

additional categories of expense: these are (1) larger capital costs of deeper wells and high capacity pumping equipment; (2) larger power costs for pumping as the water table is lowered (when the ultimate level is reached, the added power cost of lifting water must be paid in perpetuity); and (3) cost of additional pumps and of export-channels to waste lagoons or desert areas to dispose of excessively saline ground water.

Cost analyses of four types of tubewell-field designs were made in which the digital computer was used to determine the water table response to pumping. The unit costs assumed in these analyses were in part based upon past experience with vertical drainage in the northern plain and in part upon current estimates of costs by the West Pakistan Water and Power Development Authority and other engineering organizations. There are, however, a number of uncertainties entailed in cost estimates that preclude accurate delineation of the magnitude of the large-scale, long-term investment. These uncertainties and the assumptions made in our cost analysis are listed as follows:

(1) Uncertainties exist relating to average hydrological and soil parameters. These have been discussed previously; in the computations under consideration it was assumed that the aquifer had a storage coefficient (specific yield) for drawdown of 0.25 (25 percent), and a transmissivity for deep wells of 100,000 gallons per day per foot.

(2) Uncertainties exist regarding the economies of scale that can be achieved through mass production in the manufacture and installation of equipment and in large-scale construction. We believe that cost savings of fifteen to thirty percent can be attained in the long-term investment-construction program recommended by the Panel. Our cost estimates, however, are not based on this assumption.

(3) A strong possibility exists that technological innovations now in the development stage, such as plastic well-screens, will reduce costs and increase the effective life and efficiency of tubewells. For this reason we did not include in our analysis the additional cost of stainless steel screens for wells located in corrosive ground water zones.

(4) With the intensive and extensive agriculture of the our plan, tubewells can be operated at a higher capacity factor (percentage of hours in the year the well is operated) than capacity factors assumed in earlier tubewell system designs. The actual pumping capacity factors that will be attained in practice will depend upon cropping patterns, the amount of Rabi water that can economically be used, and the extent of revamping of the canal system. A considerable variation between projects in different regions and between successive years, depending upon rainfall and runoff, may be expected. It