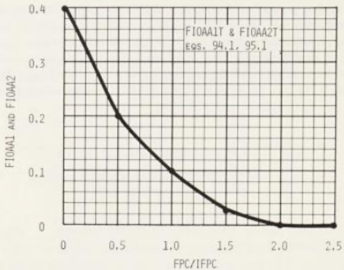

Figure 4-27 Fraction of industrial output allocated to agriculture table

Since the curve shown in Figure 4-27 is hypothetical, a CLIP function is included in the equations to allow it to be changed at any time during the model runs. We set the value of FIOAA at 0.1 when actual and indicated food per capita are equal (FPC/IFPC = 1) to suggest that a normal allocation to keep food production equal to demand is about 10 percent of annual industrial output. The main significance of the curve lies in its shape: a steeper slope represents a faster and stronger response to food shortage or surplus. A rough approximation of the slope is obtained from assumptions about possible extreme values. We assumed in World3 that the fraction allocated to agriculture FIOAA will not exceed 40 percent even in the case of extreme hunger, leaving only about one-half of the industrial output for consumption plus investment in service or industrial capital. Similarly, we assumed that a large surplus of food (twice the desired amount) will reduce the additional investment in agriculture to zero—in fact not even replacing the depreciation in the agriculture sector.

The resulting graph is only an assumption, and its values should ultimately be determined more rigorously, although the sensitivity runs shown later indicate that different graphs do not lead to any significant differences in the dynamic behavior of the overall model.

Land Development Rate LDR The total agricultural investment TAI can be allocated in two ways in the agriculture sector: to develop new arable land or to increase the yield on land already developed. The mechanism by which the allocation

decision is made will be described under loop 2, the loop that acts to increase land yield. For the moment it is sufficient to recognize that the capital investment available for land development is expressed as the total agricultural investment TAI times the fraction of that investment allocated to land development FIALD. Then the amount of land, in hectares, that can be developed each year (the land development rate LDR) simply equals the total investment available (TAI×FIALD) divided by the development cost per hectare DCPH.

```
LDR.KL=TAI.K*FIALD.K/DCPH.K                              96, R
    LDR    - LAND DEVELOPMENT RATE (HECTARES/YEAR)
    TAI    - TOTAL AGRICULTURAL INVESTMENT (DOLLARS/
               YEAR)
    FIALD  - FRACTION OF INPUTS ALLOCATED TO LAND
               DEVELOPMENT (DIMENSIONLESS)
    DCPH   - DEVELOPMENT COST PER HECTARE (DOLLARS/
               HECTARE)
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Development Cost per Hectare DCPH The relatively large amount of potentially arable land PAL still remaining in the world does not imply that any increase in the amount of arable land will be easy or cheap. Land expansion is a function of opportunities (potentially arable land), pressures (food needs or population growth), and constraints (capital, water supply, and technological capability). For example, in Africa south of the Sahara, the high cost of clearing forests, the presence of the tsetse fly, and the relative lack of population make a rapid land expansion program extremely difficult. A plan for increasing food supplies in the less industrialized areas proposes an increase of 20 percent over the 1962 level of arable land in those areas by 1985 (FAO 1970*a*, vol. 1). This expansion would increase the land fraction cultivated LFC in nonindustrialized countries from 45 to 53 percent.

The cost of developing new land is often the strongest constraint on agricultural land expansion. Development costs in World3 are assumed to include the costs of clearing the land, draining or irrigating (including the construction of dams and pipes), and building access roads—in short, all the costs necessary to make the land ready for the first crop. Development costs differ widely from region to region; they may also change with technology. Any technological variation probably affects money costs more than the physical costs (man-hours, tons of steel, energy) of developing land. In World3 we are interested in the physical resource costs, not the money costs.

The costs of land clearing are strongly dependent on local physical conditions, such as the original topography and vegetation, as well as on local economic conditions. In South America, land-clearing costs vary from 14 dollars per hectare to 550 dollars per hectare (PSAC 1967, vol. 2, p. 438). Similar cost distributions exist for irrigation, including water supply, water distribution, and water application to the land, and for drainage to improve aeration. A sample of the resulting total development costs is given in Figure 4-28.