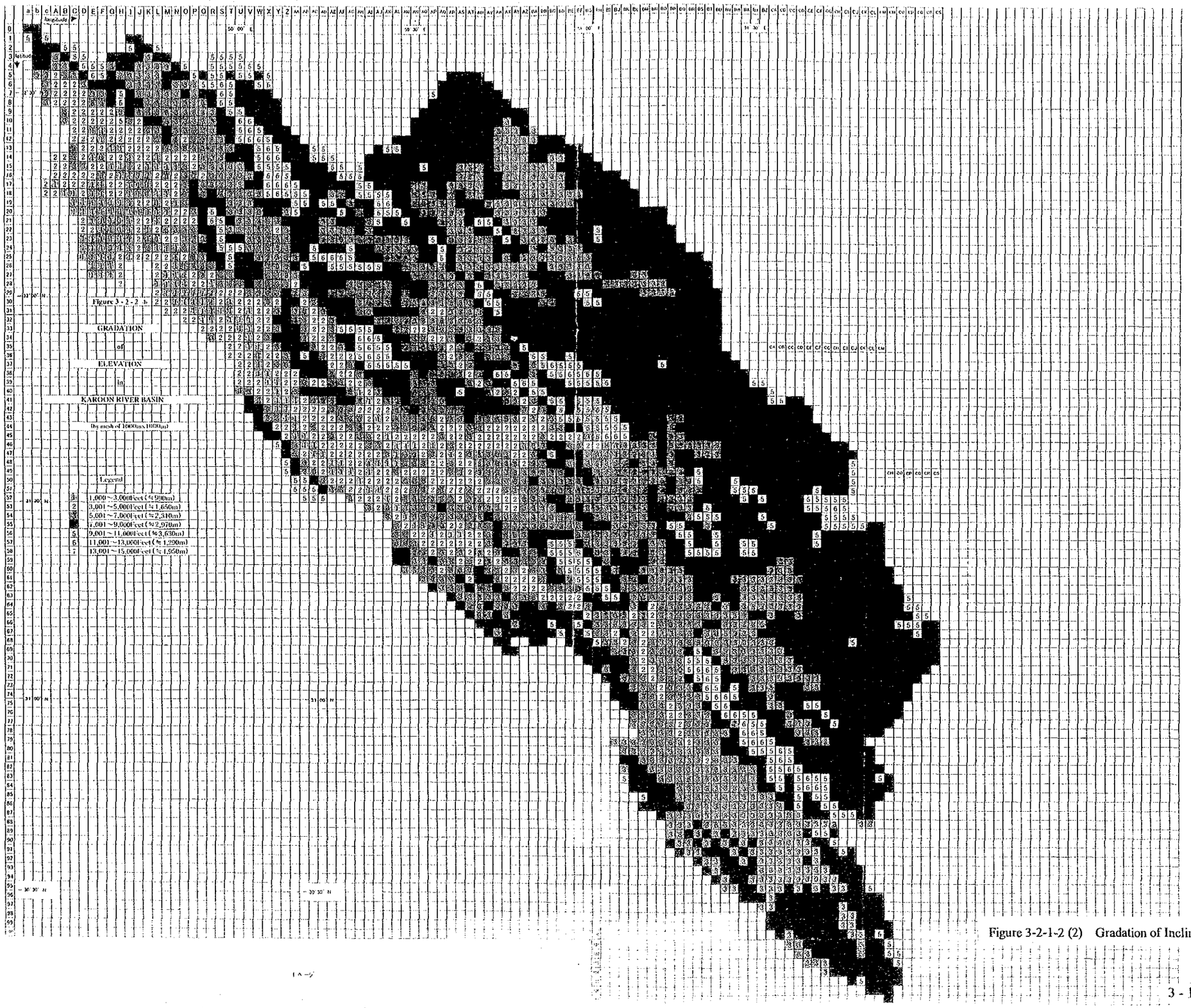


Figure 3-2-1-2 (2) Gradation of Inclination in Karoon River Basin

Table 3-2-1-1 Data of Soil Survey in Several Sample Plots

sample No.	latitude / longitude	soil color	soil texture・structure	soil hardness	pH (KCl)	exchangable Ca me/100g	available P %	soil type	sub-basin	natural condition of sample plot
1	31°48′ N / 50°33′ E	10YR4/6	stony loam ・ nutty	mm 25~30	6.9	49.4	2.14	Regosols	K3	under bush trees on talus 1910m in elevation
2	32°20′ N / 49°54′ E	7.5YR3/4	stony loam ・ crumb/nutty	mm 8~10	6.3	81.21	2.06	Regosols	K5	under oak trees on river terace 1793m in elevation
3	31°56′ N / 51°13′ E	10YR5/6	sandy loam ・ no structure	mm 15~30	7.5	92.02	0.01	Xerosols	K1	irrigated cropping field in plateau 2300m in elevation
4	31°25′ N / 51°04′ E	10YR6/4	sandy loam ・ nutty	mm 20~30	7.3	88.52	0.06	Xerosols	K6	grass land in plateau 2075m in elevation
5	32°27′ N / 50°07′ E	10YR4/6	stony loam ・ nutty	mm 20~30	7	62.97	0.26	Regosols	K2	under low bush at upper limit for cultivation 2430m in elevation

Note * soil color is based on the revised Munsell's Soil Color Charts. * soil hardness is measured by YAMANAKA soil hardness meter

* pH is tested by glass electrode with soil 1: KCl 2.5
* exchangable Ca is tested by Peech method with ammonium acetate
* available P is tested by Olsen method with HCl 0.2 Normal

Valley area: This area occupies the southwestern area of the Study area (K2, the western half of K3, K5, K6, the western half of K7 and K8), consisting of steep mountains at elevations ranging from approximately 4300 m at maximum to approximately 600 m at minimum, and narrow valleys. The mountains are mainly rocky land of Mesozoic limestone and shale with poor vegetation, and are used for rangeland. In the valleys, talus cones, alluvial fans, river terraces, alluvial flood-flats, etc. are found and in some places river terraces have developed in a considerably broad range along the valleys. The river terraces are used for cropping fields, grassland, orchards, forests, etc. The alluvial flood flats are narrow in width, however, in some places they are used for rice paddies, tree plantations, fish farms, etc.

b) Geology and land use

The Study area is located in the Zagros Mountain Region. This mountain region was formed through the uplifting and folding of sediments in the Techys Sea (the predecessor of Mediterranean Sea) which had existed until the end of the Mesozoic era. The uplifting and folding was caused by the pressure of plate tectonics from southwest. As a result, there have been formed many mountain chains, longitudinal valleys and plateaus, and transverse valleys in a few hundred kilometers-wide area from northwest to southeast of Iran in this mountain region.

The geological structure closely relates to the topography and land use in the basin. The geological zones consisting of limestone, shale and conglomerate of the Cretaceous period in the Mesozoic (partially including the period from the Paleozoic era and the Cretaceous to the early Tertiary) run from northwest to southeast, and form rocky mountains. The land in these zones is only useless rocky land, or used for rangeland and forests (natural open forests).

The sedimentary layer of the Tertiary period in the Cenozoic is alternation of strata consisting of thick non-concrete sediment associated with thin but concrete conglomerate, and forms terraces along the river valleys. In this area, various forms of land-use such as cropping fields, grassland, rangeland, forests, etc., are found. The sedimentary layer from the following Quaternary period is the non-concrete sediment and forms a flat land on the plateau, a talus cone at the foot of rocky mountain and an alluvial fan or a flood flat along the valley. These kinds of places often have a good water supply from groundwater, spring water or water intake from headwaters, and support intensive land use for cropping fields, orchards, fish farms, etc.

c) Climate and land use

Not only the Study area, but the whole land area of Iran falls under the Mediterranean climate.

The Mediterranean climate features rainy (snowy) winters and dry summers, and generally this type of climate has low precipitation. The Zagros Mountain Range lying in the southern part of the country is located in a semi-arid zone. The upper Study area belongs to the semi-arid zone, with an annual precipitation of less than 1000 mm; some sub-basin areas such as K2 and K5, which are located at high elevations, however, have annual precipitation reaching 1000-1800 mm.

Regarding temperature, areas in the range of 1500-2500 m in elevation belong to the cool temperate zone, however, in winter temperatures sometimes fall below 10°C at their lowest, and highlands above 2000 m are covered with snow. Temperatures in areas below 1500 m in elevation correspond to those of warm temperate and sub-tropical zones. Areas above 2500 m in elevation belong to the sub-frigid zone (sub-alpine zone) and on the northern slopes snow remains until May. Incidentally, since the climate of the Study area belongs to the rainy winter and dry summer type which has low rainfall and high potential evaporation in summer, the climatic conditions are generally harsh for plants. Agricultural land use largely depends on the water supply conditions other than the annual rainfall, e.g., the conditions of snowmelt, valley water, groundwater, spring water, etc.

d) Soil and land use

The types of soils are produced by the climatic, geological (parent materials), and vegetative conditions, while at the same time the vegetation is determined by soil type. Therefore, the relationship between the two is inter-dependent. According to the soil taxonomy by FAO/UNESCO, the main soil types in the Study area are Regosols. Regosols have a calcalic phase and are alkalic soils. In the rocky areas, the soil is mixed with Rithosols, which have a calcic phase and are alkalic soils as well. In the areas with little rainfall, Xerosols or Yermosols appear. In upper Karoon River Basin, since the water regime goes downwards (well drained), there is no large area of extremely saline soil. As for soil texture, the flat or gently sloping areas are of loam or sandy loam, however, the steep slope areas are of stony soil.

