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Fujikawa, Takenobu
Laboratory of Land Improvement and Conservation Engineering, Faculty of Agriculture, Kyushu University

Higuchi, Shoichiro
Department of Kage-Sanyu Group of Consulting Engineers, Iran

Kaku, Ken
Agicultural Construction Engineering, Faculty of Agriculture, Saga University

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Estimation of Consumptive Use of Crops in the Sistan Farm-land Development Project, Iran

Takenobu Fujikawa. Sboicbiro Higuchi*
and Ken Kaku**

Laboratory of Land Improvement and Conservation Engineering,
Faculty of Agriculture, Kyushu University 46-05, Fukuoka 812

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The Sistan project area is located at the south-east district of Iran near the border to Afganistan, belongs to the arid zone and the climate condition is particular. In this area, an huge farm land development project have been planned by using the water of Hermand river for irrigation. The most important factor to establish the irrigation plan is to estimate the consumptive use of the crops, which will be introduced in this area. Studying several methods, the Penman method was concluded as the most suitable one to estimate the consumptive use of crops in the area.

INTRODUCTION

Almost all the parts of Iran are in the arid or semi-arid zone, so that there is scarcely rain fall which is to be used as effective agricultural water. Therefore, irrigation water should rely on some artificial facilities. They have been wrestled with the wide scale development of water resouces since 1960. As the results, over one million hectares of uncultivated land have gained the potential to be developed as farm land. However, there are many problems, which should be clarified hereafter, in connection with how to use this developed water effectively, or how to attain the maximum irrigation effect by the minimum amount of water. Investigations and discussions on severals of these problems, such as the consumptive use of crops, the irrigation method and the method of water management, have been started. This paper describes the investigation on the estimation of the consumptive use of crops for the Sistan project area as one of these problems.

The accurate and practical value of the consumptive use of a crop should be determined by a field experiment. However, there are not any facilities for such experiment and they have scarcely planted any crops in the project area, so that presumption is necessary for the estimation of the value for this area. The climate condition of a place in the arid zone is significantly

* Director of Technical Research, Department of Kage-Sanyu Group of Consulting Engineers, Iran.
** Professor, Agicultural Construction Engineering, Faculty of Agriculture, Saga University.

influenced by its location. Therefore, the consumptive use of crops will be also influenced by the location. Although there are many uncultivated lands in Iran, the extent of the area which can be developed to farm land is restricted by the available amount of water. For the effective and successive farmland development, it is necessary to presume the consumptive use of crops accurately.

CHARACTERISTICS OF THE PROJECT AREA

1. Location

The Sistan project area is located at the south east part of Iran near the border of Iran-Afganistan and has the area of 250,000 hectares (Fig. 1). It is the inland delta formed by the flow of the Helmand River, the basin of which is in Afganistan, and is in the arid zone. The flood water of melted snow of the Helmand River flows into the south west part of the delta in spring and makes a vast lake. The lake, having the water depth of 1-l. 5

