8.7.3 Surface Soil Erosion

(1) Analytical Method of Erosion

Surface soil erosion has been analyzed based on USLE (Universal Soil Loss Equation), that gives soil loss based on rainfall, soil texture, land slope, slope length, crops or natural vegetation and farm management or natural vegetation management system. In the Phase-1 study, PSIAC Method has been applied to estimate soil loss to study whole basin of the Karoon river. This method gives sediment discharge of the basin. Since it gives sediment discharge of the basin, results are quite smaller than the results of USLE. For planning soil conservation in the river basin, it is necessary not only to grasp erosion amount but to grasp factors which largely affect to erosion. For this purpose, USLE has been applied to the study of 5 Master Plan areas.

(2) Surveys carried out for applying USLE

In order to apply USLE for the study, following surveys have been carried out in the study area.

Soil survey: Soil survey and intake rate survey have been carried out to grasp such soil properties and infiltration rate relating to the soil erodibility,.

- Profile and auger hole survey: 252 sites
- Intake rate survey: 25 sites for major soil series

Vegetation survey:

Vegetation survey was carried out at 129 sites in the different rangelands to grasp land cover and vegetation on the slopes,.

Land use survey:

Land use survey was carried out in the manner of field confirmation based on mainly 1:25,000 topographical map which is showing the latest land use of the basin in order to grasp land use and land conservation condition,.

Land Capability Analysis:

Land capability analysis has been carried out based on the result of soil survey to grasp potential of land for irrigation and land allocation,.

(3) Soil Loss Estimation by USLE

1) Factors and Procedure of Soil Loss Estimation by USLE

Since the Study Team could not obtain the actual application of USLE in Iran, equation of USLE and factors for estimation of soil loss are referring to "Farmland Conservation, Engineering Manual for Farmland Conservation, The Japanese Institute of Irrigation and Drainage, March 1992". The equation and its factors are as follows:

$A = R \times K \times LS \times C \times P$ .... (8.7.3-1)

A: Soil loss (tf/ha), given by following factors. (tf = metric ton)

R: Rainfall erodibility index (tf m^2/ha hr), given by energy of rainfall in certain period.

K: Soil erodibility factor, given by properties of soil.

LS: Topography factor, given by slope length (L) and slope steepness in angle (s).

C: Crop management factor, given by bareness of land by crop and its growing stages. In case of bare land, factor C is set at 1 and reduced by land cover of crops or vegetation. Factor C differs by crops and their growing stages.

P: Conservation practice factor, given by cultivation method relating to conservation farming techniques such as contour cropping. In case, the land is left without any conservation practices.

2) Rainfall Erodibility Index (R)

a) Theory of Calculation of Rainfall Erodibility Index (R)

Rainfall erodibility index R is calculated based on Equation 8.7.3-2 and 8.7.3-3 for whole rainfalls recorded in a sufficient periods in a year, a season or a storm. In the region of snowfall, a large quantity of soil loss emerges in the early spring. In such regions, rainfalls are increased by 0.06 during the frost period, and added to the rainfalls during the snow-melting period.

$R = (\Sigma E \times I_{60})/100$ .... (8.7.3-2)

Where R: Rainfall erodibility index (tfm^2/ha hr)

E: Rainfall energy during a unit time. (m·tf/ha)

I_{60}: Maximum 60 minutes rainfall (cm/hr)

$E = (210 + 89 \log_{10} I) \cdot r$ .... (8.7.3-3)

Where I: Rainfall intensity in a unit time (cm/hr)

r: rainfall in a unit time (cm)

b) Application to the Project Area for Calculation of Rainfall Erodibility Index (R)

Procedure of calculation of Rainfall Erodibility Index (R) in the study area is as follows:

i) Preparation of Annual Daily Rainfall in Average Year

↓

Selection of Typical Average Year

↓

Adjust to Annual Mean Amount

↓

ii) Definition of Frost Period

↓

Adjust of Rainfall in Frost Period x (1.06)

↓

iii) Rainfall Duration Analysis

↓

Calculation of Hourly Rainfall of Each Rainfall through the Year

↓

iv) Rainfall Erodibility Analysis

↓

Calculation of Rainfall Energy of Each Rainfall through the Year

↓

Estimation of Monthly and Annual Rainfall Erodibility Index (R)

Figure 8-7-3-1 Procedure for Estimation of Rainfall Erodibility Index (R)

i) Preparation of Annual Daily Rainfall in Average Year

Annual mean precipitation varies from 1,475mm in Chaman Goli –Bazoft to 692mm in Sarbaz, and rainy days from 68 days in Chaman Goli-Bazoft to 25 days in Sarbaz as shown in Table 3-7-3-1. In order to grasp annual total soil loss, a typical year close to annual mean precipitation and number of rainy days has been selected as shown in the Table. Since no years are close to the amount of annual mean precipitation for Vastegan, year 1974 – 75 has been selected taking similarity of rainy days into account.

Table 8-7-3-1 Summary of Climate Condition in 5 Master Plan Area

Area	Precipitation				
	Annual Mean Precipitation (mm)	Annual Rainy Days	Selected Typical Year	Annual Precipitation of Typical Year (mm)	Rainy Days of Typical Year
Vastegan	775	32	1974 - 75	283	32
Chaman Goli-Bazoft	1,475	68	1994 - 95	1,453	66
Sarbaz	692	25	1974 - 75	794	25
Tang Sorkh	1,151	58	1986 - 87	917	59
Zeras	773	45	1982 - 83	638	44

(Note) Details are in Table D-5-1-1

ii) Definition of Frost Period

Erosions are caused mainly in rangeland and dry farmland in the snow-melting period. It is, therefore, necessary to decide the frost and the snow-melting periods taking the altitudes of rangeland and dry farmland. Frost elevations were analyzed using the data of 12 meteorological stations in the Karoon river basin. Frost elevations were estimated as below: (Table D-5-1-2, Annex D)

December:	above EL 2,500 m
January	above EL 2,000 m
February	above EL 2,300 m

According to the above frost elevations, frost period of rangeland and dry farmland has been studied based on their altitude-area relation. Frost periods of rangeland and farmland in the study areas are defined as below: (Table D-5-1-3, Annex D)

Vastegan, Sarbaz and Tang Sorkh:	1.5 months (January - mid February)
Chaman Goli-Bazoft and Zeras:	no frost period.

