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PRECIPITATION AND RUNOFF IN ARID – MOUNTAINOUS REGIONS A CASE OF CENTRAL AND SOUTHEAST OF IRAN

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ABSTRACT The aim of this paper is to present a general information about the hydrometeorological features of Iran and to establish a relationship between the mean annual flow as well as the peak annual flood and related drainage area in arid mountainous regions similar to those in Iran. To achieve the aim the hydrological characteristics of Iranian Plateau are described and for two different arid parts of the country,the above mentioned relationships are derived.

INTRODUCTION

The plateau of Iran is generally above altitude of 1000 meters with two distinct high rugged ranges of mountains; the Alborz and Zagross which run from northwest to east along the Caspian Sea and from northwest to southeast respectively. Central Iran is relatively lower than the rest of the plateau and is mostly desert. These physical features associated with general directions of wind movement have divided Iran into three major basins, i.e. the Caspian, the Central and the Persian Gulf-Oman Sea basins. Of the above basins, the Caspian Sea basin is directly exposed to moisture moving inland from the sea. The high range of the Alborz mountains prevent most of the Caspian Sea moisture from moving into the Iran plateau, thus creating a very humid region, distinctly different from the rest of Iran plateau. In spite of large amount of precipitation, the occurence of very severe storms is not very common in this region. Moisture from the Persian Gulf and Oman sea has some influence on precipitation in Southern Iran. However, the general direction of the wind prevents them from comming far inland. Occurence of severe storms, however is common in this region. The widespread Central basin which is farther away from the source of moisture is located in the general direction of moist wind blowing inland from Mediteranean Sea after passing over Syria, Iraq and high range of Zagross mountains. The distance from the source of moisture reduces the possibility of very severe storms in Iran. One of the important aim of this paper is to elaborate the relationship between runoff and precipitation as well as runoff and related watershed area in arid – mountainous regions.

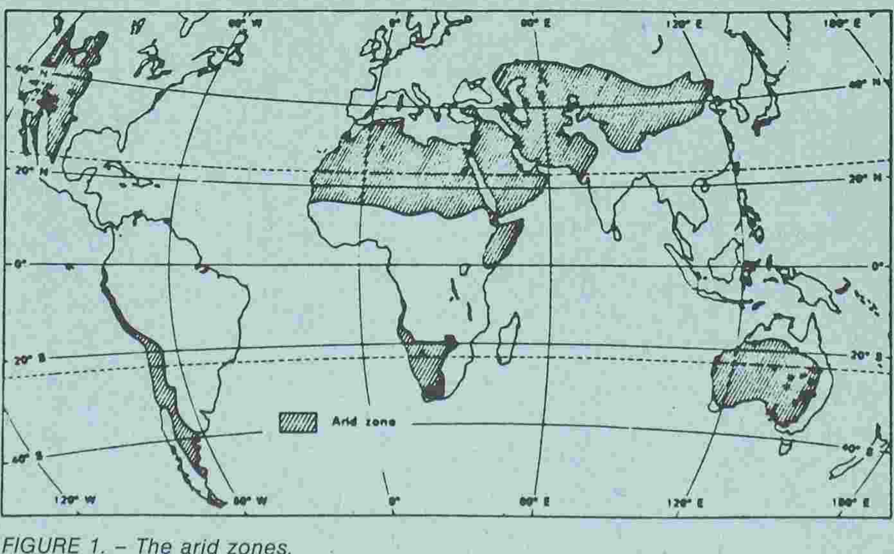

FIGURE 1. – The arid zones.

SOURCE OF MOISTURE AND PRECIPITATION

Precipitation in Iran is a result of Mediterranean depressions which governs the weather patterns of the country throughout the winter and spring seasons.During their passage, these depressions cause rain at low altitude and snow at high elevations. Occasionally, however, these Mediterranean cyclons fail and, following such winter, Iran is faced with severe drought.
In the spring, unstable air masses produce a considerable amount of precipitation over much of the country, in the form of locally scattered convection storms. This is particularly true of the mountain areas of the northeastern and western parts of the country.
Summer is dry everywhere, except along the Caspian littoral. There is practically no rain in the interior deserts and lowlands, but areas along the higher peripherals may experience occasional local showers. The southeast of Iran, especilly the southeastern mountains, are occasionally subjected to Indian monsoonal influence with some summer rain.
Autumn is the transitional season between dry summer and the wet winter. Mediterranean depressions begin to make themselves felt by mid autumn and rains start in many parts of Iran in October. In this season the Caspian littoral receives its maximum seasonal precipitation.
In addition, precipitation in Iran varies considerably with time, both during the rainy season and from year to year. Precipitation frequently departs widely from the mean from year to year, and a several year period of greater than mean precipitation can be followed by a period of several years of less than mean precipitation.
Average annual precipitation in Iran is about 220 mm. The averages vary from less