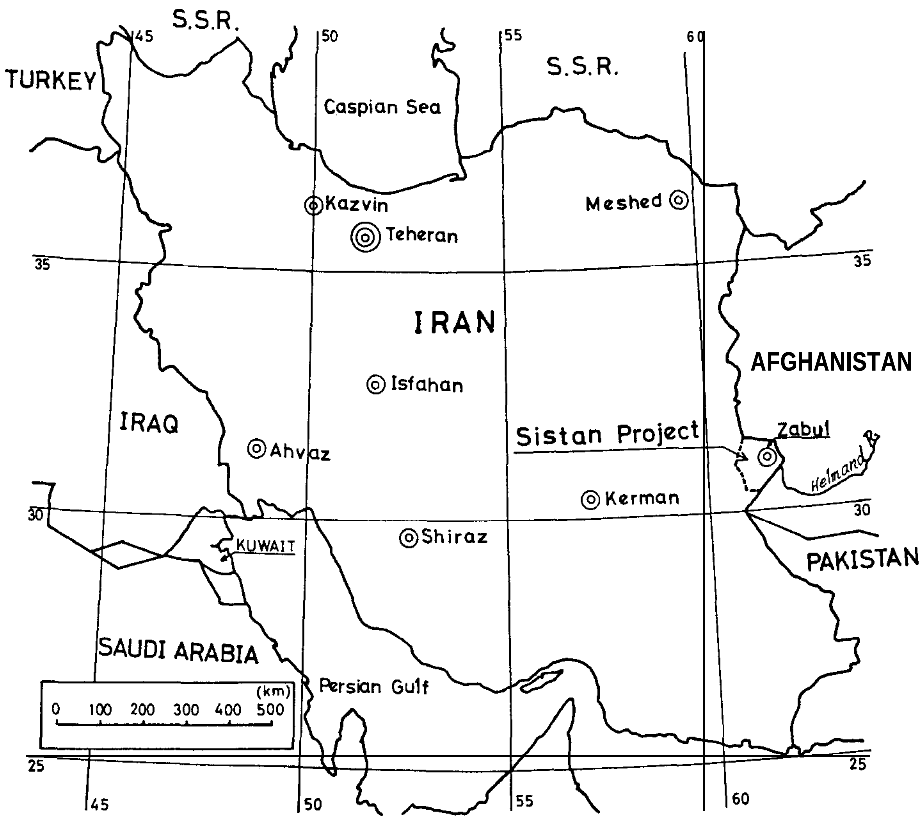

Fig. 1. Location of the Sistan project area.

meters, is 40 Kilometers from east to west and 100 Kilometers from south to north. In summer, the discharge of the Helmand River becomes almost zero because there is a reservoir at the upstream of it in Afganistan. Therefore, summer farming is impossible and they can cultivate crops only in spring.

The object of the Sistan project is to introduce summer crops in the area, by storing the spring water in the Chahnime Reservoir which is planned to be constructed at the upstream of the river, and by using this water for irrigation throughout the year. Sugarbeets, oil plants, pastures and vegetables, which have never been cultivated in the area, are planned to be introduced.

2. Climate condition

The climate condition of the area has the typical characteristics of the arid zone. Namely, the summer temperature is 30°C～45°C, the winter temperature is 0°C～5°C, the annual precipitation is about 55mm and the annual evaporation is about 4,800 mm (Table 1). In addition, there are north winds on 120 days per a year, which average velocity is about 6～8 m/sec. The larger value of the annual evaporation comparing with these (3,000 mm～3,500 mm) in the other parts of Iran, which temperature are also high, is probably caused by these north winds. The annual evaporation will have much effects on the consumptive use of crops, so that the consumptive use for the area will be very large. It can be said that the Sistan project area is in the worst climate condition among principal agricultural areas in Iran (Table 2).

Table 1. Climate conditions of Sistan project area.

Climate Conditions	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average Temperature(°C)	8.6	10.9	*17.5*	*22.5*	*28.3*	*32.2*	*33.9*	*32.4*	*27.6*	*21.8*	*15.*1	9.3
Maximum Temperature(C)	22.9	26.7	33.3	37.9	43.3	46.0	4G.1	44.0	40.9	36.9	29.5	23.5
Minimum Temperature(C)	-5.1	-2.5	2.5	8.4	14.2	19.6	21.6	19.7	11.6	6.7	0.9	-5.0
Humidity (%)	41.3	42.6	33.0	28.2	19.6	16.3					28.4	33.4
Precipitation (mm)	9.3	20.8	11.5	6.9	1.2	0	15.0	12.7	14.9	19.1	3.2	2.8
Evaporation (mm)	139	178	241	311	463	639	810	840	590	340	176	136
Wind Velocity (m/sec)	4.9	4.5	4.4	4.8	6.2	6.6	8.4	8.1	6.6	5.1	4.6	4.8

Annual Precipitation 55.7 mm, Annual Evaporation 4,870 mm.

Table 2. Climate conditions of the principal farmland development areas in Iran.