To summarize the above, soil distributed in the upper Karoon River Basin is immatured soil due to its existence in rocky mountain areas, and arid soil due to low rainfall. Organic material content in the soil layers is low due to the poor vegetation, since the soil has not aged and has a high based saturation and good drainage, when under good water supply conditions, crops grow well. The results of the soil sample survey in this basin are shown in Table 3-2-1-1. According to the table, it seems that woody vegetations contribute to the enrichment of available phosphorus and to the mitigation of salinity while herbal vegetations, particularly in case of irrigation, accelerate the leaching of phosphorus and increase the salinity of soil.

e) Vegetation and land use

The vegetation zone in all of Iran is classified into the following in terms of woody plants (by Forest and Rangeland Organization, Ministry of Jihad-e-Sazandgi)

i. Hyrcanian region

The Caspian Coast Region, with natural vegetation of forests due to the comparatively temperate humid climate. Growing species are: genera of Fagus, Carpinus, Quercus, Alnus, Zelkova, Fraxinus, Pterocarya, Acer, Boxus, etc.

ii. Arasbaranian region

The northwestern region in the country, with a semi-humid climate. Growing species are: genera of Carpinus, Quercus, Ulmus, Corylus, Fraxinus, Populus, Taxus, etc.

iii. Zagrosian region

The region of the Zagros Mountain Range including the upper Karoon River Basin, with a semi-arid climate. Growing species in open forests and bushes are: genera of Pistacia, Purunus, Crataegus, Ulmus, Celtis, Quercus, Fraxinus, etc.

iv. Irano-Tooranion region

The region with plateaus and mountains from the central to eastern part of the country including partially the upper Karoon River Basin, under an arid climate. Growing species in open forests and bushes are: genera of Pistacia, Purunus, Crataegus, Ulmus, Celtis, Salix, Tamarix, Juniperus, etc.

v. Persian Gulf coast region

The plain region on the Persian Gulf coast, under sub-tropical and semi-desert climate, forms wood lots depending on the water supply conditions. The main growing species are: genera of Acacia, Prosopis, Ziziphus, Populus, Avicennia, Rhizophera, etc.

The forest vegetation zones in this basin belong to the above iii) and iv), however in the plateau region of the head stream area, natural forests are scarcely growing, and the natural vegetations are mostly composed of herbal plants. And the vegetation in this basin includes mainly herbal plants of genera and species belonging to families such as Graminaceae, Reguminosae, Compositae, Cruciferae, Labiatae, Liliaceae, etc., which are used as forage for grazing.

(2) Condition of transportation

For the analysis of the condition of transportation in the land use study, it is practical to make a list of each sub-basins classified by accessibility to markets.

With this in mind, the following procedure was applied.

- The roads are the existing ones.
- The target markets are Eshafan, Shiraz and Ahwaz.

- The accessibility by human/animal carriers and motor-trucks was categorized into:
  - I - the places from where one can make a round trip to and from a market within one daytime
  - II - the places from where one can arrive at a market within one day
  - III - the places from where it takes more than three days to make a round trip to and from a market.

The list made according to the above procedure and is shown in the Table; Classification by Condition of Transportation & Site Class for Development in the Inventory.

(3) Current land use

The current land use of the upper Karoon River Basin is shown in the Table; Current Land Use in the Inventory and attached Map. The Table and Map are based on the studies which were carried out during 1990s by the Ministry of Jihad-e-Sazandegi and the Ministry of Agriculture. The actual figures and percentages of area for each land use are listed on the Table; Current Land Use in the Inventory. As shown in the Table, the land use types are ① Irrigated Farmland, ② Non-irrigated(Dry) Farmland, ③Rangeland, ④Forests, ⑤Forest with intercropping, ⑥Rock, and ⑦Others.

(4) Site classification

The site classification, as shown in the chart of Figure 3-2-1-1, identifies each sub-basin by its capabilities in consideration of natural, socio-economic and political criteria, or in other words, by its future development potential. Regarding the natural site classification (capability by natural conditions), the current land use categorized in the previous section is considered to be representative of each natural site classification both in the current and future situation. The natural site class of each sub-basin, therefore, could be classified by following procedure in terms of capability ;

Area of Farmland both of irrigated and non-irrigated = Weight 3 = Class I

Area of Forest and Forest with intercropping = Weight 2 = Class II

Area of Rangeland, Rock and, Others = Weight 1 = Class III

Then a summarized natural site class for each sub-basin could be determined by the following manners;

Σ(Weight a b c - - -	x	Percentage of area a b c - - -/100)	is over 2.3	= Class I-n
Σ(Weight a b c - - -	x	Percentage of area a b c - - -/100)	is 2.1～2.2	= Class II -n
Σ(Weight a b c - - -	x	Percentage of area a b c - - -/100)	is under 2	= Class III-n

As a perspective on condition of transportation, the future priority for development of road in the basin will be the same as the present priority. The upper Karoon River Basin, therefore, could be classified into the same order as the present classification in terms of transportation, i.e. Class I-t, II-t, and III-t for each sub-basin.

The applicability of land development under the consideration of costs/benefits is dependent on the number of villages and towns in each sub-basin, which indicates the number of beneficiaries. The

proposed basin could be classified into the following site classes for land development by each sub-basin:

Sub-basin which has more than two villages or towns = Class I-d

Sub-basin which has one village or town = Class II-d

Sub-basin which has no village or town = Class III-d

For each sub-basin, the integrated site class as a result of 3 classification above(-n,-t,-d) is computed by following procedure;

Weight of Class I in -n,-t,-d is 3

Weight of Class II in -n,-t,-d is 2

Weight of Class III in -n,-t,-d is 1

Weight of Integrated Site Class = Weight of Class-n x Weight of Class-t x Weight of Class-d

If a computed Weight of Integrated Site Class is 27 or 18 = Integrated Site Class is I

If a computed Weight of Integrated Site Class is 12,9,8,6 or 4 = Integrated Site Class is II

If a computed Weight of Integrated Site Class is 3,2 or 1 = Integrated Site Class is III

The list made according to the above procedure is shown in the Table; Integrated Site Class in the Inventory.

3.2.2 Land Use Category and Outline of Current Land Use

In the upper Karoon River Basin, several land use categories have been applied in the studies conducted by the Ministry of Jihad-e-Sazandegi and the Ministry of Agriculture since the 1980s.
The previous studies and their land use categories are as follows ;

① K1----K6 conducted by the Ministry of Agriculture in 1988
The categories are Irrigated Farmland, Non-irrigated(dry) Farmland, Rangeland, Forest, Forest with intercropping, Rock, Permanent snow, Lake, and Others

② K1----K6 conducted by the Ministry of Agriculture in 1998
The categories are Irrigated Farmland (includes A1:without limitation, A2: with limitation, AO:orchard), Dry Farmland, Rangeland (includes R1:dense Rangeland, R2:fairly dense Rangeland, R3:poor Rangeland, RA:Rangeland with irrigated farming, RD:Rangeland with dry farming, RB:delived land), Forest (includes F1:dense Forest, F2:fairly dense Forest, F3:poor Forest), Waste land, Rock outcrop, Town & Village, and Pond

③ a part of K7 conducted by the Ministry of Jihad-e-Sazandegi in 1994
The categories are Irrigated Farmland, Dry Farmland, Rangeland, Forest, and Barren

