INTRODUCTION

The characteristic nature of water management requires a synergetic line of reasoning. The effects of human activities on water resources have great consequences for water users. The natural and social relationships are mutually dependent and are co-existent in place and time. The behaviour of resources and demands is frequently stochastic and non-stationary.

In addition to economic objectives, "intangibles" are increasingly involved in the evaluation of alternative procedures. The recent development of this trend is common to other world problems and intangible objectives are now given the same weight as economic effectiveness, or are afforded an even higher priority, which can influence the direction of optimization methods. However, caution is necessary, as the methods of optimization have become very sophisticated, and the results may be misleading or arbitrary.

The extensive world systems, water resource systems included, require new methods of treatment common to a number of scientific disciplines.

Probability and systems approaches are involved in the striking contemporary tendencies in scientific investigation and knowledge. It can be taken for granted that these tendencies will persist in the future development of scientific methods of cognition.

The natural, technical, and social sciences such as physics, astronomy, cybernetics, biology, economics, psychology, etc. include *probability conceptions.* The process of development and implementation of probability conceptions and methods has continued for about 300 years from the time of Pascal and Fermat. However, probability has long been considered a measure of lack of knowledge and not an objective property of phenomena and processes.

The penetration of probability and statistical methods of investigation into different areas of knowledge proceeded hand-in-hand with their development and perfection. The probability theories and ideas have been used by such recently developed branches of mathematics as information theory, game theory, operations research, the theory of reliability, etc. Max Born declared probability to be a fundamental physical concept.

Social and population statistics use probability and statistical methods for the investigation of the quantitative laws of human society. Statistical laws are, without hesitation, considered natural laws.

For cybernetics, which investigates the relationships of complex dynamic systems, the concept of probability is fundamental to the understanding of its principles and

associated ideas (information, organization, control, etc.). The deterministic approach is not adequate here and can be misleading; the correct alternative is the probability approach.

The *systems approach* assumes the holistic investigation of objects as a whole but also their separation into subsystems and elements, which facilitates the investigation of the structure, organization and functional behaviour of an object.

The object investigated is defined as a system; it is treated as a *whole* and its parts are not considered independently. Moreover, with respect to the behaviour of the object, the systems approach is interested in the total activity of the system even if change is considered only in a single or in a few parts.

As in other areas of scientific research, ancient Greek natural philosophy raised the questions inherent in the systems approach to the investigation of the world. The followers of Pythagoras, with their principle of the harmonic wholeness of the universe as one of the fundamental results of human reasoning, contributed to our understanding of the world (Volkov, 1975). According to van der Waerden, the new and characteristic feature of Greek mathematics was the systems approach, using a sequence of proofs of theorems. Dialectics, inherent in the systems approach, is one of the most important gifts of the Greek philosophers to mankind. They comprehended the world as the reflection of an infinite labyrinth of interrelationships and effects, where nothing remained what it was, where it was or how it was, but where all was in movement, changing, being created, rising and declining.

The systems approach can be defined as a comprehensive method of investigation of phenomena and processes, including their internal and external relationships. It thus meets the basic condition of the dialectical method which postulates that consideration of interrelationships is a necessary condition of correct cognition. Similarly, therefore, water resource systems cannot be identified and investigated without considering the internal relationships between their elements and their relationship to the system's environment, even if the separate elements and environment are known very well.

The systems approach can be used as a methodological tool in every branch of science; it is not the basis of independent scientific research with its own subject and method of investigation.

It is characteristic of the new scientific fields mentioned that the systems approach is closely related to the probability ideas concerning the structure and behaviour of complex dynamic systems. The principle of the structure and behaviour of complex systems having a probability character, it is evident that in their investigation both the methods mentioned have to be applied *simultaneously*, viz. the probability and the systems approaches, although the probability concepts were developed independently of the systems ideas. These relationships involve the need to analyse the concept of probability and the nature of probability relationships on the basis of the systems ideas.

In spite of the fundamental importance of the probability approach, there are, even now, some tasks where the deterministic approach is adequate and, on the contrary, some tasks where the use of the probability theory alone is inadequate. In problems of water resource systems there exist, together with the probability phenomena, certain (or almost certain) phenomena that can be expressed only qualitatively, or that are only partly recognised, if at all. According to the nature of these phenomena, probability or deterministic methods, but also heuristic and other methods or combinations of these, are applied in the investigation and optimization of the structure and behaviour of water resource systems.

However, the systems approach can never be disregarded in water resource treatment as it is the fundamental and most general standpoint. This view does not eliminate simplification of systems intended as a methodological instrument in their investigation.

New ways of planning, designing and operating extensive systems based on these ideas date from approximately 1960. The possibility of their practical application was related to the development of digital-computer hardware and software. The combination of the new scientific approaches and the use of computers constituted one of the great qualitative methodological achievements of our age. However, complete implementation requires more work to be done. As in every new, rapidly developing sphere, there is much uncertainty concerning the possibilities and manner of its application and further development – the new science has been established, is expanding, and the limits of its development cannot be foreseen.