(1) Average temperature (°C)

Name of Area	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Kazvin	0.5	3.0	9.1	12.9	19.7	24.1	26.9	27.0	22.6	16.5	10.3	5.4
Meshed	3.5	2.2	8.2	13.7	19.2	23.7	25.3	23.7	19.5	14.1	8.4	3.5
Isfahan	[illegible]	5.8	11.1	14.3	17.4	26.2	28.8	27.3	19.0	17.0	10.1	4.6
Kerman	3.7	5.9	11.2	15.9	21.4	25.5	26.3	24.4	20.1	15.7	8.9	4.8
Ahvaz	12.5	13.1	17.2	22.4	30.5	33.6	35.7	35.2	26.8	27.5	19.2	13.5
Zabol (Sistan)	8.6	10.9	17.5	22.5	28.3	32.2	33.9	32.4	27.6	21.8	15.1	9.3

(2) Humidity (%)

Name of Area	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Kazvin	66	63	57	56	48	38	39	36	39	53	60	62
Meshed	72	74	69	58	45	36	32	30	34	53	62	68
Isfahan	60	52	41	41	31	20	21	20	24	31	49	58
Kerman	61	54	48	36	25	19	16	28	23	27	39	44
Ahvaz	70	70	54	52	37	30	32	39	37	49	62	70
Zabol (Sistan)	41	43	33	28	20	16	15	13	15	19	28	39

(3) Precipitation (mm)

Name of Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Kazvin	53.7	28.3	46.3	52.9	32.8	6.5	2.2	5.6	2.9	27.3	42.9	28.8	330.2
Meshed	25.6	24.2	45.1	35.0	20.0	1.7	1.6	0.2	1.4	14.0	19.9	23.9	212.6
Isfahan	20.4	12.3	13.0	19.0	9.2	0	0		0	6 8	9.5	9.7	9.99
Kerman	37.6	32.8	19.2	17.4	7.8	1.4	0.1	00.7	0.8	0’4	1.6	9.7	129.5
Ahvaz	50.6	38.0	17.8	21.0	12.5	0	0	0	0	16.4	65.5	21.7	243.5
Zabol (Sistan)	9.3	20.8	11.5	6.9	1.2	0				0	3.2	2.8	55.7

(4) Pan Evaporation (mm)

Name of Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Ahvaz	63	82	146	211	321	473	611	558	388	292	139	99	3,383
Zabol (Sistan)	139	178	241	311	463	639	812	840	594	341	176	136	4,870

Remarks: Monthly Pan Evaporation data at other area is not shown due to the difficulty to collect the accurate data. The annual evaporation is estimated about 2,800-3,000 mm at the northern part of Iran and about 3,000-3,500 mm at the southern part of Iran. There *is* a few places like the Sistan area which has annual evaporation more than 4,500 mm in Iran.

BLANEY-CRIDDLE METHOD

The Blaney-Criddle method (Israelsen and Hansen, 1962) have been widely used to estimate the consumptive use of a crop in many countries. Also in Iran, they had used this method in almost all projects up to recent. The method uses the experimental formula, which was proposed by U. S. D. A. (Blaney and Criddle, 1962). They deduced this formula by analysing the correlation between the data of climate condition and that of consumptive use which had been obtained at many places in U. S. A. untill 1945. The consumptive use of a crop for a place is experssed by the functions of the temperature, the percentage of sunshine. the growth stage of the crop and the coefficient of the crop, as the equation (1). This formula has been considered to give fairly accurate values for the area in the arid zone. If the climate condition of the area is normal, this

Table 3. Proposed monthly crop coefficients (K).

(1) Western. U. S. A.