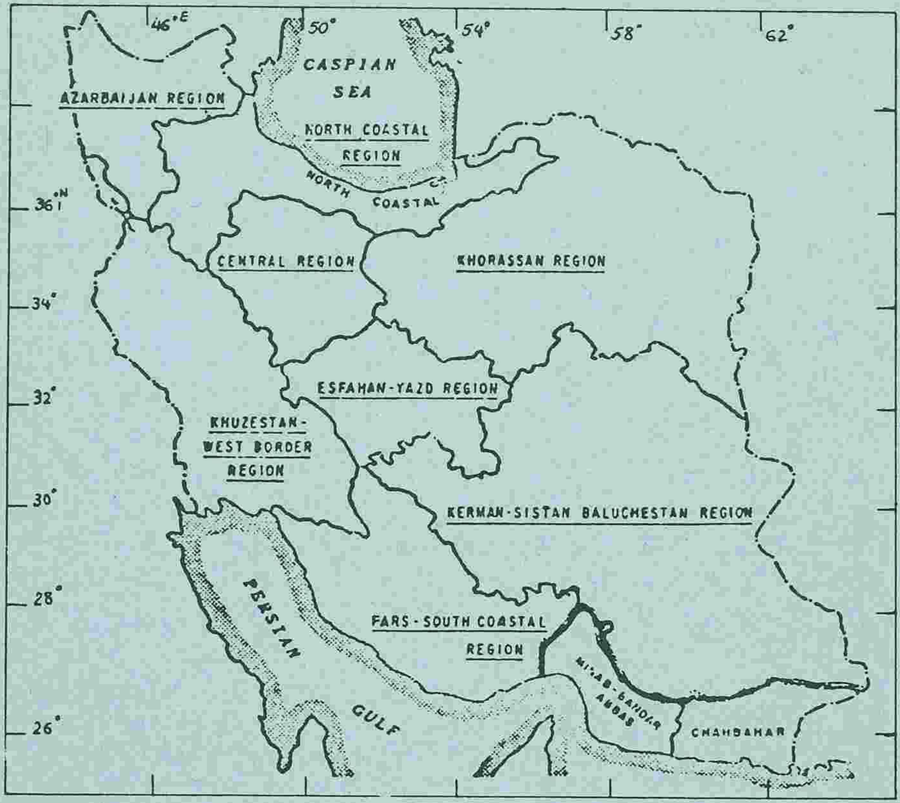

FIGURE 2. – Iran hydrological basins.

than 10 mm in desert interior to more than 1700 mm in the southwestern Caspian region. The mountain areas of Iran are characterizedi by cold winters, mild summers and a short rainy season. Winters in the higher mountains are severe and often long, exceeding six months and extendindg into the late spring monthes. Many of the higher peaks are crowned with snow until late in the summer. Mean annual precipitation and coefficient of variation for selected stations are listed in Table 1.

ALTITUDE-RAINFALL RELATIONSHIP

In previous section temporal and spatial distribution of precipitation as well as physiography of Iranian plateau was described. As illustrated in Fig. 2 this study is performed for two basins, Central and Southeastern (Oman Sea). Vegetation cover in these two basins is not good and it could be ranked from poor to bad respectively for Central and Southern areas.

For Central basin, on the southern slope of Alborz range the following relationship between mean annual precipiotation and altitude is established:

$$P = 27 + 0.28\ H \quad (1)$$

where P is the precipitation depth in millimeters and H is the altitude in meters. The equation was obtained by use of data from observed precipitation at 25 stations for altitudes ranging from 1500 to 2500 meters. Similar relationship for other stations in Central basin located between latitude 33-30 and 35-30 with altitude range between 800 to 2000 meters is:

$$P = -25 + 0.18\ H \quad (2)$$

Where P and H have the same definition and units as in equation (1)

For the Oman Sea basin correlation between precipitation and elevation is not as strong as Central basin, and it can be best described by the following relationship:

$$P = 115 + 0.08\ H \quad (3)$$

where P and H are as defined for equation (1) and H varies from sea level up to 1200 meters.

DISCHARGE-RAINFALL RELATIONSHIP

Information in Table 1 represents the situation of precipitation and temperature at synoptic stations located in the central of provinces of Iran. In areas where mean annual temperature is less than 18 degree of centigrade, some part of winter precipitation is in the form of snow. The average annual number of rainy days in Central basin is 35 and for Southeastern basin is 10 days. For this reason rivers in Central region are perennial and those in southeastern are ephemeral.

For Central basins on the southern slope of Albors range the following relationship is derived between the mean annual precipitation and annual river discharge:

$$R = 1.26\ (P - 257) \quad (4)$$

where R and P are in millimeters. This equation is valid for those watersheds with average altitude of 2500 meters and areas ranging from 300 to 1000 square kilometers. Similar relationship for catchments having average altitude ranging from 1200 to 2000 meters and areas between 200 and 1900 square kilometer is:

$$R = 0.71\ (P - 214) \quad (5)$$

and for watersheds in the southeastern regions:

$$R = 0.32\ (P - 62) \quad (6)$$

Equation (6) is valid for those watersheds with average altitude of 500 meters and areas ranging from 3000 to 8000 square kilometers.

