SECTION 6

The Effects on Zones of Agroclimatic Suitability for Crops

6.1. Introduction

In this section we examine the effects of short-term variability of precipitation on the potentially cultivable area of Chimborazo Province. After an initial discussion of the relation between climate and potential production, climatically induced shifts in areas suitable for certain crops are mapped for given scenarios of climatic variation. The areas delimited by these shifts represent areas of potential climate impact.

6.2. Climatic Limits to Cultivation

The amount of water required by a crop can be estimated by calculating potential evapotranspiration (PET). The investigation and evaluation of various methods to estimate PET in the central Sierra has indicated that the ratio between PET calculated using the Thornthwaite and Penman methods, respectively, is quite uniform at about 0.45 (Cañadas and Salvador, 1982). Further, analysis of Penman PET estimated for five locations at different altitudes suggested that mean annual Penman PET decreases only about 2 mm for every 100 m increase in elevation (Cañadas and Salvador, 1982). This is a relatively small altitudinal lapse rate. Work elsewhere in the temperate Andes tends to corroborate this result, which appears to be attributable to high net radiation in mountains even when temperatures are low (Frere *et al.*, 1975; Knapp, 1984).

In general, at higher elevations around the basin margins, precipitation is higher than in the basin centers, and crop water requirements are normally satisfied during the wet season (Cañadas and Salvador, 1982). In the drier basin interiors, precipitation totals often fall short of PET, and irrigation is often desirable or necessary, particularly for long-cycle crops such as maize.

In the central Sierra the variance of growing season rainfall is between 10 to 100 times larger than the variance of growing season PET (Cañadas and Salvador, 1982). This suggests that year-to-year variations in crop yield are more

M. L. Parry et al. (eds.), *The Impact of Climatic Variations on Agriculture*

likely to be due to variations in precipitation than to variations in potential evapotranspiration.

So far there has been hardly any experimental study to determine the lower limit of rainfall for successful rainfed agriculture in the Ecuadorian Sierra. Not only the amounts but also the temporal distribution of rainfall are, of course, important. Yields are determined by the soil water available for the development of crops. Since highland soils are derived from volcanic ash, soil moisture-holding capacity can be related to soil depth, texture and structure. PRONAREG-ORSTOM has in fact produced maps of the limits of potential wheat production, based on the assumption that the dry limit of rainfed cultivation of wheat is the ustic-aridic soil moisture regime boundary – that is, the point where the "soil moisture control section" (USDA, 1975) is dry on average for six or more months a year. Wheat, however, is less tolerant of extremes than barley.

In order to determine empirically the wet and dry limits of cultivation in Chimborazo Province, maps of potential and of actual land use were consulted (PRONAREG-ORSTOM, 1977–1982; 1982a; 1982b). A comparison of these maps with rainfall receipt indicated that the dry limit of cultivation of barley corresponded approximately to the 400 mm/year isohyet. Similarly, the wet limit of actual and potential potato and cereal agriculture corresponded to the 1400 mm/year isohyet.

Previous studies of crop records on haciendas in Chimborazo Province indicate that potato yields in years with a rainfall receipt of 1400 mm are about 39% of optimal yield, and barley yields with annual rainfall under 400 mm are about 25% of optimal (Knapp, 1984; *see also* Section 4). An annual precipitation of less than 250 mm leads to complete loss in the sense that yields are then less than the seed input.

6.3. Areas of Suitability for Crops: Average Years

The area of Chimborazo Province under 4000 m elevation with mean annual precipitation between 400 and 1400 mm is 397 630 ha. This category of suitable land may be further subdivided in terms of drought/downpour risk and frost risk as follows.

The lower limit of rainfed cultivation of potatoes is defined by PRONAREG as the ustic-udic moisture regime boundary – that is, the point where the "soil moisture control section" is dry on average for at least three months a year. As part of the present project, the ustic-udic boundary in Chimborazo was taken from PRONAREG ORSTOM (1979c) soil maps and compared with the distribution of precipitation, indicating that this boundary approximately coincides with the 800 mm isohyet.

The actual land-use map was compared with the precipitation map to determine that no areas that receive more than 1200 mm of precipitation per year are currently cultivated for barley.