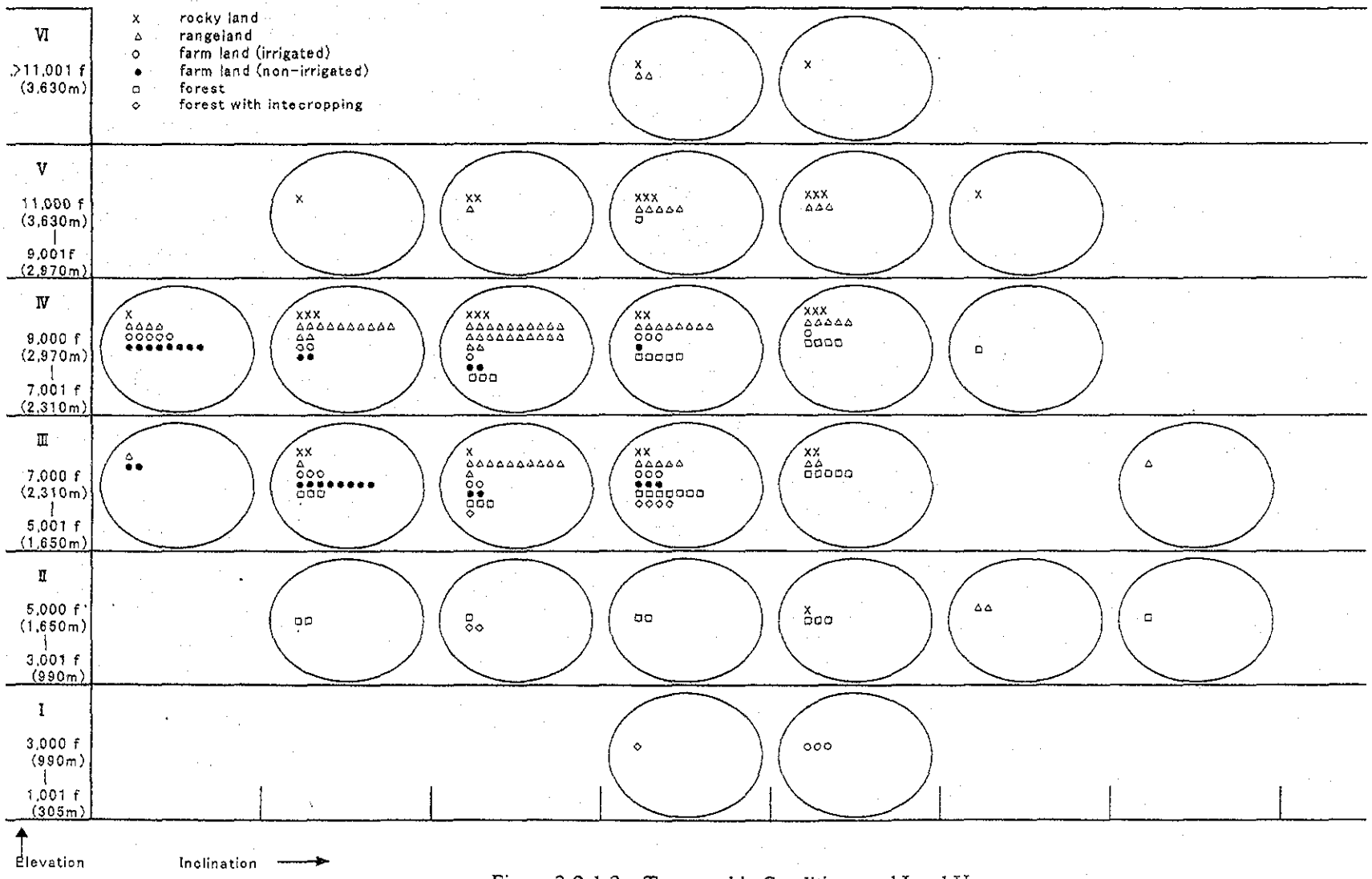


Figure 3-2-1-3 Topographic Conditions and Land Use

④ most part of K8 conducted by the Ministry of Jihad-e-Sazandegi in 1999
The categories are Irrigated Farmland (includes 2 sub-categories), Dry Farmland, Rangeland (includes 11 sub-categories), Forest (includes 24 sub-categories), Rock, and Water bodies & Others

The relationships between these categories are listed on Table F-2 in Annex.

(1) Land Use Category

a) Farmland

The Farmland consists of paddies and fields with several kinds of crops such as cereals (wheat, barley and rice), pulses (soybean, cowpea, broad bean, pea, lentil and azuki bean), vegetables (potato, tomato and onion), sugar beet as well as grasses (alfalfa, clover and wild herbal plants). The Farmland sometimes includes Orchard planted with almond trees, apple trees, pear trees, apricot trees, peach trees, grape vines, pomegranate trees, walnut trees; and Tree Plantation with Pinus halepensis (=eldarica), Juniperus Sabina, Populus sp., etc.

The Farmland is usually classified into irrigated Farmland and non-irrigated (dry) Farmland as mentioned before. Most paddy fields are irrigated more or less, however, grassland, and tree plantations are mostly not irrigated.

Irrigation in the plateau area of the riverhead is applied by drawing groundwater through qanats or conducting water from reservoirs. Irrigation in the valley is mostly performed through ditches leading from the headwaters. On the other hand, non-irrigated(dry) Farmland is located on the upper part of slopes, on many of which water from thawed snow is useful during the spring season.

b) Rangeland

Rangelands are generally located higher places than Farmlands, have stony and rocky soil, and much of them are on steep slopes.

The vegetation here consists of Astragalus spp. which are creeping woody legume and dominant plants in this area and natural herbal plants(Acantholimon, Bromus, Cirsium, Cousinia, Euphorbia, Festuca, Hertia, Hordeum, Phlomis, Stipa, etc.), as well as a low tree of Daphne sp.. The Astragalus and the herbal plants are fed to goats in seasonal ranging (from May to October). Sometimes the Rangeland associates with open forests which provide fuel wood for local people. The Rangeland is usually divided into several sub-types depending on the dominant and associated plants ; for example, Astragalus - Cousinia sub-type, Astragalus - Daphne sub-type, Phlomis - Astragalus subtype, Bromus - Stipa sub-type, etc.

The Rangeland is the largest type of land use in the Study area although its soil productivity is generally lower than Farmland and Forest because of its edaphic and climatic conditions.

c) Forest

Generally, the forest type in the Study ara is classified as "open forest" in the category of forest resources by FAO. That means the tree crowns are not closed and ground surface can be seen from above. Growing species in the Forests are naturally regenerated deciduous hardwood species such as Quercus sp., Pistacia sp., Amygdalus sp., Fraxinus sp., Acer sp., Ulmus sp., Celtis sp. and low trees such as Juniperus sp., Tamarix sp., Crataegus sp., etc.. The hardwood species are lopped and utilized for fuel wood by local people. In the same way as Rangeland, the Forest is also divided into several sub-types depending on the dominant and associated tree species ; for example, Quercus – Pistachia sub-tipe, Quercus – Fraxinus sub-type, Tamarix – Salix sub-type, etc..

As shown on the map, the Forest distributes in the valley area which is located in southwestern part of the Study area include the southwestern half of K3, K5, K6, K7 and K8. The reason for this uneven distribution is probably attributable to the fact that these areas have had less human disturbance than plateau area, at the same time, the forested area has a comparatively low elevation, and a warm, humid climate.

d) Forest with Intercropping

Some parts of forest area are converted to "Forest with Intercropping". This type of land use originates from Forest mentioned above. Due to the overexploitation of forest trees, the tree density has become low and agricultural cropping (mainly with wheat) has been introduced by local people.

The Forest with Intercropping is a kind of primitive agroforestry system, but the absence of succeeding seedlings, the erosion of top soil and the degradation of forest resources are negative impacts by this system. Some technical approaches, therefore, should be taken to enrich the succeeding young trees and to conserve soil erosion in this land use system.

e) Rock

The rocky land has no vegetation cover, with exposed bare rocks and having ground surfaces covered only with debris. Due to the steep and poor ground condition, the rocky land is not suitable for agricultural use. In addition, rocks have fallen extensively and eroded, and since these phenomena are part of the geomorphic cycle, it is hardly to apply some countermeasures against the erosion.

f) Others

The category "Others" includes water bodies such as rivers, lakes, ponds, marshes, etc., permanent snow, villages & towns, waste land, barren, mines, and facilities concerning oil and other industries.

Among them, water bodies both of natural and man-made origin are utilized for water resources, and permanent snow is the place where the remaining snow will not melt

throughout the year, although since the snow has not become ice or glacier. Permanent snow is located at approximately 4000 m in elevation. Obviously this is not the target of land use, but is one of various water resources.

(2) Outline of Current Land Use

Referring to the attached map of land use, proportion of current land use of the study area is summarized as follow:

Table 3-2-2-1 Proportion of Current Land Use in the Study Area

Sub-Basin	Proportion of Land Use (%)							
	Irrigated farmland	Dry farmland	Rangeland	Forest	Forest with intercropping	Rock	Water bodies, Permanent snow	No Data
K1	15%	6%	76%	2%	-	-	1%	-
K2	3	1	62	28	-	-	6	-
K3	1	1	38	60	-	-	-	-
K4	8	2	73	15	-	-	1	1%
K5	-	1	20	76	-	1%	2	-
K6	10	2	34	52	2%	-	-	-
K7	2	2	27	52	-	14	-	3
K8	1	3	31	54	6	2	3	-

a) K1 Sub-Basin

Due to the gentle topographic features in this basin, the farmlands are well developed in the alluvial plain. Most of them are irrigated by quanat system or channel system. In inclined field and upper part of plain, the farmlands have no or limited irrigation system. In high elevation areas in K1 are mostly the rangeland. Natural forests are scarce in K1 except in the north-western end of K1 depending on the comparatively plenty precipitation and low human disturbance in this part.

b) K2 Sub-Basin

: Since its topographic feature in valley area, the irrigated farmlands are distributed along the river terraces and on the flood flat. The slope in high elevation is mainly covered by herbal plants or bushes and utilized as a rangeland. Natural forests are growing in the mountainous area of northern part of K2.

c) K3 Sub-Basin

Due to the hilly landscape in K3, the dominant land use is natural open Quercus Forest associated with narrow farmland along the valley. In the northern part of K3, rangelands are distributed instead of natural forest.

d) K4 Sub-Basin

Because of the same topographic condition as in K1, the characteristic of land use in K4 is

similar to that in K1. The land use in K4 is composed of farmlands in flat plains, rangelands in slopes and some of natural forests in hills.

e) K5 Sub-Basin

The characteristic of land use in K5 is the existence of widely spread natural forests. Besides the natural forests, rangelands and farmlands are found in some extent.

f) K6 Sub-Basin

In the upper basin of Lordegan river which is one of tributary basins of K6, irrigated farmlands are fairly developed in flat plain. Surrounding areas of the farmlands are utilized as rangelands. Mountainous areas in K6 are managed as natural forest and forest with intercropping.

g) K7 Sub-Basin

K7 is devided into two topographic features. One is plateau area and another is valley area. The land use pattern in the former area is nearly same as the pattern in K4 which is composed of farmland, rangeland and a few forest. The land use in latter area is composed of natural forest in general, some of farmlands in the valley and a few rangelands. The mountain ranges in K7 are outcrop of rock in certain extent.

h) K8 Sub-Basin

The dominant land use in K8 is natural forest. The area of rangeland is smaller than forest area in this basin. The forest with intercropping and the farmland are developed on river terrace and along the river stream. The outcrop of Rock appears sometimes on the mountain ridge.