Taking above frost period into consideration, all rainfalls are increased multiplying 1.06 during frost period, and then added to snow-melting period in Vastegan, Sarbaz and Tang Sorkh.

iii) Rainfall Duration Analysis in the Study Area

Duration and rainfall intensity equation has been analyzed utilizing the relation of short duration and rainfall intensity in Yasuj. According to the result of analysis, following equation will be applied to estimate the short duration rainfall from the daily rainfall:

$$R_t = R_{24}\left(\frac{t}{24}\right)^{0.6} \quad \text{.. (8.7.3-4)}$$

Where,

R_{24}: Daily rainfall (mm)
R_t: t hour rainfall (mm)
t: t hours (hr)
0.6: constant

(see details in Table D-5-1-4, Annex D)

iv) Calculation of Rainfall Erodibility Index (R)

All daily rainfalls have been converted to hourly rainfall based on Equation 8.7.3-4, then rainfall energy (E) and rainfall erodibility index (R) of each daily rainfall was calculated based on Equation 8.7.3-2 and 8.7.3-3 (Table D-5-1-5, Annex D), then monthly rainfall erodibility index (R) has been estimated. (Table D-5-2-1 to D-5-2-6, Annex D)

Rainfall of typical year, adjusted rainfalls to average year, adjusted rainfall of frost period, and computed monthly and annual rainfall erodibility index (R) are summarized as shown in Table 8-7-3-2. Maximum rainfall erodibility index is 144.51 tf・m^2/ha・hr in Tang Sorkh and minimum is 37.25 tf・m^2/ha・hr in Zeras. Rainfall eodibility index is mostly governed by heavy rainfall so that annual index is not always corresponding to the amount of annual rainfall. In case of Zeras, since annual rainy day is 45 days in average that is quite large comparing to 32 days in Vastegan and 25 days in Sarbaz where annual rainfall amounts are close to Zeras, heavy rainfalls seldom occur in Zeras. Consequently, rainfall erodibility index of Zeras is lower than Vastegan and Sarbaz although their annual rainfall amounts are similar.

Table 8-7-3-2 Monthly Rainfall and Erodibility Index R

Area	Meh (Oct)	Aba (Nov)	Aza (Dec)	Dey (Jan)	Bah (Feb)	Esf (Mar)	Far (Apr)	Ord (May)	Kho (Jun)	Tir (Jul)	Mor (Aug)	Sha (Sep)	Total
Rainfall in Selected Typical Year (mm)													
Vastegan	9.0	0.0	42.0	42.0	33.0	52.0	44.0	61.0	0.0	0.0	0.0	0.0	283.0
Bazoft	38.0	314.0	444.0	185.0	96.5	153.0	121.0	90.5	0.0	0.0	4.0	6.5	1,452.5
Sarbaz	0.0	0.0	191.0	172.0	39.0	156.0	98.0	138.0	0.0	0.0	0.0	0.0	794.0
Tang Sorkh	0.0	102.4	333.5	52.7	97.8	221.5	104.1	0.0	4.6	0.0	0.0	0.0	916.6
Zeras	20.0	130.0	70.0	187.0	44.0	88.0	58.0	41.0	0.0	0.0	0.0	0.0	638.0
Adjusted Rainfall to Average Year (mm)													
Vastegan	24.6	0.0	115.0	115.0	90.4	142.5	120.6	167.0	0.0	0.0	0.0	0.0	775.1
Bazoft	38.5	318.5	450.7	187.9	98.0	155.4	122.8	92.0	0.0	0.0	4.1	6.6	1,474.5
Sarbaz	0.0	0.0	166.6	150.0	34.0	136.0	85.4	120.4	0.0	0.0	0.0	0.0	692.4
Tang Sorkh	0.0	128.7	418.6	66.1	122.7	278.0	130.7	0.0	5.8	0.0	0.0	0.0	1,150.6
Zeras	24.2	157.4	84.8	226.4	53.3	106.6	70.2	49.7	0.0	0.0	0.0	0.0	772.6
Adjusted Rainfall by Snow-melting (mm)													
Vastegan	24.6	0.0	115.0	0.0	60.9	299.3	120.6	167.0	0.0	0.0	0.0	0.0	787.4
Bazoft	38.5	318.5	450.7	187.9	98.0	155.4	122.8	92.0	0.0	0.0	4.1	6.6	1,474.5
Sarbaz	0.0	0.0	166.6	0.0	43.5	286.6	85.4	120.4	0.0	0.0	0.0	0.0	702.5
Tang Sorkh	0.0	128.7	418.6	0.0	169.2	301.6	130.7	0.0	5.8	0.0	0.0	0.0	1,154.6
Zeras	24.2	157.4	84.8	226.4	53.3	106.6	70.2	49.7	0.0	0.0	0.0	0.0	772.6
Erodibility Index R (tf・m^2/ha・hr)													
Vastegan	0.19	0.00	13.13	0.00	5.18	21.63	11.68	15.59	0.00	0.00	0.00	0.00	67.40
Bazoft	0.58	44.57	51.44	16.86	5.08	10.59	8.39	2.49	0.00	0.00	0.01	0.05	140.06
Sarbaz	0.00	0.00	32.23	0.00	1.71	34.34	4.87	5.25	0.00	0.00	0.00	0.00	78.40
Tang Sorkh	0.00	5.53	81.41	0.00	20.13	30.20	7.22	0.00	0.02	0.00	0.00	0.00	144.51
Zeras	0.20	7.91	3.69	13.78	2.24	4.98	3.38	1.07	0.00	0.00	0.00	0.00	37.25

(Note) Detail computation is presented in Table D-5-2-1 to D-5-2-5, Annex D.

3) Soil Erodibility Factor (K)

a) Theory of Calculation of Soil Erodibility Factor (K)

Soil erodibility factor (K) is a number to express soil erodibility and an index to imply characteristics of infiltration, resistibility against soil scraping and transportation by rainwater and runoff, and their combinations. For estimating K factor, there are following three methods.

i) Estimation of K from Field Measurements

ii) Estimation of K by Monogram

iii) Estimation of K by Conversion Equation

(Detail Explanation for Method ii and iii is in D-5-3, Annex D)

In case Method-i), the factor K is determined from the measured annual soil loss A and the corresponding annual rainfall erodibility index R in the standard plot, L, S, C and P in the soil loss equation (A = R x K x LS x C x P) are all 1.0 so that K can be obtained from the loss volume A divided by the annual rainfall erodibility index R. Field investigation at 10 places in Japan has shown that the soil erodibility factor K was from 0.0 to 0.7. In case applying this method to this Study, it needs a lot of standard plots for different soils and time consumption. This method is, therefore, not applicable to this Study.