Crop, Location	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Alfalfa												
Arizona (Salt River Valley)	0.35	0.55	0.75	0.90	1.05	1.15	1.15	1.10	1.00	0.85	0.65	0.45
California (Davis)	……	……	……	0.70	0.80	0.90	1.00	1.00	0.80	0.70	……	……
California (San Fernando Valley)	0.35	0.45	0.60	0.70	0.85	0.95	1.00	1.00	0.95	0.80	0.55	0.30
Corn												
Arizona (Phoenix)	……	……	……	1.09	1.29	0.20	……	……	……	……	……	……
California (Davis & Sacramento)	……	……	……	……	0.12	0.40	0.60	0.62	0.45	……	……	……
Cotton												
Arizona (Salt River Valley)	……	……	……	0.20	0.40	0.60	0.90	1.00	0.95	0.75	……	……
Melon												
California (Murrieta)	……	……	……	……	……	0.45	0.70	0.74	0.64	……	……	……
Pastures												
California (Davis& ***Sacramento)***	……	……	0.10	0.27	0.42	0.52	0.57	0.55	0.35	0.15	……	……
California (Murrieta)	……	……	0.20	0.49	0.74	0.84	0.87	0.85	0.78	0.55	……	……
Peas												
Arizona (Salt River Valley)	0.25	0.55	0.98	1.08	1.10	……	……	……	……	……	……	……
Potatoes												
Arizona (Salt River Valley)	……	0.20	0.50	1.00	1.20	1.05	……	……	……	……	……	……
California (Davis & Sacramento)	……	……	……	0.45	0.80	0.95	0.90	……	……	……	……	……
Sorghum												
Arizona (Salt River Valley)	……	……	……	……	……	0.40	1.00	0.85	0.70	……	……	……
Sugar ***Beets***												
California (Northern)	……	……	……	0.31	0.69	0.96	1.01	0.83	……	……	……	……
Montana (Huntley)	……	……	……	……	0.33	0.84	1.06	1.11	1.06	0.63	……	……
Nebraska (Scottsbluff)	……	……	……	……	0.27	0.50	0.80	1.08	1.00	0.69	……	……
Barley												
Arizona (Salt River Valley)	0.32	0.60	0.98	1.08	0.45	……	……	……	……	……	……	0.15
Oats												
Arizona (Salt River Valley)	……	0.30	0.80	1.10	1.22	0.92	0.40	……	……	……	……	……
Wheat												
Arizona (Salt River Valley)	0.20	0.40	0.80	1.10	0.60	……	……	……	……	……	……	……
Tomato												
California (Northern Sacramento)	……	……	……	……	0.41	0.74	0.93	0.98	0.89	……	……	……
Vegetables												
California (Delta)	……	……	……	0.23	0.49	0.67	0.78	0.78	0.64	0.40	……	……

Remarks: These values of "K" are quoted from Blaney and Criddle (1962).

(2) Kazvin project area, Iran

Name of Crop	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wheat & Barley	0.45	0.60	0.80	1.00	0.80	……	……	……	……	0.30	0.40	0.50
Chick Peas	……	……	……	0. 70	0. 90	0. 80	……	……	……	……	……	……
Sugar Beets	……	……	……	**0.** 25	0. 50	0.80	0. 90	1.00	0. 75	……	……	……
Alfalfa	……	……	0.50	0.80	0.90	1.05	0.95	0.95	0.80	0.60	……	……
Deciduous Orchards	……	……	0.35	0.55	0.70	0.80	0.80	0.80	0.60	0.35	……	……
Potatoes & Onion	……	……	……	0.20	0.60	0.80	0.95	0.90	0.75	……	……	……
Vineyards	……	……	……	0.30	0.60	0.80	0.90	0.80	0.60	0.40	……	……

$$U=K \cdot P\ (0.46\ t+8.13) \qquad (1)$$

U; monthly consumptive use of crop (mm/month)
K; empirical coefficient of crop
P; monthly percentage of daytime hours of the year
t ; mean monthly temperature

method gives reasonable results. However, there is the difficulty of determining the coefficient of crop. The coefficient should be modified, if the climate condition of the project area is not similar to that of any experimented places.

Table 4. Consumptive use of each crop in Iran (mm).

