PART III

MODELS OF ECONOMIC-ECOLOGICAL SYSTEMS

This part of monograph is concerned with models of economic-environmental systems (EES) and control problems for such systems. It is based on using economic, environmental and ecological models considered in two preceding parts of the book.

Estimation of the *negative economic impact on environment* contains the following aspects:

- degradation of environment due to consumption of renewable and non-renewable resources required for production processes;
- pollution into the environment by industrial and agricultural enterprises due to emissions of wastes and by-products to air, water, and soil, possibly causing environmental and human hazards (as well as due to transportation of goods and raw materials);
- land-use and pollution during construction, including temporary problems caused by transportation, equipment, etc.;
- environment contamination and acute hazards to man during abnormal operating conditions and accidents (explosions, toxic spills, nuclear power station breakdown, and so on);
- secondary environmental impacts due to changes in land use, population density, and social-economic structure around industrial centers;
- secondary environmental impacts due to consumption and eventual discarding of industrial products.

However, there is also a *positive economic impact*, i.e., environmental improvement as a consequence of industrial development. It may be direct (investments into environment) or indirect (due to increased revenues).

Another aspect of economic-environmental interaction is the *influence of environment on economy and man.* Many drawbacks arise already on the stage of choice and formalization of evaluation criteria for such influence. Rather shallow formulations like "creation of favorable living conditions", "achieving high quality of human population life", "rational harmonious development" do not give enough information for corresponding formal mathematical constructions. More concrete and usually used in practice approach is based on achieving prescribed sanitary norms (for water and air quality, radiation situation, and others). However, experience shows that such norms do not often match a "life quality" required, hence, they have to be subjected to careful mathematical scrutiny.

During last decades the *average human lifetime* is often used as an evaluation criterion for environmental influence on man. Such approach is connected with an aggregated modeling of the influence of environment state on population health. In so doing, a combination of qualitatively different ecological, economic and social factors has to be taken into account (water and air quality, foodstuff quality, degree of food and water supply, and so on). Some positive results in solving the problem can be achieved by means of statistical correlative methods, models of minimal risk, expert methods. However, in these cases mathematical description of the process remains to be implicit ("black-box" approach). It hardly gives a way to understand the essence of the interrelationship under study.

Modeling of total interrelationship of all mentioned factors is complicated problem with no satisfactory solution obtained by present. In the book we restrict ourselves to analysis of some rather known problems and models. Simple aggregate models of resource exhaustion and economic-environmental interaction are described in the Chapter 10. The analysis of more complex and real models accounting environmental impact of several economic factors mentioned above (so-called global models or world dynamics models) is provided in the Chapter 11. The Chapter 12 is concentrated on control and optimization problems in pollution propagation. In the Chapter 13 the influence of technological renovation on environment is analyzed. The last Chapter 14 is connected with the mathematical description of human control in ecological communities.