The Methods-ii) and iii) give the K value from the surveyed results on grain size distribution, organic matter content, structure and permeability of the soil. In this Study, Method iii "Conversion Equation" has been applied (Details are in D-5-3, Annex D). The equation is as follows:

$$K = 1.18\ (EI_{30}/EI_{60})\ Ku \quad \text{......} \quad (8.7.3\text{-}5)$$

$$100\ Ku = 2.1\ M^{1.14}\ (10^{-4})\ (12 - a) + 3.25\ (b - 2) + 2.5\ (c - 3) \quad \text{......} \quad (8.7.3\text{-}6)$$

Where

Ku: Soil erodibility factor in Original USLE (yard-pond unit)
K: Soil erodibility factor (metric unit)
EI_{30}: Rainfall energy by 30 minutes unit ($tf.m^2/ha/hr$)
EI_{60}: Rainfall energy by 60 minutes unit ($tf.m^2/ha/hr$)
M: Grain size parameter of the soil
M = [content % of (silt + very fine sand)] x [100 – clay content %]
Very fine sand (0.05 – 0.10 mm), Silt (0.002 – 0.05 mm), Clay (< 0.002mm)
a: Organic matter content of the soil (%)
b: Soil structure
c: Grade of permeability

By above conversion equation, K value can be calculated under the condition that the content of silt + very fine sand is below 70%. In calculation of equation (8.7.3-5), the ratio of EI_{30}/EI_{60} was around 1.3 for several rainfalls in the Study Area. Then, K = 1.53 Ku has been applied.

b) Application to the Project Area for Calculation of Soil Erodibility Factor (K)

In this study, soil survey has been carried out to obtain soil structure, organic contents, gravel contents, and permeability by basic intake rate test, in order to apply Method-iii. Based on the obtained data, K values have been calculated for different soil series in the Study area. Detail procedure of calculation is presented in Table D-5-2-6 Annex D, and soil units are grouped by similarity of K values. K value and its group of soil series are as follows:

Table 8-7-3-3 Soil Series Groups by Soil Erodibility Factor K

Area	K value	Soil Units	Area	K value	Soil Units
Vastegan	0.35	S1.2, S2.1	Sarbaz	0.35	S5.3, S1.1+2.1
	0.30	S3.1, S4.1		0.31	S4.2, S5.1, S9.1, S4.1+5.1
	0.24	S5.1, S5.2		0.25	S3.1, S6.1
	0.17	S4.2, S6.1, S6.2		0.19	S5.2, S7.1, S8.1
	0.11	S1.1, S1.3, S6.3, S6.4	Tang Sorkh	0.37	S2.1
Chaman Goli-Bazoft	0.35	S2.2, S3.2		0.26	S1.1, S2.2, S2.3, S5.2
	0.26	S2.1, S3.1		0.19	S3.1, S4.1, S5.1, S6.1
	0.14	Association	Zeras	0.49	S1.1, S1.2, S2.1, S2.2, S3.1, S3.3, S3.4, S3.5
				0.41	S2.3, S3.2

(Note) Detail analysis is in Table D-5-2-6, Annex D.

As shown in above Table, soils of Zeras have relatively high K values as 0.41 and 0.49. It means that soils of Zeras are sensitive to erosion comparing to other areas.

4) Topography Factor (LS) (Slope Length: L, Slope Steepness Factor: S)

a) Theory of Calculation of Topography Factor (LS)

Slope factor S and length factor L are indices of erodibility by topographic elements relevant to slope, length and inclination. These are expediently handled together as the topography factor LS. The L and S values are both 1.0 for the standard slope length of 20 m and inclination of 5° (8.7%). A value of LS of a slope surface of dimension-less and indicates the rate of soil loss to that of the standard plot. Their calculation is as follows.

$LS = (L/20)^{0.5} (68.19 \sin^2 \theta + 4.75 \sin \theta + 0.068)$........................(8.7.3-7)

L: Slope length (m)

θ : Inclination (degree)

b) Application to the Project Area for Calculation of Topography Factor (LS)

Inclinations of farmland and rangeland are measured on the map of 1:25,000, and slope length is confirmed on the map of 1:10,000 because smaller channels and streams are shown in this map so that the length of surface flow can be more accurately recognized. Inclination of farmland is classified into 7 categories, namely 0 to 5%, 5 to 13%, 13 to 20%, 20 to 30%, 30 to 40%, and over 50% (Figure D-5-1-1, Annex D). In the farmlands of 0 to 5% inclination, cultivation can be carried out extensively without severe surface erosion, while MOA recommends dry farming within 13% inclination and allow up to 20% inclination with full care in farming.

In the irrigated farmland, furrow irrigation is dominant in the flatter area with a slope of less than 5% inclination, while small narrow basin irrigation is dominant in the steeper farmland. In case furrow irrigation, slope causes some erosion but the distribution ditches running in the field work as the contour bund. Irrigation ditches are generally provided at about 50 m distance. Then, distance (L) of contour bunds is assumed at 50 m. On the other hand, all rainfall is stored in the field in case of basin irrigation so that LS is assumed at 0 for basin irrigation. It means that no erosion is caused in the basin irrigation field.

On the other hand, typical inclination and slope length of rangeland are measured in each vegetation zone along the slope until it reaches stream channels.

Table D-5-2-7 in Annex D shows the measured inclination, slope length and calculated topography factor (LS) for each category of farmland and vegetation zone of rangeland.

5) Crop Management Factor (C)

a) Theory of Crop Management Factor (C)

Crop management factor C indicates a ration of soil loss from the field cropped under some specific condition compared to that from bare fallow land. The C value varies depending on kind of crop, and state of crop management such as crop growth. The field is a bare fallow land then C value is equal to 1.0. If the field is completely and densely covered as in pastureland, C value decreases to nearly zero to cause no soil loss. Table 8-7-3-4 shows the crop management factor C for major crops in Japan.

Table 8-7-3-4 Crop Management Factor C by Crops in Japan

Crop	Crop Management Factor C	Crop	Crop Management Factor C
Pasture grasses	0.02	Maize (Corn)	0.4
Grape (orchard)	0.1	Carrot	0.4
Straw/dry grass mulch	0.1	Horseradish	0.4
Wheat	0.2	Beet	0.4
Cabbage	0.3	Celery	0.4
Broccoli	0.3	Eggplant	0.4
Pumpkin	0.3	Soybean	0.4
Potato	0.3	Onion	0.5
Tomato	0.3	Pea	0.5
Peanut	0.3	Spring bean	0.5
Sesame	0.3	Tobacco	0.5
Sesame	0.3	Tobacco	0.5

(Source) Farmland Conservation, Engineering Manual for Farmland Conservation

(Note) In Japan, patterns of both cropping periods and rainfall distributions are so similar that the C value are into those through the year without dividing into periods.

b) Application to the Project Area for calculation of Crop Management Factor (C)

Since crop and vegetation growing conditions are drastically changing by season in the Karoon basin, it is necessary to consider the changes of crop management factor C by season. Since there is no experienced data in Iran, following C values are applied in the Study area, taking C values in Table 8-7-3-4 into consideration.