3.2.3 Land Capability

Land capability is one of the most essential and useful elements for regional development planning because the land capability integrates and expresses many related factors as topography, soil, vegetation, land use and suitability on development. Tow different methods are common for land capability analysis in Iran. One is the topography-base method, and the other is the irrigation-base method. The former one is applied based on the classification of topography with such data of altitude, slope, soil, vegetation and current land use. It is utilized for the potential analysis of agricultural development in the large extent of area. The later one is applied based on the details of soil with data of soil texture, permeability, slope and current erosion etc.. It is utilized for the potential analysis of irrigation development by means of classification into six classes in the particular area. Land capability has been already studied in most part of the Study Area by several studies

under JIHAD and MOA. Those previous studies are employing the former topography-base method because of large extent of the study areas. The previous studies are as follows:

Table 3-2-3-1 Previous Studies on Land Capability in the Study Area

River Basins	Studies	Study Area
K1-K6	Agricultural Master Plan for the North Karoon River Basin By YEKOM Consulting Engineers under MOA, 1988 & 1999	Whole area of K1-K6 river basins.
K7	Agricultural Master Plan for Kohggiluyeh-va-Boyerahmad Province. By ZOUMAR Consulting Engineers under MOA, 1994	Southwestern part of K7, bounded by provincial boundary.
	Explanatory Study of Natural Resources Management in the Boshar and Marbor River Basin By ZOUMAR Consulting Engineers under JIHAD, 1994	Mid and Southeastern parts of K7 bounded by Marbor and Boshar river basins.
K8	Agriculture Master Plan in Dez – Karoon River Basin By VISAN Consulting Engineers under MOA, 1991	Whole area of K8 river basin.

(Note) Study area of each study is shown in Figure D-1-1 in ANNEX D.

As shown in above Table, northern part of K7 river basin (river basins of Semiron river and Khersan river) has not been studied yet. Preliminary study has been given for grasping land capability of this study blank area in order to evaluate whole study area. Preliminary study has employed the topography-base method to harmonize with the previous studies. Explanatory Study of the Boshar and Marbor River Basin applied different classification of land capability, but basically topography-based method, so that modification was given to classification to correspond to other studies.

(1) Study of the Study Blank Area

The study blank area, Semiron and Khersan river basins, has been studied on land capability in accordance with the following procedure:

a) Classification of topography

Topography has been classified into following 6 categories on the map of 1:50,000. (Analysis of topography is described in Section 3.1.2)

A: Mountain (Code=1 in the Topography Base Method)
B: Hill (Code=2)
C: Terrace (Code=3 including Plateau)
D: Alluvial Flat Plain
E: Alluvial Fan
F: Water

Among above 6 categories, Alluvial flat plain and Alluvial fan have been further classified in order to correspond to the classification of the topography-base method. Alluvial flat plain has been classified into 3 categories, namely (4) Piedmont Plain located nearby the piedmont and rather free from flood, (4/5) Elluvial Plain located along the river in narrow extent, and (6) Lowland affected by flood frequently. Alluvial fan has been classified into 2 categories, namely (8) Gravelly colluvial fan with a slope of 2 to 6% and (9) Gravelly river fan with a slope of 0.5 to 2%.

b) Classification into land capability

Above identified topographies have been classified into land capabilities taking gradient, soil cover, vegetation, present land use (mainly agriculture) and erosion into consideration. Materials utilized in this work are topographical maps of scale 1:50,000 and 1:25,000, aerial photos of 1:40,000 scale, Spot satellite image of scale 1:100,000. Major classifications of land capability in the study blank area are as below:

Table 3-2-3-2 Classification of Land Capability in the Blank Area

Topographical Classification	Classified Land Capabilities
A: Mountain	Mountains (1.2): Almost high mountain with rounded ridges formed from limestone, shale and conglomerate.
B: Hill	Hills (2.3): Small hills with rounded edges formed from red and gray marls, gyps and silt.
C: Terrace	Piedmont and Upper Terrace (3.3): Plateau varied by fixed dune. Overall slope is 3 – 5%.
D: Alluvial Flat Plane	Piedmont Plaines (4.2): Piedmont plains with a very small fine slopes, almost flat. Slope: 0.5 – 1%
E: Alluvial Fan	Plateaus and Upper Terraces (3.3): Plateau varied by fixed dune. Overall slope is 3 – 5%. (In case, land is sloping and locating beside the mountain.)
	Piedmont Plaines (4.2): Piedmont plains with a very small fine slopes, almost flat. Slope: 0.5 – 1% (In case, land is flat, and far from mountains.)
	Gravelly river fans (9.2) : Gravelly river fans with almost flat. (In case, land is narrow and nearby mountain or hill.)

(2) Modification of Land Classification in Marbor River Basin

Explanatory study of Boshar and Marbor River Basin has applied more detail classification of land capability so that classification has been simplified to correspond to other previous studies.

Table 3-2-3-3 Simplification of Land Capability in Marbor River Basin

Classification by Explanatory Study	Simplification
Mountains (M1-1, M1-2, M1-3, M2-1, M2-2, M2-4, M3-2)	Mountains (1.2)
Hills (H1-1, H1-2, H2-2)	Hills (2.3)
Plateaus and Upper Terraces (T1-1, T1-2,T2-1, T2-2, T3-1)	Plateaus and Upper Terraces (3.3)
Piedmont Plains (P1-1, P1-2)	Piedmont Plains (4.2)

(3) Land Capability in the Study Area

Land capability has been studied mainly by compiling the existing previous report, together with above additional studies of the study blank area and simplification in Marbor river basin. Land capability of the Study Area is summarized in Table 3-2-3-4. Detail category and description of land capability is shown in Table D-1-1, ANNEX D, and land areas by categories are compiled in Table D-1-2, ANNEX D.

