CHAPTER 1

INTRODUCTION

Mathematical models of watershed hydrology have become an essential tool for planning, development and management of water resources. They are being used to analyse quantity and quality of streamflow, groundwater development and protection, surface and groundwater conjunctive use and a range of water resources management activities (Singh and Woolhiser, 2002).

Hydrological modelling involves quantification of water fluxes among different components of hydrological cycle. This requires modelling of wide range of inter-related processes such as rainfall, evapotranspiration, infiltration, overland flow, channel flow and groundwater recharge etc. Simultaneous evaluation of all these complex phenomena, based on physical laws, has never been achieved so far. The rational approach has been, to model these components individually and transfer the fluxes at the interface of two interacting components as a boundary condition. Chow *et al.* (1988) advocated the use of simplified approach, *the system concept*. The hydrologic cycle may be treated as a system that has different components as sub-systems to represent the hydrologic phenomena. Each sub-system is treated separately and the results are then combined to get the system response.

The first hydrological model was probably introduced by Mulvany (1850), popularly known as **rational method**. Since then, the hydrological modelling has traversed a long path. First half of twentieth century saw development of a large number of empirical and conceptual hydrological models (Blackie and Eeles, 1985). These models, built on either black box or grey box approach, require long historical records and have no physical basis. They try to find a relationship between historical inputs (e.g., rainfall) and outputs (runoff measured at the watershed outlet). However, non-transferability of their parameters restricts the domain of their application to the specific problems they were designed for.

To overcome this limitation, there is growing trend towards the development of distributed physically based models. In physically based models, the flow of water in the individual processes is defined by equations, which have direct physical significance. Since they represent the physics, they are best understood (Freeze and Harlan, 1969). Their parameters are physically measurable in the field; they can be calibrated with few sets of data and are applicable for a wide range of watersheds. Apart from rainfall-runoff relationship, they provide details about water availability at different stages in space and time. This makes them acceptable for wide range of purposes like irrigation planning, design of hydraulic and water conservation structures etc. Consequently, a large number of physically based watershed hydrology models have been developed around the world (Bureau of Reclamation, 1991; Singh, 1995; Wurbs, 1998).

In the 150th Anniversary Paper of the American Society of Civil Engineers, Singh and Woolhiser (2002) provided a historical perspective of hydrologic modelling of watershed and included a sample of popular hydrologic models from around the globe. They discussed various models being used in United States, Canada, Australia, Europe, China, Italy, Japan and Scandinavian countries. However, there was no mention about any model being popular in Indian subcontinent. This exemplifies the fact that in spite of recent advancements in technology and exponential increase in computational speed, physically based hydrological modelling has failed to pickup momentum in Indian sub-continent.

The reasons for laggard adaptation are manifold, the most important being the cost of the model itself. It becomes really difficult for water management agencies involved in decision making to acquire, implement and maintain these models in developing countries scenario. The second major reason is unavailability of code. The model has to be applied "as is", with no or limited scope of incorporating future changes in the watershed.

Though, a few models are available free of cost, even with the source code, these lack a user-friendly Graphic User Interface (GUI). With the advances in Geographic Information System (GIS) and remote sensing technologies, the information like

Digital Elevation Model (DEM), soil and land use maps etc are easily available / obtainable. Since the distributed hydrological modelling requires spatially distributed information, the use of GIS tools is the most appropriate technology for input database management and visualization of outputs.

In India, attempts have been made (Jain *et al*., 2004; Mishra *et al*., 2008) to develop site specific hydrological simulation models, which describe hydrology of selected area, but limited efforts have been made to develop general purpose software for hydrologic simulation of watershed. Panigrahy (2002) developed a physically based model (HYDROMOD) and used it to describe the hydrology of single rainfall event for the selected watershed. The model performed well, and quantified various components of hydrological cycle like infiltration, evapotranspiration, overland and channel flows. However, being event-based, the model ignores the effect of relatively slow process of groundwater changes. Moreover, the model cannot be used for seasonal water budget planning of the watershed. Thus, there is a need to develop user friendly software package with GUI and GIS capabilities for hydrologic simulation of the watershed.

In view of the above facts, the present research programme is undertaken with the following specific objectives.

- To develop of a physically based, distributed hydrological model having a GIS integrated graphic user interface.
- To test the efficacy of the developed model for a test watershed.