Crop management factor (C) values applied in the Study Area are as follows:

<Crops>

Wheat:	C= 0.2 (growing stage) - 0.6 (after harvesting)
Fallow:	C= 0.6 (because not plowed after harvesting in the area)
Irrigated Alfalfa:	C= 0.02 (through the year)
Dry Type Alfalfa:	C= 0.02 (rainy season) -- 0.1 (hot dry season)
Fruit trees:	C= 0.1 (through the year)

<Rangeland>

Seasonal vegetation:	C= 0.02 (growing stage) - 0.5 (working as litter in dry condition)
Perennial vegetation:	C= 0.02 (through the year)
Rock (Ø > 10cm):	C= 0.001 (through the year)
Stone (Ø < 10cm):	C= 0.02 (through the year, but not permanent like as rock.)
Litter:	C= 0.1 (through the year) taking the C value of Straw/dry grass mulch into consideration.
Bare land:	C= 0.6 (through the year) reduced from standard value of 0.9 taking compaction by livestock movement into consideration.

Seasonal changes of crop management factors (C_i) are supposed as shown in Table 8-7-3-6. Based on seasonal crop management factors, annual crop management factor (C_a) is defined as below:

$$C_a = \frac{1}{R_a}\sum_{i=1}^{12}(R_i \times C_i) \quad \text{(8.7.3-8)}$$

C_a = Annual crop management factor

C_i = Monthly crop management factor

R_a = Annual rainfall erodibility index (tfm^2/ha hr)

R_i = Monthly rainfall erodibility index (tfm^2/ha hr)

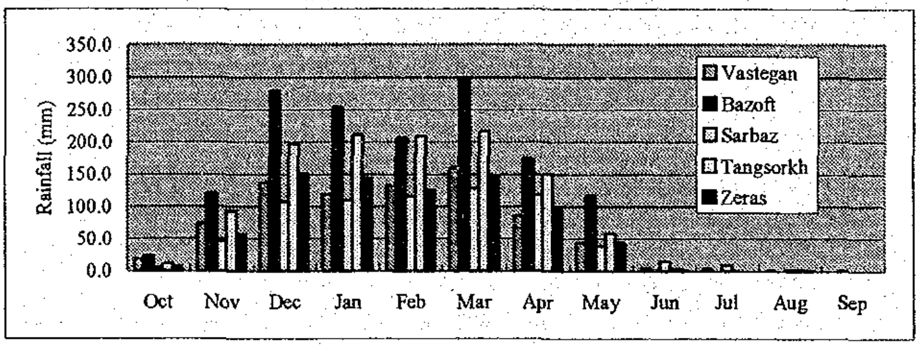
Based on above the monthly crop management factor in Table 8-7-3-6 and raifall erodibility index in Table 8-7-3-2, annual crop management factors (C_a) of wheat and dry type alfalfa are calculated as below:

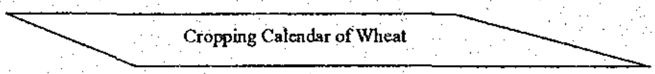
Table 8-7-3-5 Annual Crop Management Factor C_a of Wheat and Dry Type Alfalfa

Area	Wheat	Dry Type Alfalfa
Vastegan	0.20	0.02
Bazoft	0.27	0.03
Sarbaz	0.20	0.02
Tang Sorkh	0.21	0.02
Zeras	0.24	0.03

(Note) Details are in Table D-5-1-6, Annex D.

Table 8-7-3-6 Seasonal Crop Management Factor (C_i)





Crop/Vegetation	Meh (Oct)	Aba (Nov)	Aza (Dec)	Dey (Jan)	Bah (Feb)	Esf (Mar)	Far (Apr)	Ord (May)	Kho (Jun)	Tir (Jul)	Mor (Aug)	Sha (Sep)
Crops												
Wheat	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.6	0.6
Pasture Crop												
Dry type alfalfa	0.1	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.06	0.1	0.1	0.1
Irrigated alfalfa	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fallow Land	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fruit trees	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rangeland												
Perennial Vegetation	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Seasonal Vegetation												
Vastegan, Bazoft, Sarbaz	0.5	0.2	0.1	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.5	0.5
Zeras	0.5	0.2	0.1	0.05	0.02	0.02	0.02	0.02	0.02	0.5	0.5	0.5
Non-vegetative cover												
Rock	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*
Stone	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Litter	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bare soil	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

(Note)
1) Crop management factor of seasonal vegetation is taking germination by first rain into consideration.

c) Annual Crop Management Factor (C_a) of Rangeland

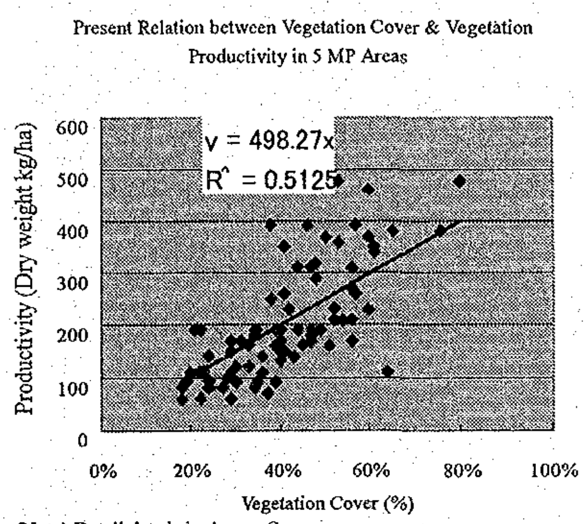
Land covers of rangeland are composed of 5 factors as perennial vegetation, seasonal vegetation, rock /stone, litter and bare land. As mentioned in Section 10.3.5, it is reported that the vegetation productivity increases by 75 kg/ha in average when rangeland is protected. On the other hand, present average vegetation productivity and land cover were surveyed at about 200kg/ha and 41%

respectively by the vegetation survey in the Study area.

When vegetation covers the whole rangeland area, vegetation productivity is estimated to reach to the ultimate productivity of 498kg/ha as shown in the Figure.8-7-3-2. The incremental productivity of 75kg/ha by protection is equivalent to 15% of the ultimate productivity. Therefore, rangeland protection will increase the vegetation cover by 15% of the rangeland area and reduce bare land.

