Lectures 8,9,10( tutorial)

**MODELING OF WATER RESOURCES SYSTEMS**

**INTRODUCTION:-**

In this lecture we will discuss about the concept of a system, classification of systems and modeling of water resources systems.

**CONCEPT OF A SYSTEM**

A system can be defined as a set of objects which interact in a regular, interdependent manner. It is a collection of various factors arranged in an ordered form with some purpose or goal. A system is characterized by:

 A system boundary: Rule that determines whether an element is a part of the system or the environment

 Statement of input and output interactions with the environment

 Statement of interrelationships between the various elements of the system called feedback

State of the system represents the conditions or indicates the activity in the system at a given time e.g. water level in a reservoir, depth of flow. System analysis deals with arriving at the management decisions based on the systematic and efficient organization and analysis of relevant information.

**CLASSIFICATION OF SYSTEMS**

**Physical system**: One that exists in the real world Sequential system: A physical system with input, working medium and output

**Static system**: Output depends only on current input Dynamical system: Output depends only on current and previous inputs

**Time-varying system**: Kernel changes with time (A kernel is a weighting function used to estimate the probability density function of a random variable in a nonparametric way)

**Time-invariant system**: Kernel does not change

**Deterministic system**: Kernel and inputs are known

**Stochastic system**: Kernel and inputs are not exactly known

**Continuous-time systems**: Inputs, outputs and kernel vary continuously with time

**Discrete time systems**: Inputs, outputs and kernel are known at discrete times :

**HYDROLOGIC SYSTEM**

Hydrologic systems are distributed in time and space. Systems are divided into sub-systems for the purpose of solution. Hydrologic system is a physical, sequential and dynamic system. The input-output relationship can be expressed as: *y*(*t*) = Φ [*x*(*t*)] where *x*(*t*) and *y*(*t*) are time functions of input and output respectively; and Φ[] is the transfer function or the operation performed to transform input to output. For a catchment system, the input is water or energy of various forms and the transfer function may be the unit hydrograph

**SYSTEM ANALYSIS**

In system analysis an optimal plan is selected through a systematic search and evaluation of various alternatives that meet the objectives and constraints. System analysis consists of five steps:

 Defining the problem

 Identifying the system and its elements

 Defining the objectives and constraints

 Identify feasible alternatives that satisfy the above said constraints

 Identify the most efficient alternative that best meets the objectives

**Need for Systems Approach**

The system approach is necessary due to the following aspects:

 Water resource projects are large-scale and most of the times permanent ones

 They have huge impact on both society and economy

 They need the participation from various fields simultaneously

 Require large capital investments and hence have a major effect on economy

 Even a small improvement over traditional solution is thus desirable

Hence, the adoption of systems approach is better than conventional techniques based only on experience, to achieve an improved overall project output.

**ADVANTAGES OF SYSTEM APPROACH**

 Focuses on definite goals and objectives

 Systematic searching for alternatives

 Provides with modern technology to analyse the system scientifically and objectively

 Forces the user to identify the known and not readily known elements of the system

 Regularly provides feedback from each step thus providing flexibility for correction and modification

 Can deal with highly complex multi-objective multi-constraint problems

**DISADVANTAGES OF SYSTEM APPROACH**

 System approach is not suitable when there is a lack of proper and full understanding of water resources systems and its conflicting objectives

 Most of the decisions are irreversible in nature and hence hazardous if used without recognizing and integrating the quantitative and non-quantitative dimensions of the system (physical, social, economic, political etc)

 Can face some practical difficulties due to the gap between the theory and the practice. The transfer of technological advances to practical on field use requires professionals with both theoretical background and practical experience

 Most water resources systems are complex thereby demanding difficult mathematical computations

 Unavailability or high cost of software and also unavailability of a part of the data required

 Dealing with intangibles. Systems are not that simple to be fully expressed in mathematical terms

**MODELLING OF WATER RESOURCES SYSTEMS (WRS)**

Models are simplified representations of actual real-world systems through assumptions and approximations. Models can be classified as

(i) Physical model that designs the physical components of a project

(ii) Mathematical models that evaluate consequences of alternative plans by analyzing the various physical processes through arithmetical and logical statements

The features to be included and to be excluded will be decided by the modeller. Models are inexpensive and convenient. The accuracy of the model depends on the skill of the modeler and his/her understanding of the real system and decision making process and also on the time and money available. Models produce information - but not decisions. They aid planners and managers to improve their understanding and provide various alternatives that help in the decision making process.

Example: An example of system management is water quality problem in which the objective is to maintain certain quality standards throughout the stream. The stakeholders involved are Pollution Control Agency (PCA) and the dischargers (municipal and industrial). The goal of PCA is to improve the water quality while that of the dischargers is to reduce the water treatment cost. This necessitates the need for a waste load allocation model with multiple objectives and conflicting constraints. Modeling is not suitable for each and every water resources planning and management problem. It is appropriate when:

 The objectives are well defined and beneficiaries (organizations and individuals) are identified

 The best decision is not obvious among various alternatives that satisfy the stated objectives

 The system and objectives can be expressed reasonably through mathematical representations

 The impacts (hydrological, economic, environmental and ecological) resulting from the decision can be better estimated through the use of models

 The data is readily available for the estimation of parameters of the model

The main challenges for any planners and managers are to:

 identify creative alternative solutions

 find out the interest of each group involved in order to reach an understanding of the issues and a consensus on what to do

 develop and use models and reach a common or shared understanding and agreement that is consistent with the individual values by presenting the results

 make decisions and implement them duly taking care of the differences in opinions, social values and objectives

**SYSTEM DECOMPOSITION**

A real WRS is a complex system with multiple objectives and decision makers, numerous variables and parameters, large spatial and temporal data base, numerous sub-systems and nonlinear complex relationships among variables. While modeling, first the system is Water Resources Systems Planning and Management:

decomposed into various subsystems.

One such method is the Hierarchical approach by Haimes (1977) in which the complex large-scale systems are modeled by decomposing into independent sub-systems through the concepts of levels and layers. There are four major types of decompositions: temporal, physical-hydrological, political-geographical and goal-oriented or functional. **Temporal:** Normally planning horizon of WRS projects span large periods. In such period, the system conditions drastically change with time. Therefore, planning is done by segmenting the time periods. However, these segmented plans should be compatible and coordinated with each other. **Physical – hydrological:** Water resources program may consider several river basins. Instead of considering the entire basin together, each basin can be divided into sub-basins while modeling. **Political - geographical:** The basin considered may cover two or more national territories or different political or administrative units. These can be decomposed considering either political or natural boundary. **Goal oriented or functional:** Analysis is done with respect to economic and functional goals. For example, Demand – Supply models, Irrigation, Hydroelectric models.

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