

release of bank storage. During the monsoon period in the summer, heavy prolonged rains in some years may increase the flows to massive discharges and cause damaging floods. In Table 7.1, values are given of seasonal and annual mean flows, and the standard deviation of flows for the Indus, Jhelum, and Chenab Rivers, as based on a thirty-five year record starting in 1921. The total mean annual flow from these three western rivers is 138 million acre feet per year.⁽²⁾ The serial correlation between flows of the Indus River in successive years is quite high - the product moment correlation coefficient is 0.4 - indicating that there is a definite tendency for wet years to follow wet years, and dry years to follow dry years. This tendency is unusual in the great rivers of the world. The serial correlation between successive annual flows on the Jhelum and Chenab Rivers is low and not statistically significant.

In Figure 7.1, the average relative magnitudes of the monthly flows for the three rivers have been plotted. The proportion of the runoff occurring in the Kharif season is 83 percent of the total.

There are few good dam sites in West Pakistan for the creation of large reservoirs. This circumstance and the high degree of serial correlation between successive annual flows on the Indus River, which impairs the efficiency of regulation, combine to make surface storage expensive and therefore of limited use in the management of the water resource.

The irrigation plain area is remarkably level. The ground slopes gently toward the southwest. The average gradient from the northern rim to the Arabian Sea is about one foot per mile. This mild slope makes it difficult and expensive to utilize surface drainage extensively for the return of irrigation flow to the rivers. The plain lies on an enormous downwarp which contains sands, silts, and other materials that have been deposited in past geological ages by the Indus River and its tributaries. The deposition of alluvium occurred over a period of several million years. When the deposits rose high enough a great lake was formed. The waters of this lake spilled over and finally cut through the Aravali Salt Range and the submerged extension of pre-tertiary rock formation between the Punjab and the Sind. Since the drainage of the lake, the rivers have had no permanent channels and have moved with freedom over the plain in meandering courses for thousands of years.

At the present time in the irrigation plain, 19.5 million acres of cultivable land are commanded by the irrigation system in the Former

(2) This figure is slightly higher than that given in Table 1.2 because a different number of years of record was used.