Based on seasonal crop management factor (C_i) in Table 7-8-3-6 and above consideration, annual crop management factor (C_a) of rangeland has been estimated in each vegetation type zone (Table G-4, Annex G). For estimating Ca of rangeland, following assumptions have been set.

- Present land cover is based on Table G-4 in Annex G.
- In case of protection, 15% of rangeland area will be changed to seasonal vegetation from bare land.
- In case of seeding, all bare land will be changed to seasonal vegetation.

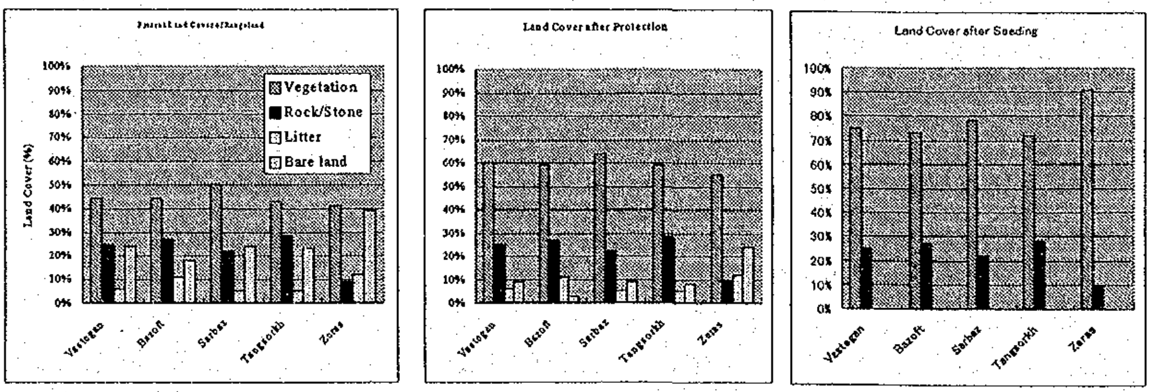


(Note) Detail data is in Annex-G

Figure 8-7-3-2 Present Vegetation Productivity and Vegetation Cover in the Study Area

Based on above conditions, annual crop management factor (Ca) of rangeland has been estimated for present, protection and seeding as shown in Table D-5-1-7 in Annex D. Land cover of rangeland will change as shown in Figure 8-7-3-3. Bare land ratio is especially high in Zeras at about 40%, but it can be improved by seeding significantly. However, it is difficult to improve bare land ratio only by protection because effect of protection is limited within 15% of rangeland area.

(Present) (Protection) (Seeding)



(Note) Detail composition is described in Table D-5-1-7, Annex D

Figure 8-7-3-3 Present and Future Potential Land Cover in the Rangeland

6) Conservation Practice Factor (P)

a) Theory of Conservation Practice Factor (P)

Conservation practice factor P reflects farm management effects for prevention of soil loss such as ridge direction and contour cropping. The P value shows the ratio of soil loss from the field treated with some conservation farming compared to that from the untreated field ploughed up and down the slope. If the field is an inclined plain ploughed up and down the slope then P is equal to 1.0. Table 8-7-3-7 shows the example of observed conservation practice factor P for contour ridge cropping in Japan.

Table 8-7-3-7 Conservation Practice Factor P

Field Inclination		P in case contour ridge cropping
(o)	(%)	
1 - 4	2% - 7%	0.27
4 - 7	7% - 12%	0.30
7 - 10	12% - 18%	0.40
10 - 15	18% - 27%	0.45
15 - 25	27% - 47%	0.50
25 -	47% -	0.50 *

(Note) Observation in Japan, except * (* assumed for This Study)

b) Application of Conservation Practice Factor (P) to the Project

In the Karoon river basin, most farmlands are cultivated with contour ridge cropping so that above P values are applied for the farmland. On the other hand, livestock generally moves horizontally from the observation of foot trace of sheep and goat. This table has been, therefore, applied also to the rangeland. Applied conservation practice factors (P) to the farmland and rangeland are shown in Table D-5-2-9, Annex D.

(4) Present Surface Soil Erosion

Based on above conditions, present surface erosion of each study area has been assessed and estimated. The results are shown in Figure 6-1 to 6-5 as erosion hazard map in Database Map. Unit erosion amount of different land use is studied in Table D-5-2-7, and present erosion amount of each Master Plan Area is estimated in Table D-5-2-8 in Annex D. The results are summarized as in Table 8-7-3-8. The results are compared to the result of PSIAC to grasp the differences between PSIAC and USLE.

Table 8-7-3-8 Present Soil Erosion Estimation by USLE and Comparison to PSIAC

Master Plan Area	Soil Loss by Areas: Vastegan		Chaman Goli-Bazoft		Sarbaz		Tang Sorkh		Zeras		Weighted Average	
Rainfall Erodibility Index (R)	67.40		140.06		78.40		144.51		37.25		93.52	
Soil Erodibility Factor (K)	0.11 - 0.35		0.14 - 0.35		0.19 - 0.35		0.19-0.37		0.41 - 0.49		0.11 - 0.49	
Land Use	(t/ha)	(mm)	(t/ha)	(mm)	(t/ha)	(mm)	(t/ha)	(mm)	(t/ha)	(mm)	(t/ha)	(mm)
Farmland	0.5	0.04	17.0	1.21	3.7	0.26	6.3	0.45	41.1	2.94	12.7	0.91
Irrigated Farmland	0.3	0.02	1.4	0.10			1.6	0.11			0.5	0.04
Dry Farmland	11.1	0.79	25.3	1.81	32.8	2.34	18.1	1.29	41.1	2.94	34.1	2.44
Orchard	0.0	0.00	5.2	0.37	0.7	0.05	1.6	0.11			0.8	0.06
Tree Plantation	0.0	0.00			1.0	0.07	6.5	0.46			0.5	0.04
Rangeland	55.5	3.96	33.8	2.41	26.8	1.91	48.4	3.46	63.0	4.50	42.5	3.04
Rock	46.4	3.31	13.7	0.98	9.7	0.69	9.7	0.69	9.7	0.69	17.7	1.26
Total Soil Loss (USLE)	27.7	1.98	17.7	1.26	14.6	1.04	29.0	2.07	48.1	3.44	24.0	1.71
Total Sediment (PSIAC)	9.1	0.65	6.2	0.45	4.6	0.33	7.6	0.54	9.7	0.69	7.4	0.53
USLE/PSIAC	3.1		2.8		3.2		3.8		5.0		3.2	

(Note) 1) *Soil density is estimated at 1.4 t/m^3 by soil analysis.*
2) Soil loss of rock is estimated based on the result of GIS erosion map prepared by the Phase-1 Study except Vastegan.
3) Detail analysis is shown in Table D-5-2-8 in Annex D.
4) Sediment amount by PSIAC is derived from Inventory by Phase-1 Study.