Table 3-2-3-4 Area and Area Ratio by Land Capabilities

Land Type	Symbol	River Basins (Km²)								Total
		K1	K2	K3	K4	K5	K6	K7	K8	
		Behest abad	Ab. Kurang	Middle Karoon	Vanak	Bazoft	R. Lordegan	Khersan	Karoon	
Mountains	1.1	0.0	73.4	0.0	23.3	0.0	0.0	750.3	507.2	1,354.3
	1.2	236.6	821.7	950.5	985.1	906.8	329.1	2,669.4	61.8	6,961.1
	1.3	716.6	0.0	0.0	253.3	0.0	0.0	0.0	0.0	969.9
	1.4	285.7	0.0	16.0	32.7	0.0	0.0	23.6	0.0	357.9
	1.5	0.0	0.0	1,019.4	178.3	1,147.6	482.4	2,838.1	2,344.2	8,010.0
	1.6	28.2	4.0	71.6	91.1	25.8	0.0	0.0	0.0	220.9
Hills	2.1	125.0	0.0	1.9	50.7	6.4	17.4	50.5	16.7	268.6
	2.2	0.0	0.0	0.0	0.0	0.0	0.0	133.2	0.0	133.2
	2.3	231.6	0.0	27.7	429.5	6.3	7.8	589.0	0.0	1,291.8
	2.4	186.7	15.8	17.7	55.1	0.0	0.0	0.0	0.0	275.3
	2.5	0.0	0.0	145.9	0.0	38.4	157.8	106.2	77.9	526.2
	2.6	0.0	136.1	14.2	0.0	0.0	1.8	0.0	0.0	152.1
Plateaus and Upper Terraces	3.1	363.2	0.0	0.0	40.2	0.0	30.4	144.1	10.5	588.4
	3.2	431.7	4.7	0.0	56.6	0.0	0.0	10.2	0.0	503.3
	3.3	3.1	21.7	28.0	314.1	0.0	30.6	1,094.1	87.1	1,578.6
	3.4	0.0	0.0	0.0	289.9	0.0	31.6	0.0	0.0	321.4
	3.5	0.0	0.0	4.3	0.0	29.7	63.5	0.0	32.5	130.0
	3.8	0.0	0.0	0.0	0.0	0.0	0.0	83.8	0.0	83.8
Piedmont Plains	4.1	274.6	0.0	0.0	62.5	0.0	0.0	16.9	5.7	359.7
	4.2	36.2	0.0	15.1	4.6	13.5	123.0	269.5	0.0	462.0
Elluvial Plains	4/5	160.4	3.8	0.0	0.0	0.0	0.0	0.0	0.0	164.2
Low lands	6.1	93.4	0.0	0.0	61.5	0.0	22.5	0.0	0.0	177.3
Gravelly Colluvial Fans	8.1	320.0	0.0	0.0	81.9	0.0	9.5	155.5	3.1	570.0
	8.2	20.4	23.0	35.3	39.6	0.0	44.2	73.0	0.0	235.6
	8.5	0.0	0.0	0.1	0.0	0.0	47.5	0.0	0.0	47.6
Gravelly River Fans	9.1	61.9	0.0	0.0	13.9	0.0	0.0	0.6	0.0	76.4
	9.2	0.0	0.0	0.0	12.9	0.0	31.6	0.0	0.0	44.5
Complexes	C1	54.3	0.0	15.5	0.0	0.0	0.0	0.0	88.4	158.1
	C2	0.0	0.0	0.0	72.2	0.0	15.0	0.0	0.0	87.2
	C3	11.3	101.2	112.8	0.0	0.0	0.0	0.0	0.0	225.3
	C4	14.0	0.0	31.8	23.9	0.0	0.0	0.0	0.0	69.7
	C5	244.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	244.5
	C6	0.0	0.0	0.0	4.9	0.0	28.4	0.0	0.0	33.2
	C7	0.0	15.9	0.0	0.0	0.0	0.0	0.0	0.0	15.9
River Beds	RW	16.7	2.2	0.0	0.0	0.0	0.0	0.0	0.0	18.8
Marsh	Ma	1.3	0.0	1.3	28.4	0.0	0.0	0.0	0.0	31.0
Reservoir	110	2.9	0.0	0.0	8.8	0.0	0.0	7.1	38.6	57.3
City	111	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	5.9
Mountains	1	1,267.1	899.2	2,057.6	1,563.8	2,080.3	811.5	6,281.4	2,913.3	17,874.1
Hills	2	543.3	151.9	207.3	535.3	51.1	184.8	879.0	94.6	2,647.3
Plateaus and Upper Terraces	3	798.0	26.5	32.2	700.8	29.7	156.0	1,332.2	130.1	3,205.5
Piedmont Plains	4	310.8	0.0	15.1	67.1	13.5	123.0	286.5	5.7	821.7
Elluvial Plains	4/5	160.4	3.8	0.0	0.0	0.0	0.0	0.0	0.0	164.2
Low lands	6	93.4	0.0	0.0	61.5	0.0	22.5	0.0	0.0	177.3
Gravelly Colluvial Fans	8	340.4	23.0	35.5	121.5	0.0	101.2	228.5	3.1	853.1
Gravelly River Fans	9	61.9	0.0	0.0	26.8	0.0	31.6	0.6	0.0	120.9
Complexes	C	324.2	117.1	160.0	100.9	0.0	43.4	0.0	88.4	834.1
River Beds	RW	16.7	2.2	0.0	0.0	0.0	0.0	0.0	0.0	18.8
Marsh	Ma	1.3	0.0	1.3	28.4	0.0	0.0	0.0	0.0	31.0
Reservoir	110	2.9	0.0	0.0	8.8	0.0	0.0	7.1	38.6	57.3
City	111	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	5.9
Total		3,920.2	1,223.7	2,509.0	3,214.9	2,174.7	1,474.0	9,021.1	3,273.6	26,811.2
Mountains	1	7.1%	5.0%	11.5%	8.7%	11.6%	4.5%	35.1%	16.3%	100.0%
Hills	2	20.5%	5.7%	7.8%	20.2%	1.9%	7.0%	33.2%	3.6%	100.0%
Plateaus and Upper Terraces	3	24.9%	0.8%	1.0%	21.9%	0.9%	4.9%	41.6%	4.1%	100.0%
Piedmont Plains	4	37.8%	0.0%	1.8%	8.2%	1.6%	15.0%	34.9%	0.7%	100.0%
Elluvial Plains	4/5	97.7%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Low lands	6	52.7%	0.0%	0.0%	34.7%	0.0%	12.7%	0.0%	0.0%	100.0%
Gravelly Colluvial Fans	8	39.9%	2.7%	4.2%	14.2%	0.0%	11.9%	26.8%	0.4%	100.0%
Gravelly River Fans	9	51.2%	0.0%	0.0%	22.2%	0.0%	26.1%	0.5%	0.0%	100.0%
Complexes	C	38.9%	14.0%	19.2%	12.1%	0.0%	5.2%	0.0%	10.6%	100.0%
River Beds	RW	88.5%	11.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Marsh	Ma	4.1%	0.0%	4.2%	91.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Reservoir	110	5.0%	0.0%	0.0%	15.3%	0.0%	0.0%	12.4%	67.3%	100.0%
City	111	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Total		14.6%	4.6%	9.4%	12.0%	8.1%	5.5%	33.6%	12.2%	100.0%
Mountains	1	32.3%	73.5%	82.0%	48.6%	95.7%	55.1%	69.6%	89.0%	66.7%
Hills	2	13.9%	12.4%	8.3%	16.7%	2.4%	12.5%	9.7%	2.9%	9.9%
Plateaus and Upper Terraces	3	20.4%	2.2%	1.3%	21.8%	1.4%	10.6%	14.8%	4.0%	12.0%
Piedmont Plains	4	7.9%	0.0%	0.6%	2.1%	0.6%	8.3%	3.2%	0.2%	3.1%
Elluvial Plains	4/5	4.1%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%
Low lands	6	2.4%	0.0%	0.0%	1.9%	0.0%	1.5%	0.0%	0.0%	0.7%
Gravelly Colluvial Fans	8	8.7%	1.9%	1.4%	3.8%	0.0%	6.9%	2.5%	0.1%	3.2%
Gravelly River Fans	9	1.6%	0.0%	0.0%	0.8%	0.0%	2.1%	0.0%	0.0%	0.5%
Complexes	C	8.3%	9.6%	6.4%	3.1%	0.0%	2.9%	0.0%	2.7%	3.1%
River Beds	RW	0.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Marsh	Ma	0.0%	0.0%	0.1%	0.9%	0.0%	0.0%	0.0%	0.0%	0.1%
Reservoir	110	0.1%	0.0%	0.0%	0.3%	0.0%	0.0%	0.1%	1.2%	0.2%
City	111	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Mountains are extending largely in the study area and share the land of 17,874 km^2, that is 67 % of the study area as shown in Figure 3-2-3-1. Plateaus and upper terraces follows the mountains, and its area is 3,205 km^2 or 12 % of the Study Area. Area of hills is the third largest share, that is 2,647 km^2 or 9.9 %. The piedmont plains, the gravelly colluvial fans and the complexes are the fourth group of area, that is at 3 % mark. Areas of other categories are smaller as less than 1.0 %.

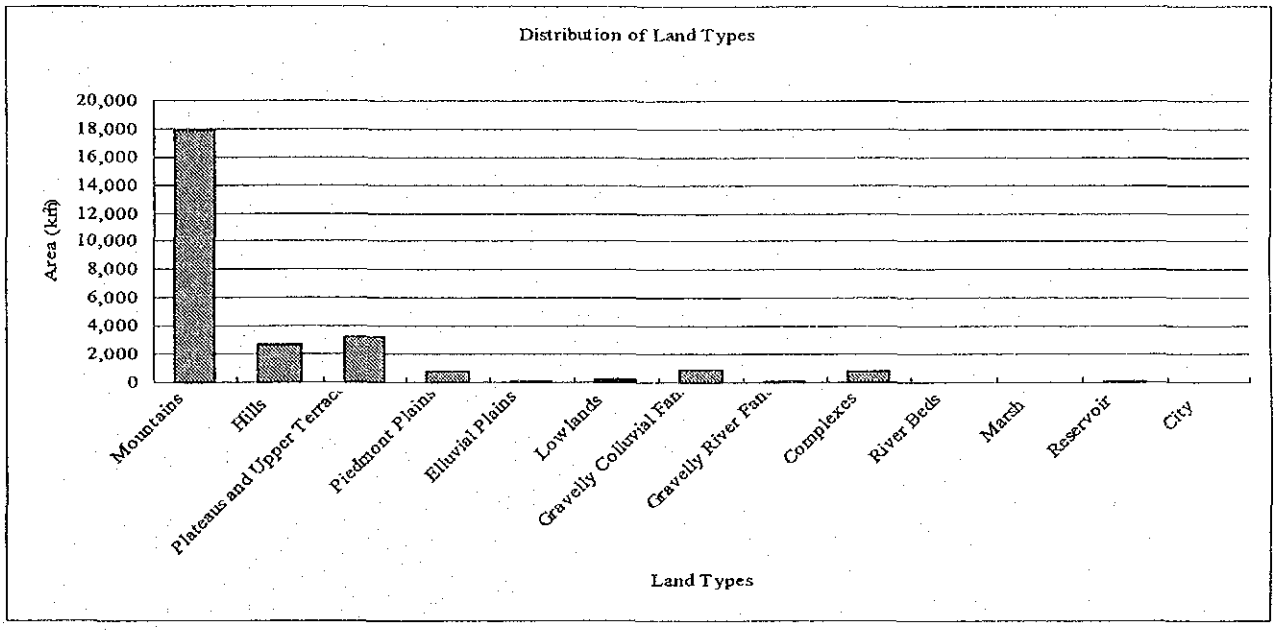


Figure 3-2-3-1 Distribution of Land Types in the Study Area

a) Mountains (1.1, 1.2, 1.3, 1.4, 1.5, 1.6)

Total area of mountains is 17,874 km^2 which is equivalent to 67 % of the Study Area. As shown in Figure 3-2-3-2, mountains are distributed largely in K7, and followed by K8. Out of total mountains, as shown in Table 3-2-3-4, forest mountain (1.5) shares the largest area of about 8,010 km^2, that is 45 % of total mountains. Forest mountains are commonly covered by oak tree forests in most parts of the mountain.