Although equation (4) indicates negative runoff for annual precipitation less than 257 millimeter, but It should be realized that, this equation is just valid for a specified range of precipitation. Moreover 40 years of record show that the average annual precipitation over these watersheds has been more than 380 millimeters.

DISCHARGE-AREA RELATIONSHIP

Runoff from a drainage area is a function of different variables such as physiography,-vegetation, average precipitation and evapotranspiration of the watershed. The re-

Table 1. – Location and mean annual precipitation of selected raingauges (1960-1990).

Station	Latitude	Logitude	Altitude	Annu. (mm)	prec. Cv(%)	Mean Ann. Temp. C
Rasht	37-15	49-36	-7	1270	17	16
Gorgan	36-51	54-16	130	638	47	18
Bakhtran	34-16	47-07	1320	450	34	14
Uromieh	37-32	45-05	1310	364	26	11
Shiraz	29-32	52-35	1490	333	34	17
Tabriz	38-05	46-17	1360	272	37	12
Mashad	36-16	59-38	980	228	28	13
Tehran	35-41	51-21	1190	223	35	17
Ahvaz	31-20	48-40	20	216	33	25
Kerman	30-15	56-58	1750	166	41	15
Bandar-Abas	27-13	56-22	10	131	60	27
Esfehan	32-37	51-40	1590	110	52	16
Zahedan	29-28	60-53	1370	105	45	18
Zabol	31-20	61-29	490	59	47	22
Yazd	31-54	54-24	1230	56	48	19

lationship between the river discharge and related drainage area considers all these factors. In this study the following equation is derived for catchments on southern slope of Alborz with characteristics defined in previous section:

$$Q = 0.02\ A^{0.97} \quad (7)$$

where Q is mean annual discharge in cubic meter per second and A is drainage area in square kilometer, ranging from 400 up to 1000. Similar equation for catchments of Central basin located between latitude 33-30 and 35-30 is:

$$Q = 0.024\ A^{0.594} \quad (8)$$

Where Q and A are the same as equation (7) and A ranges from 100 up to 15 000 square kilometers.
The above relationship for southern basin is:

$$Q = 0.00065\ A^{1.059} \quad (9)$$

where Q and A are the same as in equation (7) and A ranges from 3000 up to 9000 square kilometers.

FLOOD

Severe floods in Central basin are the results of high intensity rainfall rather than snowmelt. The flood season is usually from late winter to mid-spring. According to the available data for recorded raingauges, rainfall intensity in Southern basin is far greater than in the central basin. Maximum daily rainfall in Tehran has not exceeded 40 millimeters while in Southern basin has gone up to 156 millimeters. The flood season in southeastern is during winter and summer. The summer flood is as a result of monsoon from Indian Ocean.
The following equations represent the relationship between peak annual floods with 2 years of return period and the related drainage areas. Having the above mentioned relationship and ratios given in Table 2, one can estimate the peak floods with the desired return periods.

Table 2. – Ratio of peak annual flood to the peak flood with two years return period.

Basin	$Q10/\bar{Q}$	$Q100/\bar{Q}$	$Q1000/\bar{Q}$	$Q10000/\bar{Q}$
Central(southeastern)	2.2	4.2	8.6	15.8
Central(southern slope of Alborz)	2.2	4.7	9.1	16.7
Southeastern	2.3	4.3	6.1	7.7

The following equation is derived for catchments on Southern slope of Alborz ranges with characteristics defined in runoff-rainfall section:

$$Q = 9.006\ A^{0.32} \quad (10)$$

where Q is peak annual flood with two years return period and A is the drainage area in square kilometers.
Similar relationship for catchments of Central basin located between latitude 33-30 and 35-30 is:

$$Q = 22.10\ A^{0.18} \quad (11)$$

where Q and A are the same as in equation (10) and A ranges as defined in equation (8).
The above relationship for Southern basin is:

$$Q = 0.08\ A^{1.12} \quad (12)$$

where Q and A are the same as in equation (10) and A ranges as described in equation (9).

CONCLUSION AND RECOMENDATION

Information snd relationships in this paper reflects the conditions of precipitation, temperature, river discharge and floods in arid mountainous regions of the world similar to those in Iran. Results of this paper might be used in data quality control, estimation of average annual precipitation over a catchment and river discharge as well as the order of magnitude for peak floods. The correlation coefficients for all relationships presented in this paper are valid, at least, at 5 percent level of significance.
It would be recommended to discuss the result of similar studies for similar climate at a workshop in order to regionalize the result of these kind of research and investigations.

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