1) Comparison to PSIAC

The erosion amount by USLE is larger than the sediment amount by PSIAC in any cases in this Study. The differences vary from 2.8 times larger in Chaman Goli-Bazoft to 5.0 times larger in Zeras, and 3.2 times larger in average. As explained in the preceding section, the result of PSIAC is sediment, and that of USLE is soil loss or erosion. Erosion is the source of sediment so that erosion is usually larger than sediment because the eroded soil is deposited in the channels and the depressions, and some parts are drained as the sediment. It is difficult to grasp the ratio between sediment and erosion amounts, because it may differ by physiography, channel gradient, size of particles, etc.. As far as the results obtained in this Study, it can be roughly said that about 1/3 of erosion amount is drained out to the downstream basin as the sediment and the remaining 2/3 is deposited in the depressions or the channels to mitigate the steepness of landform. Average annual erosion amount is estimated at 24 t/ha/yr or 1.7 mm/yr against 7.4 t/ha/yr or 0.5 mm/yr of sediment discharge.

2) Evaluation of Overall Erosion

From the aspect of basin-wise erosion, the heaviest erosion is observed in Zeras as 48 t/ha/yr or 3.4 mm/yr, and followed by Tang Sorkh as 29 t/ha/yr or 2.1 mm/yr. In Zeras, heavy erosion is caused in spite of low rainfall erodibility (R=37.25), because soils are sensitive to erosion due to high soil erodibility (K = 0.41 to 0.49), steep land slope (up to over 50%), high bare land ratio of about 40% in the rangeland due to heavy grazing and bareness by dry farming. On the other hand in Tang Sorkh, since rainfall erodibility is very high at R=144 tf·m^2/ha·hr due to high intensity of rainfall, heavy erosion is caused especially in the wasteland and the rangeland. In Tang Sorkh, the reasons of heavy erosion other than high intensity of rainfall are the existence of the erosive marl hills in the wasteland (WL) and the highly inclined rangeland (AG1). The marl hills can be developed by fruit tree plantation with the drip irrigation, because the hills are relatively gentle in slope and close to the Boshar river that can be water source for the hills. There is a plan to develop those hills by MOJA in future. Vastegan follows Tang Sorkh by 28 t/ha/yr or 2.0 mm/yr. In Vastegan, since the weathered marl formation extensively covers the upstream basin, erosion is very high at about 80 t/ha/yr or 5.7 mm/yr in the marl formation (Vegetation zone: R-1 in Table D-5-2-8(1) in Annex D). It is, however, difficult to control and protect such geological weathering by the present technology level. Soil losses in Chaman Goli-Bazoft and Sarbaz are relatively small as 18 t/ha/yr (1.3 mm/yr) and 15 t/ha/yr (1.0 mm/yr) respectively.

3) Evaluation of Erosion by Land Use

From a viewpoint of land use, rangeland is severely high in soil loss as 43 t/ha/yr or 3.0 mm/yr in average of 5 areas as shown in Table 8-7-3-8. It is caused by poor vegetation and over grazing. Soil loss of dry farmland follows the rangeland. Its soil loss reaches 34 t/ha/yr or 2.4mm/yr in average. From the aspect of soil loss amount, following classification has been set as shown in Table 8-7-3-9. As shown in the Table, most rangeland and dry farmland are classified into more than Fair (over 15 t/ha/yr). Rangeland of 12,788ha (85% of total rangeland) and dry farmland of 2,936 ha (78% of total dry farmland) are classified into more than Fair. On the other hand, there are no or less problems for irrigated farmland, orchard and tree plantation.

Table 8-7-3-9 Soil Loss Severity by Land Use in 5 Master Plan Areas

Land Use	Area by Soil Loss Amount (ha)								Average Soil Loss (t/ha/yr)
	Trace	Little	Moderate	Fair	High	Severe	Very Severe	Total	
(t/ha/yr)	(0-5)	(5-10)	(10-15)	(15-20)	(20-30)	(30-50)	(50-)		
(mm/yr)	0-0.4	0.4-0.7	0.7-1.1	1.1-1.4	1.4-2.1	2.1-3.6	3.6-		
Farmland	6,683	659	170	84	933	1,220	699	10,448	12.7
Irri. Farmland	4,304	0	0	0	0	0	0	4,304	0.5
Orchard	2,353	23	0	0	0	0	0	2,376	0.8
Dry Farmland	26	636	170	84	933	1,220	699	3,768	34.1
Tree Plantation	87	4	0	0	0	0	0	91	0.5
Rangeland	0	1,237	990	1,171	2,724	5,085	3,808	15,015	42.5
Rock	0	10,360	7,491	0	0	2,184	1,855	21,890	17.7
Others	911	0	0	0	0	315	0	1,226	10.3
Total	7,681	12,260	8,651	1,255	3,657	8,804	6,362	48,670	24.0
	(Ratio of Area by Soil Loss)								15 t/ha<
Farmland	64%	6%	2%	1%	9%	12%	7%	100%	28%
Irri. Farmland	100%	0%	0%	0%	0%	0%	0%	100%	0%
Orchard	99%	1%	0%	0%	0%	0%	0%	100%	0%
Dry Farmland	1%	17%	5%	2%	25%	32%	19%	100%	78%
Tree Plantation	96%	4%	0%	0%	0%	0%	0%	100%	0%
Rangeland	0%	8%	7%	8%	18%	34%	25%	100%	85%
Rock	0%	47%	34%	0%	0%	10%	8%	100%	18%
Others	74%	0%	0%	0%	0%	26%	0%	100%	26%
Total	16%	25%	18%	3%	8%	18%	13%	100%	41%

(Note) 1) Others: Village, River bed, Waste land
2) Tables of sub-basin wise are in Table D-5-1-9 (1) to (5) in Annex D

(5) Considerations on the Factors of Erosion

From a viewpoint of factors which affect to erosion, following important issues are elaborated for soil protection measures in the area.

R: Rainfall erodibility index is not able to change because of natural climate condition.

K: Soil erodibility factor is possibly to be changed by improvement of infiltration rate by putting organic matters, but basically difficult to be changed in large areas such as rangeland.