Crop.	Location	Month.												Total
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Wheat & Barley														
				80	110	140	……	……	……	……	40	40	……	410
		50	***70***	***140***	90	……	……	……	……	……	10	40	50	450
		·	····	· · ·	……	……	……	……	……	……	……	……	……	400
		……	……	……	20	90	150	180	190	110	40	……	……	780
		……	10	60	100	200	240	290	130	……	……	……	……	1,030
		……	……	……			……	……	……	……	……	……	……	***900***
Alfalfa														
		· · ·	· · ·	30	90	160	200	220	180	120	70	·	……	1,070
		40	50	110	160	250	280	330	280	210	130	60	50	1,950
		·····	····	· · ·	· · ·	····		……	……	……	·	.	……	1, 500
		……	80	160	190	120						……	……	550
		……	……	……	……	····	……	……	……	……	……	……	……	330
Percian														
		50	70	120	180	210	220	240		……	……	……	40	1,130
		……	……	……	70	140	240	70	……	……	……	……	……	520
		……	……	……	……	……	……	……	……	……	……	……	……	400
		· · ·	····	·····	90	150	230	250	60	····	·····	····	·····	780
		……	……	……	……	……	……	……	……	……	……	……	……	570
Grape														
		10	20	30	80	180	260	280	260	160	80	30	10	1,400

Remarks: Monthly data was not obtained in the crop of Ahvaz.

Because the climate condition of the Sistan project area is particular, some modifications are necessary. Considering several actual values in Iran, they were modified as Table 3(2). Table 4 shows the consumptive use of crops estimated by using these K values, which was adopted as standards at the early stage of the Sistan project.

PENMAN METHOD

Penman (1948), based on his experimental study on irrigation for meadow, mentioned that the ratio of the evapo-transpiration (E_p) of a crop to the evaporation (E_0) from free water surface was constant and that the ratio E_p/E_0 is 0.6 for the period of Nov.-Feb. (winter), 0.7 for Mar.-Apr. and Sept.-Oct. (spring and autumn) and 0.8 for May-Aug. (summer). Therefore, the consumptive use of a crop can be estimated, knowing pan evaporation and the growth period of the crop. However, there will be question in estimating

Table 5. Evaporation from pan and free water surface.

(1) Zabol at Sistan area

Evaporation	Month												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Pan (E_p) (mm)	139	178	241	311	463	639	812	840	594	341	176	136	4,870
Free Water Surface (E_0) (mm)	84	95	146	228	372	411	512	481	354	232	117	84	3,116
Ratio (E_0/E_p)	0.6	0.53	0.61	0.73	0.80	0.64	0.63	0.57	0.60	0.68	0.66	0.62	Average : 0.64

(2) Ahvaz

Evaporation	Month												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Pan (E_p) (mm)	63	82	146	211	321	473	611	558	388	292	199	99	3,383
Free Water Surface (E_0) (mm)	56	78	121	177	242	279	295	276	210	151	84	53	2,022
Ratio (E_0/E_p)	0.89	0.95	0.83	0.84	0.75	0.59	0.48	0.49	0.54	0.52	0.42	0.54	Average : 0.65

(3) Sistan project area **in Iran**

Name of Crop	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wheat & Barley	0.60	0.85	1.00	0.80	......	......	......	......	......	0.30	0.40	0.50
Sugar Beets	......	0.30	0.40	0.60	0.95	1.10	1.25	0.90	......	......	......	......
Sunflower	......	0.90	1.15	1.20	0.60	......	......	......	......	......	......	......
Alfalfa	0.40	0.60	0.80	1.00	1.20	1.30	1.40	***1.30***	1.20	0.90	0.60	0.50
Percian Clover	0.50	0.80	0.90	1.10	1.00	1.00	1.00	......	......	......	......	0.40
Sudan Grass	......	......	0.90	0.90	1.15	1.20	1.10	0.90	......	......	......	......
Pulses	......	......	......	0.45	0.75	1.10	0.60	......	......	......	......	......
Melon	......	......	......	0.55	0.80	1.05	1.10	0.55	......	......	......	......
Grape	0.15	0.15	0.25	0.50	0.95	1.20	1.25	1.20	0.85	0.55	0.30	0.15

Remarks : These **values of "K" is determined by our study.**

evaporation from free water surface based on pan evaporation. Namely, evaporation from free water surface is almost the same as pan evaporation in the humid zone, while the one differs significantly from the other in the arid zone especially in summer. Table 5 shows comparisons of the values of pan evaporation and these of evaporation from free water surface obtained at the Sistan area and Ahvaz area, both of which are on the same latitude. Furthermore, the ratio E_p/E_0, which is considerd as constant for each seasons, corresponds to the K value of the Blaney-Criddle method and may vary with the species and the growth stage of the crop. Therefore, it is unreasonable to apply this method to the area in the arid zone.