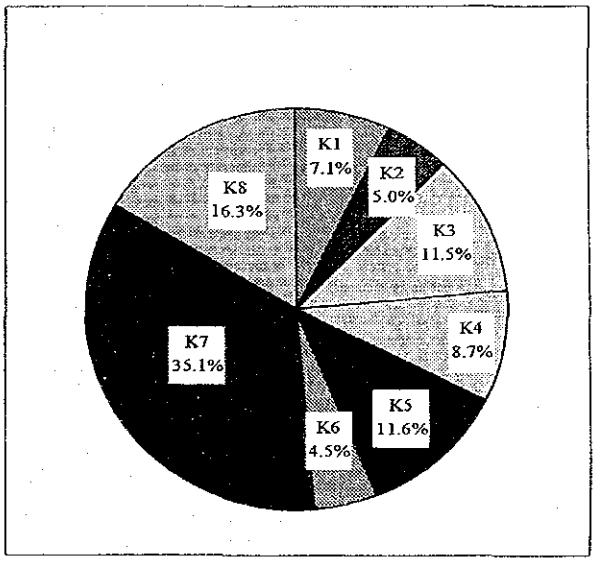


Figure 3-2-3-2 Distribution of Mountains

High mountains (1.2), which are with rounded ridges formed from limestone, shale and conglomerate follow the forest mountains. The area of high mountain is 6,961 km^2, that is equivalent to 39% of total mountains. Total area of forest mountains (1.5) and High mountains (1.2) shares most area of mountains as about 84%. Very high mountains (1.1) follows them, and the area of very high mountains is 1,354 km^2, that is 7% of the total mountains. Most mountains are formed by very hard limestone without soil cover. The mountains are to be conserved properly by watershed management, and afforestation and controlled grazing are recommended by the previous studies.

b) Hills (2.1, 2.2, 2.3, 2.4, 2.5, 2.6)

Total area of hills is 2,647km^2, that is 10% of the Study Area. The hills are distributed mainly in K7, K1 and K4 as shown in Figure3-2-3-3. Small hills (2.3) are sharing the largest area of hills, about 1,292 km^2 equivalent to 49% of total hilly area. Small hills are distributing mainly K1, K4 and K7 River Basins as same as total hill distribution. High forest hills (2.5) follows small hills (2.3), and the area is 526 km^2, that is 20 % of total hilly area. Main limitations of hills are shallow soils, steep slope and erosion.

In the previous studies, the hills are recommended to be conserved as forest and utilized under controlled grazing and dry farming.

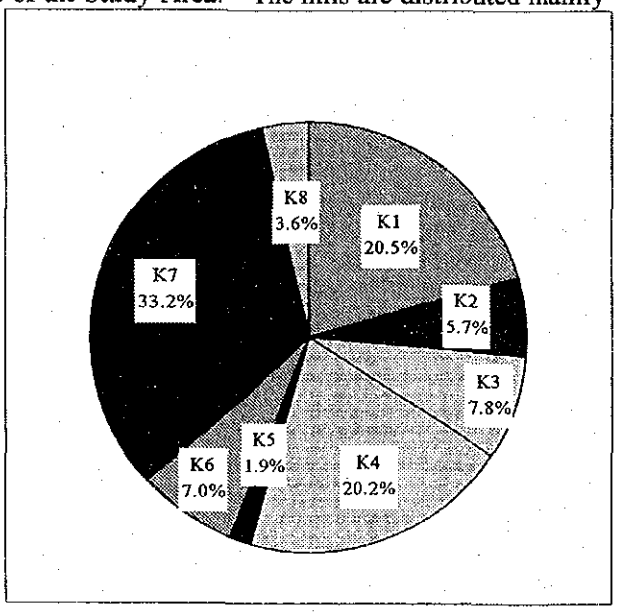


Figure 3-2-3-3 Distribution of Hills

c) Plateaus and Upper Terraces (3.1, 3.2, 3.3, 3.4, 3.5, 3.8)

Plateau and upper terraces are located along hills and mountains commonly in K1, K4 and K7 as shown in Figure 3-2-3-4. Total area of plateaus and upper terraces is 3,206 km^2, that is equivalent to 12% of the Study area. Among plateaus and upper terraces, plateau buried by fixed dunes (3.3) shares the largest area of 1,579 km^2, that is 49% of total area of plateaus and upper terraces. Following this type plateaus, the upper terraces with moderate to high relief (3.1) and the old plateaus with a little relief (3.2) share large area of 1,092 km^2 in total. In the plateaus and upper terraces, grazing and dry farming are extensively conducted, and irrigated farming and paddy cultivation are carried out in some areas. Limitations of the lands are relief in topography, erosion and soil depth. Forest and controlled grazing are suited and dry farming and irrigated farming are moderately suited after improvement in this type of land.

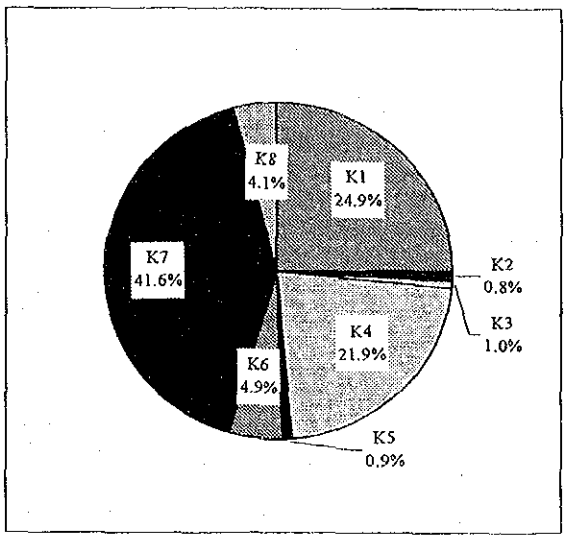


Figure 3-2-3-4 Distribution of Plateaus and Upper Terraces

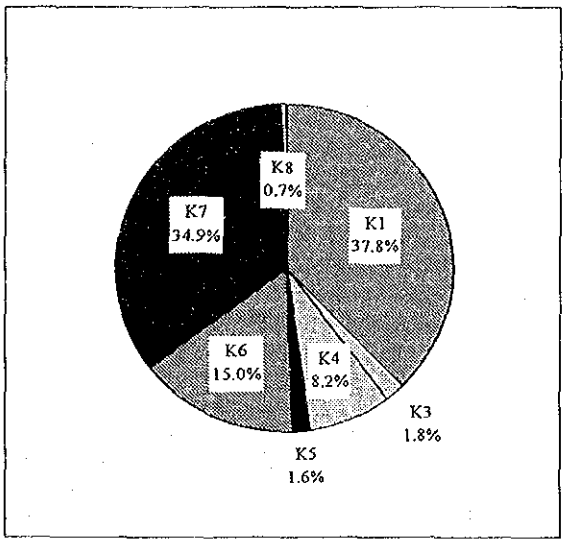


Figure 3-2-3-5 Distribution of Piedmont Plains

Piedmont Plains (4.1, 4.2)

Piedmont plains share 822km^2, that is only 3.1% of total area of the basin, but the piedmont plains are very important for agriculture. Grazing, dry farming and irrigated farming are extensively carried out in the area. Main limitation of this area is relief and gravel in some part, and water. In this area, irrigated farming is suited when water is ensured and lands are leveled. Piedmont plains extend largely in K1 and K2 River Basins as shown in Figure 3-2-3-5.

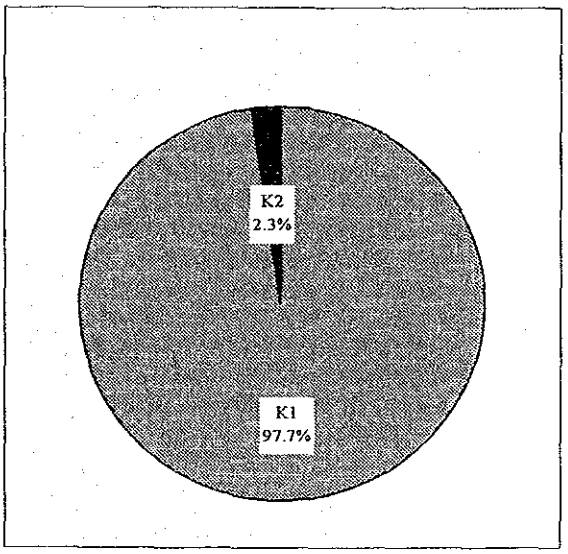


Figure 3-2-3-6 Distribution of Elluvial Plains

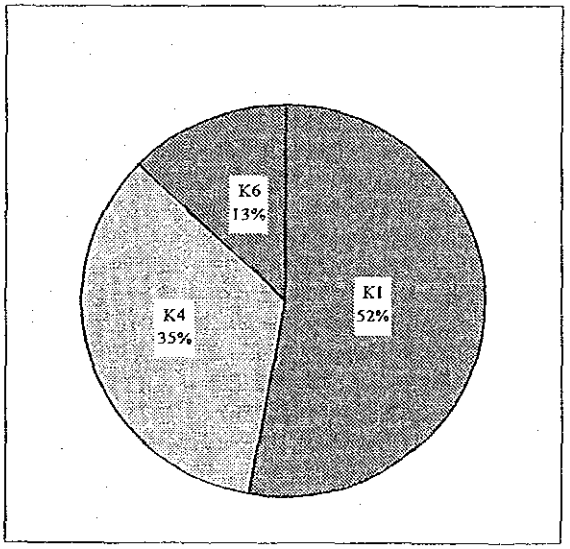


Figure 3-2-3-7 Distribution of Lowlands

d) Elluvial Plains (4/5)

Elluvial plains are mostly located along rivers in K1 as shown in Figure 3-2-3-6. The area of elluvial plains is limited only at 0.6% of the Study Area. Although the area is small, elluvial plains are important for agriculture as well as piedmont plains. Major limitations of this area are water and erosion, so that irrigated farming is the most suited land use when water is ensured.

e) Lowlands (6.1)

Lowlands are formed along the rivers generally surrounded by the piedmont plains. Lowlands are abundant in K1 as well as in K4 and K6 as shown in Figure 3-2-3-7. Agriculture and grazing are major activities in the lowlands, and floods and poor drainage are the major limitations. If lowlands are developed with considerable extent of irrigation without drainage, salinity will become severe limitation in the lowlands. The area of lowlands is small only at 177 km^2 or 0.7 % of the Study Area. According to the previous studies, more studies are recommended for development of the lowlands.

