SECTION 3

Effects on Agricultural Productivity

3.1. The Setting

The dry tropics are characterized by a short and intense rainy season followed by a relatively long dry season. Generally the rainy season lasts from two to four months; the amount of rainfall received ranges between 400 and 1200 mm; the rainy season may have one peak (unimodal) or two peak periods of rainfall (bimodal). In the dry tropics, the rainy season is distinctly bimodal in areas lying between 5 and 12° N latitude, while it is generally unimodal in those areas located above 20° N latitude. The areas lying between 12 and 20° N show some tendency towards bimodality. The dry tropical region is also characterized by warm thermal regimes throughout the year. The annual potential evapotranspiration for most of the dry tropics ranges between 1500 and 2500 mm. The potential evapotranspiration is quite intense in the hot dry season preceding the rainy season. The US Class A open pan evaporation rates during this period range between 10 and 15 mm/day.

As was described in the previous section, the dry tropical areas show considerable variability of rainfall from year to year. The distribution of rainfall during the rainy season is quite erratic. Therefore, for developing alternate crop production strategies, it is important to consider the rainfall distribution pattern as well as its reliability. At ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), it has been found that the rainfall can be characterized, in agronomic terms, most usefully by estimating the probabilities of rainfall and soil water in a stochastic process.

Markov chain procedures for estimating initial and conditional probabilities of rainfall can be used effectively for defining the dependability of rainfall during the rainy season (Robertson, 1976; Virmani *et al.*, 1982). The risks that sowing rains received by crops will not be enough to ensure survival, and the dependability of rainfall later at critical stages of crop development, can then be assessed through such analyses.

Water balance studies are important for characterizing the variations in availability of soil water for crop production, but few empirical data are available. The water-holding capacity of the soil has a considerable influence on the

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availability of soil water during the growing season. Information on daily soil water availability can be generated using soil water balance models. Such information is useful to agricultural scientists in devising cropping strategies for optimizing production in different types of soils, for evaluating risks and for optimizing inputs.

The objective of this section is to examine the variability of climate with particular emphasis on rainfall, and soil water availability, and their impact on agricultural productivity at 5 locations in India: Jodhpur (26°18′N, 73°01′E), Anantapur (14°41′N, 77°37′E), Hyderabad (17°27′N, 78°28′E), Dharwad (15°27′N, 75°00′E) and Indore (22°43′N, 75°48′E) (*see Figure 3.1*). These locations were chosen to represent a broad gradation of conditions from arid to wet semi-arid. This section first describes the agroclimatic characteristics, such as annual rainfall, weekly rainfall, soil water and runoff, for these locations. It then deals with the assessment and ranking of the locations in terms of productivity, using actual and simulated crop yield data.

3.2. Agroclimatic Description

3.2.1. Annual rainfall

The annual rainfall variability for the five locations is shown in *Figure 3.1*. The mean annual rainfall based on data from 1941–1970 ranged between 382 mm (Jodhpur) and 1001 mm (Indore), and the coefficients of variation ranged between 20 (Hyderabad) and 42% (Jodhpur). To calculate the frequency of occurrence of drought in these locations, we followed the definition of drought that the Indian Planning Commission (1973) used while evolving their relief and development approach toward drought-prone areas in the country. Accordingly, if the annual rainfall is 75% or less of the long-term average of the location, it is considered to be a drought situation (*see* Section 1). This definition has also been used in Sections 2 and 4 of this case study. The number of years in which rainfall fell below 75% of the corresponding average for the location was 8 in Jodhpur, 6 in Anantapur, 2 in Hyderabad, 4 in Dharwad and 6 in Indore. The lowest rainfall during 1941–1970 was 135 mm in Jodhpur in 1960, and the highest rainfall was 1743 mm in Indore in 1959.

The probability of occurrence of annual rainfall gives important preliminary information to help in developing alternative cropping systems for any region. The probability of receiving at least 800 mm of rainfall was 75% in Indore, 70% in Dharwad, 45% in Hyderabad, 7% in Anantapur and 3% in Jodhpur (*Figure 3.2*). In 70% of the years the rainfall received was at least 300 mm in Jodhpur, 470 mm in Anantapur, 700 mm in Hyderabad, 800 mm in Dharwad, and 860 mm in Indore (*Figure 3.2*). Farming systems research at ICRISAT has amply demonstrated that in the Hyderabad region a double crop system (e.g., intercrop, sequential or relay systems) is feasible if the water-holding capacity of soil exceeds 150 mm so that it can store sufficient available