L: Slope length is possible to change by providing the contour bunds in the slope by the farmers, but understand of farmers and supporting system to them are essential.

S: Slope steepness factor is possibly to change like as by terracing, but it needs a lot of cost for earth work.

C: Crop management factor is possible to change by converting crops to more protective crops like as alfalfa in the farmland and protecting or seeding in the rangeland, but understand of farmers and supporting system to them are essential as same as contour bund.

P: Contour cultivation is essential to improve conservation practice factor, but understanding of farmers is strongly required. Most farmers are employing contour cultivation in the area, while slope direction cultivation is carried out in some places where mechanized cultivation is introduced in the Karoon river basin.

(6) Further Study on Surface Soil Erosion Protection

For the practice of soil conservation and the selection of proper measures, the most important are to know what factors are governing erosion and to grasp correct erosion amount not only at present stage but also in future. As mentioned in the previous paragraph, many factors are affecting to surface erosion. Those factors can be classified into two categories, namely the factors not able to be changed by human activities and the factors able to be changed. Important and essential factors are the those able to be changed by human activities like as the topography factor (LS), crop management factor (C) and conservation practice factor (P). Estimation of erosion amount varies largely by those parameters. For deciding the correct parameters, it is necessary to grasp the correlation to the actual erosion amount. In order to grasp correlation and to decide correct parameter, it is necessary to carry out a large quantity of experimental work. In Iran, such experimental work has not been yet carried out so far.

On the other hand, the unchangeable factors like rainfall erodibility index (R) and soil erodibility factor (K) are to be grasped correctly and adequately for proper conservation practice. For grasping the correct rainfall erodibility index, it is necessary to provide enough number of the recording type rain gages to grasp short duration rains which cause the major part of erosion. Regarding to the soil erodibility factor, adequate soil survey has to be carried out to grasp soil properties and infiltration rate.

For this purpose, following experimental research works are to be considered:

1) Experimental Research Items

Although some attempts have been given in This Study, following items are to be considered as the research items for proper planning of soil conservation in the Karoon river basin.

- To determine proper crop management factors (C) for the crops cultivated in the basin and vegetation in the rangeland and in the forest.
    (Crops: Wheat/barley, sugar beat, beans, alfalfa, clover, forage, apples, grapes, fallow land, difference between irrigated and non-irrigated etc.)
    (Vegetation: Perennial vegetation, seasonal vegetation, auk trees, other natural trees, bare land etc.)
- To determine proper conservation practice factor (P) for various inclination of farmland and rangeland.
- To grasp unchangeable factors such as the rainfall erodibility index (R) and the soil erodibility factor (K) exactly.

2) Items of Observation and Survey

Following items are to be observed and surveyed not only for research works but for future implementation of soil conservation works.

i) Rainfall intensity observation

In order to grasp rainfall erodibility index (R), rainfall intensity has to be observed by the recording type rain gages at different places in the basin.

ii) Soil survey

In order to implement the experimental research works, following soil survey has to be carried out.

- To carry out the supplemental soil survey and infiltration tests in the research field and the experimental fields.
- Soil survey items should involve at least 1) soil texture including gravel, 2) organic matter contents, 3) apparent-specific gravity, 4) infiltration rate and 5) chemical properties.

iii) Vegetation and land cover survey in the rangeland

In order to grasp the effects of protection and seeding in the rangeland, vegetation and land cover survey should be carried out to monitor the changes of vegetation and land cover by protection and seeding in the experimental fields.

3) Field Experiments

Field experiments may be classified into two groups: those carried out in the research field and those designed to assess erosion at a number of the experimental fields over a large area.

i) Experimental Research Field

Works at the experimental research field is based on the small bounded runoff plots, with an each size of 20m length and 5m width bounded by a metal edge, of known slope steepness, slope length, crops and soil type. Runoff and soil loss from each plot are collected in a collecting tank and monitored for each rainfall in order to grasp the crop management factors (C) for different crops and the conservation practice factors (P) for different slopes and different practices. Among small runoff plots, standard plots with an inclination of 5° or 8.7% and 20 m length (topography factor LS = 1) will be prepared. Experimental research field will be recommended to select such as in Chaman Goli-Bazoft or Tang Sorkh, where different types of land uses, dry and irrigated farming, and different inclinations locate closely. Experimental research field needs a land of about 1 to 2 ha.

ii) Experimental Fields

Works at the experimental fields are based on the certain extent of fields in different land use, such as irrigated farmland, dry farmland, orchard, rangeland and natural forest or mixed land. Runoff and sediment are monitored from each site for each rainfall in order to confirm the crop management factors (C), the conservation practice factors (P) and topography factor (LS), and those changes by crop diversification like as alfalfa, protection and seeding in the rangeland and provision of contour bund in actual fields. For the large experimental fields or where runoff volumes are very high, two collecting tanks will be installed. The first one is an overflow type tank with a divider to divide the overflow to the certain proportions, and the second one collects a part of overflow as a sample. Total runoff and sediment will be estimated to measure collected runoff and sediment in two tanks. Taking representativity of different land use, rangeland, farmland and farming into consideration, tow or three experimental fields will be selected in each Master Plan areas, totally 10 to 15 fields. Provisions of necessary facilities are roughly as follows:

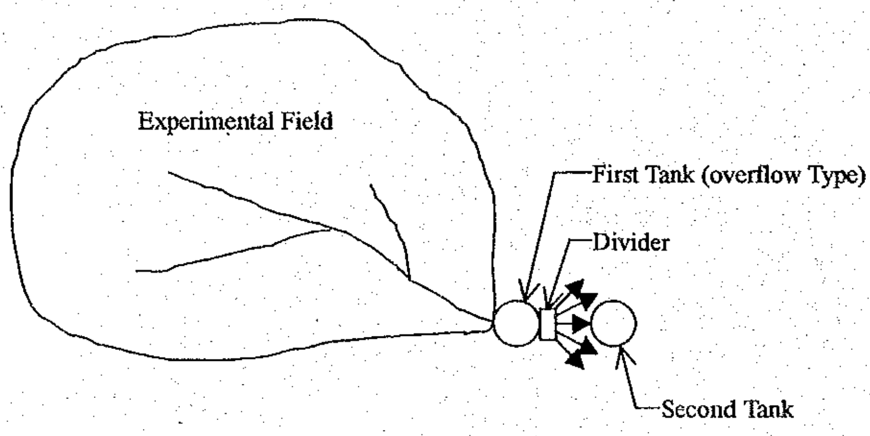


Figure 8-7-3-4 Observation System for the Experimental Field

4) Experimental Researches for Rangeland Improvement and Dry Farmland Protection

Following studies are necessary of rangeland improvement for erosion protection.

i) Seeding technology on the steep sloping rangeland inclined more than 40% as well as study on economic return.
ii) Contour bund construction in the large extent of rangeland area as well as its economic return.
iii) Vetiver grass for contour bund in the very steep farmland and side protection of gully erosion.