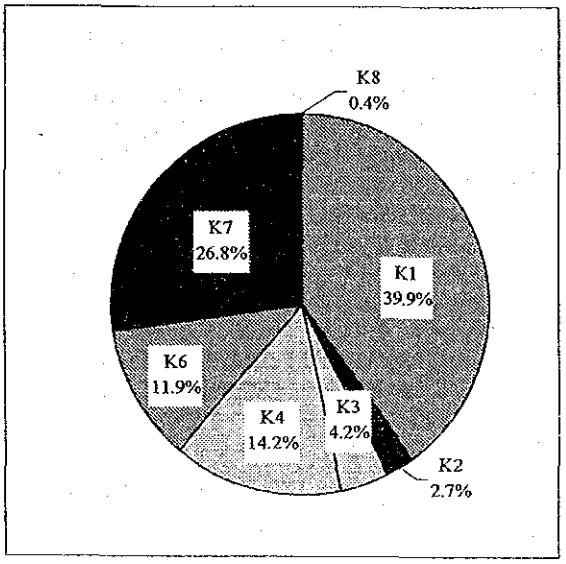


Figure 3-2-3-8 Distribution of Gravelly Colluvial Fans

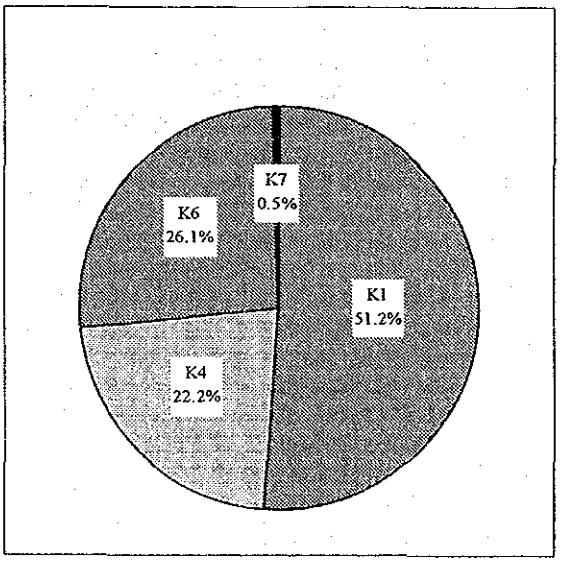


Figure 3-2-3-9 Distribution of Gravelly River Fans

f) Gravelly Colluvial Fans (8.1, 8.2, 8.5)

Gravelly colluvial fans are located at the foot of mountains mainly in K1, K4, K6 and K7 as shown in Figure 3-2-3-8. Total area of the gravelly colluvial fans is 853 km^2, that is equivalent to 3.2% of the Study Area. Major activities in this area are grazing and dry farming as well as irrigated farming in some places. Major limitations of this area are gravel, shallow soil depth, slope and erosion. The lands are suited to controlled grazing, planting of fruit trees and protected forest.

g) Gravelly River Fans (9.1, 9.2)

Gravelly river fans are generally located at the foot of mountains and hills. Distribution of area is concentrating in K1, K4 and K6 as shown in Figure 3-2-3-9. Total area of the gravelly river fans is 121 km^2, that is only 0.5 % of the Study Area. Present utilization of this area is grazing, dry farming and cereal irrigation as well as fruit tree planting in some places. Major limitations of this area are soil depth and erosion. When grazing and erosion are controlled and prevented, grazing and dry farming are suited. If water is ensured, irrigated farming is also recommended.

(4) Evaluation of Land Capabilities

a) Weight of Land Capability

Productivity of land is varied largely by the land capabilities as explained above. Since land capability is presented by categorized acreage, it is difficult to compare differences of productivity among sub-basins. For evaluating land capability and productivity of each sub-basin, weights are considered based upon following assumptions in accordance with land suitability:

Table 3-2-3-5 Assumed Weights by Land Suitability

Land Suitability	Assumptions
Possibility of large extent of irrigation.	10
Possibility of some limited irrigation.	5
Fruit tree planting as well as soil protection.	5
Dry farming under erosion protection.	3
Controlled grazing under soil protection.	1

Based upon above assumption, following weights are given to the respective land categories.

Table 3-2-3-6 Evaluation Weights of Land Capability

Land Type	Code	Weight	Land Type	Code	Weight
Mountains	1.1	0	Piedmont Plains	4.1	10
	1.2	1		4.2	10
	1.3	0	Elluvial Fans	4/5	10
	1.4	1	Lowlands	6.1	5
	1.5	1	Gravelly Colluvial Fans	8.1	3
	1.6	1		8.2	5
Hills	2.1	0		8.5	3
	2.2	3	Gravelly River Fans	9.1	3
	2.3	3		9.2	5
	2.4	1	Complexes	C1	4
	2.5	1		C2	3
	2.6	1		C3	1
Plateaus and Upper Terraces	3.1	4		C4	4
	3.2	5		C5	1
	3.3	6		C6	1
	3.4	3		C7	1
	3.5	6	River Bed	RW	0
	3.8	6	Water/City	Ma, City	0

b) Weighted Land Capability and Land Capability Index

Weighted land capability is estimated by summing the multiplication of acreage and weight of respective land capabilities as below.

$$LCw = \sum_{i=1}^{10}\left(\sum_{j=1}^{n} Aij \times Wij\right)$$

LCw : Weighted land capability of each sub-basin

Aij : Acreage by land types on land capability in each sub-basin (km^2)

Wij : Weight of respective land types on land capability (see Table 3-2-3-6)

i : Number by land type (1 = mountains, 2 = hills, ……, 10 = complexes)

j : Suffix number of land type (mountain = 1 to 6, hills = 1 to 6, …., complexes = 1 to 10)

Weighted land capability is still not easy to understand because its value generally increases in proportion to the acreage of sub-basin. Weighted land capability is generally large for large sub-basins so that the land capability index has been created to compare capability and productivity easier.

Land capability index is an averaged weight of each sub-basin. It is computed as below:

$$LCindex = LCw / As$$

$LCindex$: Land capability index

LCw : Weighted land capability of each sub-basin

As : Acreage of each sub-basin (km^2)

Productivity and capability of sub-basins can be relatively compared by their land capability indexes. Weighted land capability and land capability index have been compiled into the inventory.

c) Comparison of Land Capability and Productivity by Sub-basins

Land capability and productivity have been compared utilizing the land capability index as shown in Table 3-2-3-7. Average land capability indexes varies largely by sub-basins from 1.12 in K8 to 3.24 in K1. It means that productivity or capability of unit land in K1 might be approximately three times of it in K8. The comparison of 8 sub-basins can be summarized as shown in Figure 3-2-3-10.

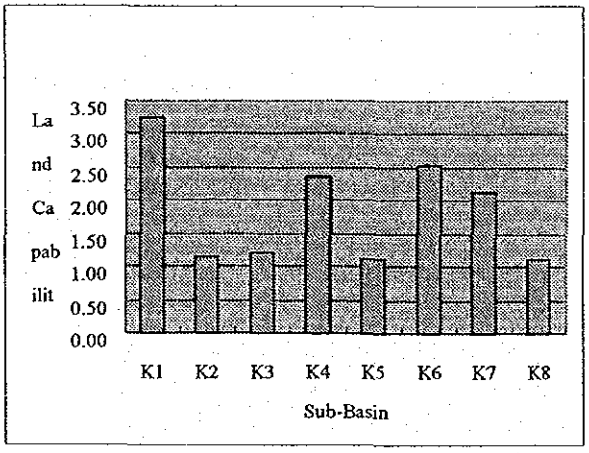


Figure 3-2-3-10 Land Capability Index by Sub-Basins

Four sub-basins, namely K1, K4, K6 and K7, are considered as relatively high productive or capable sub-basins, and other four sub-basins, K2, K3, K5 and K8, are relatively low from an aspect of land capability

Table 3-2-3-7 Weighted Land Capability and Land Capability Index by Sub-Bains

Sub-basin	Area (km^2)	Weighted Land Capability by Land Types (Weighted Capability =Area x Weight)										Average Land Capability Index	Maximum Land Capability Index	
		Mountains	Hills	Plateaus and Upper Terraces	Piedmont Plains	Elluvial Fans	Lowlands	Gravelly Colluvial Fans	Gravelly River Fans	Complexes	Total			
	(A)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(T)	(T/A)		
K1	3,920	551	881	3,630	3,108	1,604	467	1,062	186	1,221	12,709	3.24	6.70	K1-2-6i
K2	1,224	826	152	154	0	38	0	115	0	117	1,402	1.15	2.05	K2-5-4
K3	2,509	2,058	261	193	151	0	0	177	0	206	3,046	1.21	3.60	K3-1-17
K4	3,215	1,287	1,344	3,198	671	0	307	444	106	245	7,603	2.36	4.53	K4-1-11
K5	2,175	2,080	57	178	135	0	0	0	0	0	2,451	1.13	3.38	K5-13-1b
K6	1,474	811	183	781	1,230	0	112	392	158	73	3,741	2.54	5.89	K6-1-8
K7	9,021	5,531	2,273	7,695	2,865	0	0	832	2	0	19,196	2.13	6.55	K7-0-10-6b
K8	3,274	2,406	78	760	57	0	0	9	0	354	3,663	1.12	3.04	K8-2
Total	26,812	15,550	5,229	16,589	8,217	1,642	887	3,031	452	2,217	53,812	2.01	6.70	K1-2-6i