Beside the above method, Penman (1956) proposed the theoretical equation, by which evapo-transpiration could be calculated from radiant energy of sun and wind velocity. The equation seemed to be reasonablly applied to the area in the arid zone, because it considered almost all the factors of climate condition, but it was so complicated that it was not practical. Slabbers (1969 a, b) obtained a practical equation to estimate evapo-traspiration, studying the data of the consumptive use of crops in Iran and modifying the Penman's equation. This method may be applied adequately to the Sistan project area.

The modified Penman method is summarized as follows.

(I) ***Evaporation** from free water surface*

$$E_0=\frac{(\Delta\cdot H_{nt}/L)+\gamma E_a}{\Delta+\gamma} \qquad (2)$$

E_0; evaporation from free water surface (mm/day)

Δ; slope of saturation vapor-pressure versus temperature curve at the absolute temperature T

H_{nt}; radiation energy $=(1-\gamma_w)R_i-R_u$ (cal/cm²/day)

γ_w; reflection factor of water (0.05)

R_i; radiation energy of short wave $=(0.25+0.54\ n/N)\ Q_n$ (cal/cm²/day)

R_u; radiation energy of long wave $=\gamma_T{}^4(0.56-0.092\sqrt{e_z})\cdot(0.10+0.90\ n/N)$ (cal/cm²/day)

Q_n; theoretical max. radiation energy from soil surface (cal/cm²/day)

n; measured sunshine duration (hour)

N; max. of possible sunshine duration (hour)

e_z; average vapor pressure in air $=(E_z\cdot h_z)$ (mm•Hg)

E_z; saturated vapor pressure at mean temperature (mm•Hg)

h_z; humidity, γ; constant (0.485)

T; absolute temperature, (T_z+273) °C

L; latent heat of water vapor

E_a; drying power of air $=0.35(E_z-e_z)\cdot(0.5+0.54U_2)$ (mm•Hg)

U_2; wind velocity at the point with the height of 2 meters above ground surface, (if this data is not available, the following equation may be used)

$$U_2=U\frac{0.8}{\log h+0.5}\ (\text{m/sec})$$

U; wind velocity at the point with the height of h meters above ground surface

The values of evaporation from free water surface calculated by the equation (2) for each places in Iran are shown in Table 6. The value for the Sistan project area is significantly larger than these for other places. The wind velocity is high and the humidity is low in the Sistan project area, so that the value of transpiration becomes larger and therefore the consumptive use of crops will be large (Van te Chow 1964). If the Blaney-Criddle method is used, the values of consumptive use of crops for the Sistan area and the Ahvaz area will be about same, because the temperature and the latitudes of both areas are about same, and only duration of sunshine and temperature are taken into account in the method.

Table 6. Evaporation from free water surface in Iran (E_0).

Name of City	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	31	45									50		
Ghazuvin	28	42	74	114	174	222	236	214	153	96	42	28	1,444
Mashad			105	114	180	222	246	208	147	87		25	1,415
Isfahan	40	59		138	189	228	242	220	168	115	60	37	1,601
Kerman	47	67	112	144	189	219	229	208	159	118	66	47	1,605
Ahwaz	56	78	121	177	242	279	295	276	210	151	84	53	2,022
Zabol (Sistan)	84	95	146	228	372	411	512	489	354	232	117	84	3,116

(2) ***Consumptive use of crops***

In general, the evapo-transpiration of a crop will be given by the equation (3), in which the

$$E_p = f \cdot E_0 \tag{3}$$

E_p; evapo-transpiration (mm / day)

E_0; evaporation from free water surface (mm / day)

coefficient of the crop f should be determined by experiments. If the value of f is unknown, it should be assumed empirically as the Blaney-Criddle method. The equation (4) was proposed to cover this deficiency.

Table 7. The relation between height of crop and g(l), and wind velocity at 2m above ground surface and h(U).