8.8 Environment

Based on initial assessment through field investigation, including observation of footmarks and feces of wild animals. And analysis of collected documents and information, including inquiry from villagers, nomads and shepherd, natural environment characteristics of five Master Plan Areas are hereby given.

(1) K4-1-9 Vastegan

Vastegan being a part of Sabz Kouh, which is a branch of Zagros mountain range, is home to a number of flora and fauna, some of which being endemic.

Of flora, Astragalus (milkvetch), Gundelia (artichoke), Bromus (bromegrass), Glycyrrhiza (liquorice), Alhagi (camelthorn), Centaurea (blue centaury) and Thymus (thyme) species are widely spread and commonly seen in the area.

Mammals living in this area include Canis Lupus (wolf), Sus scrofa (wild pig), Canis oureus (jackal), Ursus arctos (bear) and Vulpus Vulpes (Fox).

Birds are Alectaris chukar (partridge), Aquila (eagle), and Strix aluca (owl).

Echis carinatus (green viper) and Watterinneasia aegipta (cobra) are among the reptiles living in this area.

About 18.5 km^2 of the sub basin is designated as "protected area" by Department of the Environment.

No national park or cultural assets exist in this sub basin.

(2) K5-19a Chaman Goli-Bazoft

Dense forest of Quercus (oak), inaccessible mountain of Kouh Sefid, and Bazoft River provide a safe and suitable habitat for wildlife. There are a variety of plant and animal species in this area some play important roles in maintaining ecological balance and genetic values.

The wide spread flora in the area are Quercus (oak), Amygdalus (wild almond), Pistacia (wild pistachio), Juniperus (juniper), Crataegus (hawthorn), Astragalus (milkvetch), Poa (bluegrass), Stipa (needlegrass), and Hordeum (wildbarley).

Mammals living in the area include Capra aegarus (wild goat), Panthera pardus (leopard), Sus scrofa (wild pig), Ursus arctos (bear), Hyaena hyaena (hyaena), and Vulpus Vulpes (Fox).

Birds are Columba palumbus (wood pigeon), Gypaetus barbatas (osprey), Falco peregrinus (lagger falcon) and Falco cherrag (saker falcon).

Of reptiles Echis carinatus (green viper), Coluber rhodorhachis (rattle snake), and Vipera lebetina (viper) are to be mentioned. Viper is very poisonous and nuisance to people of the area.

No protected area, national park or cultural assets exist in this sub basin.

(3) K7-0-19-1 Sarbaz

Occurrence of high peaks, deep valleys and Marbor River provide a suitable habitat for wildlife. Some of flora are unique and have medicinal and genetic values, while some of fauna contribute in maintaining ecological balance and environmental status of the area.

Among the flora Quercus (oak), Amygdalus (wild almond), Pistacia (wild pistachio), Juniperus (juniper), Acer (maple), Fraxinus (ash tree) Crataegus (hawthorn), Astragalus (milkvetch), Hordeum (wildbarley), Agropyron (wheatgrass), and Psathyronstachys (wildrye) are the wide spread species.

Mammals living in this area include Felis catus (wild cat), Capra aegagrus (wild goat) Canis Lupus (wolf), Canis oureus (jackal), Ursus arctos (bear), Panthera pardus (leopard), Martes Martes (sable), and Sefur momolus (squirrel) which plays an important role in planting seed of trees such as oak. This animal hides the plant seeds into soil for future use, but often fail to recover them. When season comes, the seeds germinate and produce new plants.

Many birds some being predatory, inhabit here, these include Aquila heliaca (eagle), Gypaetus barbatas (osprey), Falco pelogrinus (lagger falcon), Falco cherrag (saker falcon), Alectaris chukar (partridge), Strix aluca (owl), and Columba palumbus (wood pigeon).

Reptiles include Echis carinatus (viper), and Watterinneasia aegipta (cobra).
About 10.8 km^2 of the sub basin is designated as "protected area" by Department of the Environment.

No national park or cultural assets exist in this sub basin.

(4) K7-48 Tang Sorkh

Due to conduction of intensive commercial activities such as establishment of fishpond, orchard/commercial vegetation, and expansion of farmlands, natural status of the area has changed. Many localities nearby villages are almost denuded of natural plants and in mountain areas vegetation is in poor condition.

Quercus (oak), Amygdalus (wild almond), Pistacia (wild pistachio), Agropyron (wheatgrass), Astragalus (milkvetch), Hordeum (wildbarley), Acanthophyllum (soaproot), and Gundelia (artichoke) are some of plants growing in this area.

Ursus arctos (bear), Hyaena hyaena (hyaena), Felis catus (wild cat), Canis Lupus (wolf), Sus scrofa (wild pig), and sefur momolus (squirrel) are among the mammals of this area.

Birds are Strix aluca (large owl), Gypaetus barbatas (osprey), and Alectaris chukar (partridge).
Of reptiles poisonous and non-poisonous snakes are commonly seen in this area.

No protected area, national park or cultural assets exist in this sub basin.

(5) K8-28 Zeras

Natural environmental status of this sub basin is poor, because with time flora has been cut for various uses, including creation of spaces for dry farming. This area is not safe for wildlife. Only predatory animals such as wolf and eagle approach the area to hunt livestock and poultry. However inhabitants of the area claim that the wild animals come and disturb them, the expert believes that the people have encroached the natural area and pushed the wild life to remote/less favorable parts. Entrance of animals into village for seeking food is an indicator of ecological imbalance, means more predator, less natural prey.

Flora comprises mostly of annual grasses, which are scattered in inaccessible localities. Quercus (oak), Astragalus (milkvetch), Avena (oat), Sisymbrium (hedge mustard), Gundelia (artichoke), and Hordeum (wildbarley) are among the plants growing in this area.

Canis Lupus (wolf), Sus scrofa (wild pig), Vulpus Vulpes (fox), and Lepus capenise (rabbit), are some of mammals roaming in this area.

Birds are Aquila species (eagle), Neophron percnoplerus (vulture), Anthene noctua (small owl), and Columba palumbus (wood pigeon).

Reptiles of the area include poisonous snake such as Vipera lebetina (viper).

This sub basin, possess no protected area, national park or cultural assets.