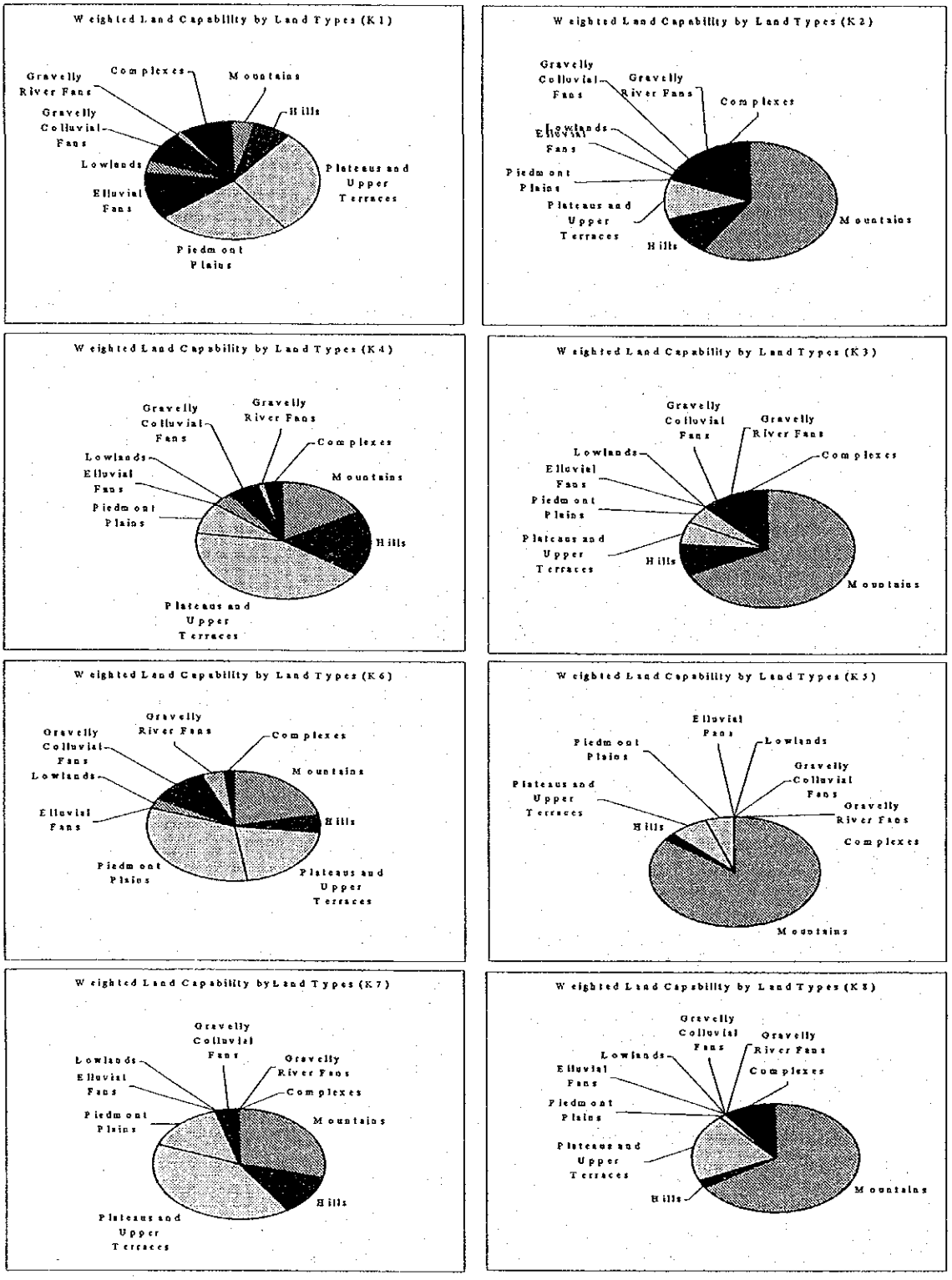
(Note) derived from Land Capability Inventory.

As shown in Table 3-2-3-7, maximum land capability index of 6.70 is given to K1-2-6i sub-basin, and second one is 6.55 to K7-0-10-6b. These sub-basins are the areas where the large piedmont plains are extensively extending. The former one is the area that involves the extensive fertile plain at the south of Share Kord. The latter one is the area where the Hana irrigation system is extending.

Major reason of differences on capability and productivity is considered to be the differences of weighted land capability ratio of the mountains and the flat plains such as piedmont plain, plateau and terrace. As shown in Figure 3-2-3-11, two different groups, high productive group and low productive group, can be clearly separated. High productive group, K1, K4, K6 and K7, has a large ratio of the weighted land capability on piedmont plain, plateau and terrace. On the other hand, low productive group, K2, K3, K5 and K8, has a large ratio of it on mountains.

As explained above, land capability analysis is very important for understanding the capability of land and for studying the future regional plan.

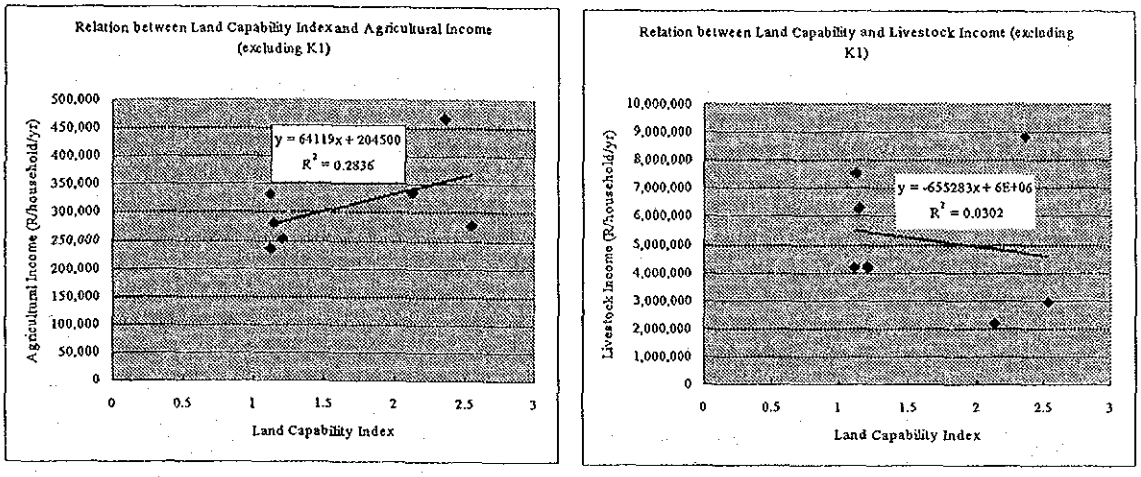
In the sub-basins classified into high productive group, the area has relatively rich soil and flatter land. Such sub-basins may be easier for mechanization and be more competitive than sub-basins classified into low productive group. Figure 3-2-3-12 shows the relation between land capability index and incomes of agriculture and livestock presented in Section 3.3.4.



High Productive Group

Low Productive Group

Figure 3-2-3-11 Grouping of Productivity by the Ratio of Weighted Land Capability



(Note) K1 sub-basin is excluded in this analysis because of relatively higher non-agricultural income than other sub-basins.

Figure 3-2-3-12 Relation between Land capability Index and Agricultural Income

From Figure 3-2-3-12, it may be understood followings;

a) Agricultural income is high in the sub-basins where land capability index is high.

b) On the other hand, opposite phenomena is resulted in the relation to livestock income. It is difficult to explain this phenomena clearly by land capability index.

When the livestock income is compared with the over-carrying ratio of livestock that is analyzed in Section 3.2.7, it is understood that livestock income increases in proportion with the increase of over-carrying ratio as shown in Figure 3-2-3-13. It can be said that livestock income is kept by deprivable grazing in the area.

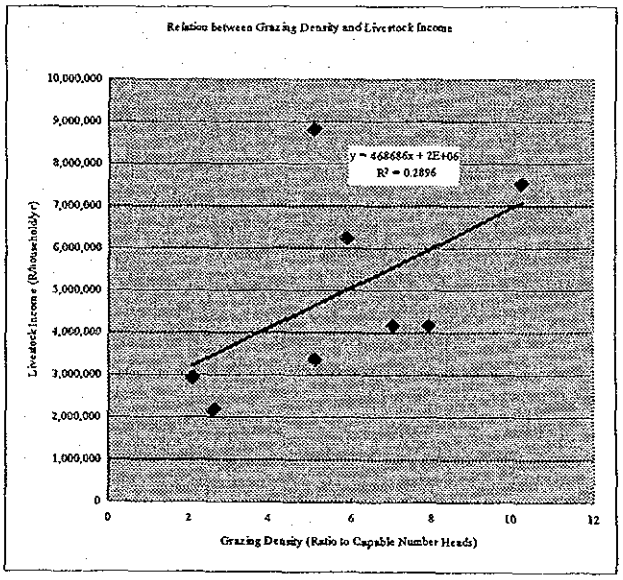


Figure 3-2-3-13 Relation between Over-Carrying Ratio and Livestock Income