Height and g(l)		Wind velocity at 2 m above ground surface (U)	
Height of crop	Value of g(l)	Wind velocity at 2m above ground surface (m/sec)	Value of h(U)
Ocm	0. 18	0. 5	1.32
2 cm	0. 23	1. 0	1.17
5 cm	0. 47	1. 5	1.05
10 cm	0.74	2. 6	0.96
20 cm	1.00	2. 5	0.90
30 cm	1. 12	3. 0	0.86
40 cm	1. 22	4. 0	0.79
50 cm	1.32	5. 0	0.75
70 cm	1.42		
90 cm	1.50		

$$E_p = [1 + a + c\{f(z_0, d) - 0.28\}]E_0 + d\{f(z_0, d) - 0.28\} - b \quad (4)$$

$f(z_0, d)$; function of the height of crop and wind velocity, namely $f(z_0 \cdot d) = g(l) \cdot h(U)$, the values are shown in the Table 7

a, b, c, d; constants by the climate condition of the area, the values are shown in the Table 8 for several principal places in Iran

The consumptive use of crops for the Sistan project area by the equation (4) are obtained as Table 9.

Table 8. Value of a, b, c and d in Iran.

	(a)	(b)	(c)	(d)
Ghazvin	0. 20	0. 15	0.62	0.80
Mashad	0. 20	0. 16	0.73	0.40
Isfahan	0.21	0. 15	0.79	0.80
Kerman	0.21	0. 14	0.89	0.76
Ahvaz	0.18	0. 27	0. 70	0.50
Zabol (Sistan)	0.19	0.28	0. 76	1.40

Table 9. Consumptive use of crops by Penman method (mm).

Crop	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Wheat	42	62	145	155	—	—		—	—	21	45	34	504
	38	59	130	134	—	—	—	—	—	20	42	32	455
Sugar Beet	—	17	67	125	194	285	341	264	—	—	—	—	1,293
	—	9	59	116	184	249	311	229	—	—	—	—	1,157
Sunflower	—	61	105	189	335	—	—	—	—	—	—	—	690
	—	33	100	177	329	—	—	—	—	—	—	—	639
Alfalfa	56	64	171	213	291	333	372	347	264	118	75	56	2,360
	25	43	141	192	263	301	324	290	229	84	42	25	1,959
Persian Clover	59	78	155	258	265	285	378	—		—	20	50	1,548
	36	63	137	208	244	275	238			—	9	32	1,242
Sudan Grass	—	—	28	138	267	285	310	297		—		—	1,325
	—	—	18	120	245	280	297	218		—	—	—	1,178
Grape	—	—	—	—	—	—	—	—	—	—	—	—	—
	12	27	66	117	188	225	247	160	105	68	18	16	1, 249

Remarks : (1), The upper figures of each rows in the Table show the consumptive use of crops under the present conditions.
(2), The lower figures of each rows in the Table show the consumptive use of crops under the conditions with wind breaker forest.

CONCLUSION

The most important matter in planning a farm land development project is to estimate an accurate amount of water requirement in the project area. The water requirement consists of the consumptive use of crops and irrigation loss. The former depends on the natural circumstance of the area and the species of crop, such as the location, the elevation, the climate condition, the soil condition, the species and the growth period of the crop, and others. Therefore, the artificial improvments on these factors to save the amount of water requirement is almost impossible. Although windbreak forests or mulching may save some of it, is difficult to introduce these countermeasures into the arid zone. The latter is the loss of water from irrigation channels and field surfaces, so that the amount of water requirement will be saved considerably by artificial countermeasures.

The consumptive use of crops for the Sistan project area was estimated by the Blaney-Criddle method and the Penman method. Comparing the results of these two methods, the following items were clarified.

(1) For wheat, which is winter crops, the results by both methods did not have significant difference.

(2) For other crops, there was not significant difference in winter and at the begining of spring, but showed some difference in summer. It would be caused by the effect of wind on the value of evapo-transpiration.

(3) The consumptive use of crops in the Sistan farmland development project should be estimated by the Penman method, considering its climate condition.

The results of this investigation should be confirmed by field experiments. The amount of water requirement was supposed to be over twice the consumptive use of crops because of the water losses due to channel loss, irrigation method or leaching of alkaline soil. These problems will be investigated in future reports.

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