productive system underlying those patterns. This section describes the fundamental concepts and definitions we found useful in modeling the operation of the global productive system in the capital sector of World3.

Classification of Capital and Output

For our study it was important to divide the constituents of GNP into groups of economic activities that have similar effects on the other sectors of World3—pollution, resources, and population. In World3 the criteria used to disaggregate GNP were the degrees to which an economic activity depletes nonrenewable resources and generates persistent pollution (as defined in Chapters 5 and 6). Specifically, we identified four categories of output:

1. Service output, the intangible component of GNP, is composed of activities that promote the population's health, education, culture, and so on. The utilization of service capital to produce service output does not deplete resources or generate persistent pollution.*
2. Agricultural output is the portion of GNP composed of those activities required to produce, process, and distribute food. The utilization of agricultural capital to produce agricultural output does not deplete nonrenewable resources but may generate persistent pollution.†
3. Production of nonrenewable resources is the component of GNP composed of activities needed to locate, extract, process, and distribute minerals and fuels. The capital required to obtain resources is considered a part of industrial capital.
4. Industrial output is composed of the total global stream of manufactured goods. The utilization of industrial capital to produce industrial output both depletes resources and generates persistent pollution.

The four categories are not perfectly distinct from each other. For example, any item of capital stock constituting social infrastructure, like a road, contributes to each of the four categories. However, most productive stocks and most activities can be related to one of the three capital categories. For example, in the year it is produced, an airplane intended for civilian transport appears as a component of industrial output. The airplane's manufacture causes some pollution generation and resource consumption, part of the total pollution generation and resource depletion caused by that year's industrial output. After construction the airplane is added to the service capital stock, where its use contributes to service output during its lifetime. The mere existence of the airplane does not cause pollution; only if the airplane consumes fuel (or spare parts or tires) does it generate pollution and consume resources. The fuel consumed by the airplane is produced by a fuel oil refinery whose output may be consumed by homes, factories, airplanes, and other users. The oil refinery is considered part of industrial capital, and its oil production is part of industrial output.

Since the process of constructing buildings to house educational or medical facilities may cause some pollution, construction facilities are treated as part of industrial capital. But little pollution and resource depletion are associated with the services provided by those buildings once they become part of the service capital stock. Similarly, the operation of a pesticide plant consumes resources, so the plant is categorized as part of industrial capital. Persistent materials introduced into the environment through the manufacture of pesticides are classed as industrial pollutants. Pesticides are agricultural capital. When this capital is used for agricultural output, the pesticides introduced into the ecosystem are classified as persistent pollution from agriculture.

While the stock of nonrenewable resources is calculated in a separate sector of World3, the capital allocated to obtaining resources (oil wells, mining equipment, smelters) is defined as part of the total industrial capital stock. Thus each of the nine major ISIC economic output divisions in Figure 3-2 is associated with a particular capital stock in World3. In our model the agriculture sector provides most of the output in the first ISIC division: agriculture, hunting, forestry, and fishing. The World3 industrial capital stock provides the output in ISIC divisions 2 through 5: mining and quarrying; manufacturing; electricity, gas, and water; and construction. Service capital in the model is associated with the activities listed under ISIC divisions 6 through 9: wholesale and retail trade, restaurants and hotels; transport, storage, and communication; financing, insurance, real estate, and business services; and community, social, and personal services. We have used these operational definitions of agriculture, industry, and services to convert the ISIC data presented by the United Nations (U.N. 1969) into a set of statistics on the economies of fifty-four countries. The data are presented in Figure 3-7 and will be used throughout this chapter to estimate the capital sector coefficients.

Columns 2, 3, 4, and 8 of Figure 3-7 are taken directly from the U.N. publication. Columns 5, 6, and 7 were obtained by summarizing the appropriate ISIC categories to obtain the total value of the agriculture, industry, and service components of GNP for each country. Each component of GNP (as defined in World3) was then divided by the country's total GNP to determine the relative share of each sector.

Basic Flows in the Productive System

Given the fourfold division of output we defined, it is possible to construct the summary flow chart of the goods and services involved in global production processes shown in Figure 3-8. (This figure would also apply to a single nation if exports and imports were added.)

The three capital stocks labeled agricultural capital, service capital, and industrial capital in Figure 3-8 represent the accumulated supplies of material equipment

*The manufacture of service capital is an industrial process and does therefore cause both resource depletion and pollution.

†The production of agricultural chemicals and equipment does deplete resources and cause pollution. This production is included in World3 as a component of industrial output. Thus fertilizer factories are part of industrial capital, but the fertilizer they produce is invested in the agriculture sector as a part of agricultural capital. The use of capital in the agriculture sector may cause significant deterioration in the globe's air, water, and soil resources.