

Then, to obtain the land yield multiplier from capital LYMC, it was only necessary to convert the horizontal axis of Figure 4-47 from multiples of the 1966 value of agricultural inputs per hectare AIPH in the developing world to dollar equivalents. Our calculated approximate dollar values of AIPH in various developing areas of the world are shown in Figure 4-32. Assuming from that figure a value of 12 dollars per hectare for the developing world in 1966, we obtained the relationship for LYMC shown in Figure 4-48 and expressed in the following equations:

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LYMC,K=TABHL(LYMC,T,AIPH,K,0,1000,40) 107, A
LYMC=1/3/3.8/4.4/4.9/5.4/5.7/6.6/6.9/7.2/ 102.1, T
7.4/7.6/7.8/8.2/8.4/8.6/8.8/9.2/9.4/9.6/9.8/ 10
LYMC - LAND YIELD MULTIPLIER FROM CAPITAL
(DIMENSIONLESS)
TABHL - A FUNCTION WITH VALUES SPECIFIED BY A TABLE
LYMC - LYMC TABLE
AIPH - AGRICULTURAL INPUTS PER HECTARE (DOLLARS/
HECTARE-YEAR)
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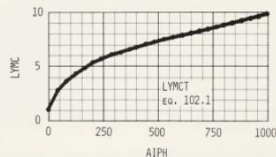


Figure 4-48 Land yield multiplier from capital table

As a rough check on the validity of this relationship, Taiwan in 1957 had "operating expenses" of 343 dollars for its average 1.6-hectare farm (Tsui 1959), or an agricultural inputs per hectare AIPH value of 215 dollars per hectare. According to Figure 4-48, Taiwan ought to have an average yield of approximately 3,000 (5×600) vegetable-equivalent kilograms per hectare-year, which compares reasonably well with the actual value of 2,540 vegetable-equivalent kilograms per hectare-year given in Figure 4-40.

As shown in Figure 4-48, World3 incorporates the assumption that yields will not continue to increase indefinitely as more and more capital is invested in agricultural inputs. The relationship chosen implies zero returns to additional inputs when agricultural inputs per hectare AIPH exceeds 1,000 dollars per hectare-year—a value roughly 30 times higher than the 1966 global average value.

Land Yield LY The land yield LY is the average total weight of crops (in kilograms) produced on a hectare of land in one year. In World3 the land yield LY is partly determined by the land fertility LFERT, which is defined as the weight of crops the land will produce in a traditional setting, using only traditional inputs such as human or animal energy and natural fertilizers such as manure. The land yield LY can be increased significantly above the land fertility LFERT by the use of modern agricultural inputs. The extent to which these inputs can raise yield is indicated by the land yield multiplier from capital LYMC.

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LY,K=LYF,R*LFERT,K*LYMC,K*LYMAP,K 103, A
LY - LAND YIELD (VEGETABLE-EQUIVALENT KILOGRAMS/ 103, A
HECTARE-YEAR)
LYF - LAND YIELD FACTOR (DIMENSIONLESS)
LFERT - LAND FERTILITY (VEGETABLE-EQUIVALENT
KILOGRAMS/HECTARE-YEAR)
LYMC - LAND YIELD MULTIPLIER FROM CAPITAL
(DIMENSIONLESS)
LYMAP - LAND YIELD MULTIPLIER FROM AIR POLLUTION
(DIMENSIONLESS)

LYF,K=CLIP(LYF2,LYF1,TIME,K,PYEAR) 104, A
LYF1=1 104.1, C
LYF2=1 104.2, C
LYF - LAND YIELD FACTOR (DIMENSIONLESS)
CLIP - A FUNCTION SWITCHED DURING THE RUN
LYF2 - LYF, VALUE AFTER TIME=PYEAR (DIMENSIONLESS)
LYF1 - LYF, VALUE BEFORE TIME=PYEAR
(DIMENSIONLESS)
TIME - CURRENT TIME IN THE SIMULATION RUN
PYEAR - YEAR NEW POLICY IS IMPLEMENTED (YEAR)
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The land yield factor LYF is simply a multiplier (normally equal to one and therefore inoperative) that allows the entire land yield calculation to be altered by a constant factor at any time chosen by the modeler.

Land Yield Multiplier from Air Pollution LYMAP A final factor affecting land yield LY is air pollution, which operates through the land yield multiplier from air pollution LYMAP. Pollution (defined in Chapter 6) interacts with the agriculture sector in two ways. The persistent pollutants (heavy metals, pesticide residues, and radioactive isotopes) represented in the pollution sector of World3 are assumed to affect land yield LY indirectly through land fertility LFERT after a long delay (described later in this chapter). But other pollutants that would disappear instantaneously (within a year) if their production ceased, most notably air pollution, are not included in the persistent pollution sector. Because the effects of air pollution on land yield can be significant, they are represented separately in the agriculture sector of the model.

The level of air pollution is closely related to industrial output IO (given a constant level of air pollution control technology) because the residence time for a particle in the atmosphere is only of the order of weeks. This air pollution may affect food output in two different ways: by actually reducing plant growth or by making food inedible because of its content of aerially supplied poisons.