SIMULATED FLOWS IN HIMALAYAN RIVERS

In the Himalayan basins, precipitation falling as snow during winter period accumulates in the basin and snow pack is developed. Depending upon the climatic conditions, the snow pack depletes either fully or partially during the forthcoming summer season. Because of variation in climatic conditions and changes in the aerial extent of snow-covered area with time, the contributions from the rain and snow to the streamflow vary with season. Streamflow gets higher share from snowmelt during spring and summer. The contribution from rain dominates in the lower part of the basins (altitude < 2000 m). The middle and upper parts of the basins (altitude > 2000 m) have contribution from both, rain and snowmelt and their contribution changes with altitude. As the elevation of the basin increases, rain contribution to streamflow reduces but snow melt contribution increases.

After depletion of seasonal snow, melt runoff is generated from the glaciers. Runoff is dominated by the snowmelt runoff and glacier melt runoff above 3000 m altitude. Different components of runoff make these rivers perennial in nature.

The annual water yield from a high Himalayan basin is roughly double than that of an equivalent size basin located in the Peninsular part of India. A higher water yield from the Himalayan basins is mainly due to the large water inputs from the melting of snow and glaciers. Himalayan basins have very high potential of hydropower generation due to its topographical characteristics and available water resources, particularly in the form of snow and glaciers. A number of hydropower projects exist and are being proposed at the potential sites on the Himalayan Rivers.

The streamflow of Himalayan Rivers is integrated runoff generated from different sources. The process of generation of streamflow from such basins involves primarily the determination of the input derived from snowmelt and rain, and its transformation into runoff. The National Institute of Hydrology, Roorkee has developed a conceptual snowmelt model (SNOWMOD) for simulating the streamflow of snowfed rivers.

TECHNOLOGY

The conceptual snowmelt model (SNOWMOD) is designed to simulate daily streamflow components (rainfall, snow melt and baseflow) for the mountainous basins having contribution from both,

snowmelt and rainfall. The model is designed primarily for the snowfed basins and conceptualises the basin as a number of elevation zones depending upon the topographic relief. Various hydrologic processes relevant to snowmelt and rainfall-runoff are evaluated for each zone.

Keeping in view the poor availability of meteorological data in the high altitude region of Himalayan basins, precipitation, temperature and snow cover area data are used as inputs to the model. Temperature index or degree-day approach has been used to compute the snowmelt in the basin and heat content supplied by the rain is also incorporated.

A part of the rainfall and snowmelt contributes to the direct surface runoff. The remaining water contributes to soil moisture of the unsaturated zone. As soon as the soil moisture content reaches to the field capacity, additional infiltrated water contributes to the groundwater storage as ground water recharge. The groundwater contributes to streamflow in the form of baseflow with much delayed response. A part of the soil moisture is depleted because of evapotranspiration. The routing of surface runoff components is carried out separately for snow-covered area and snow-free area because their hydrological response is different and also the extent of each of them varies with time. Three components together

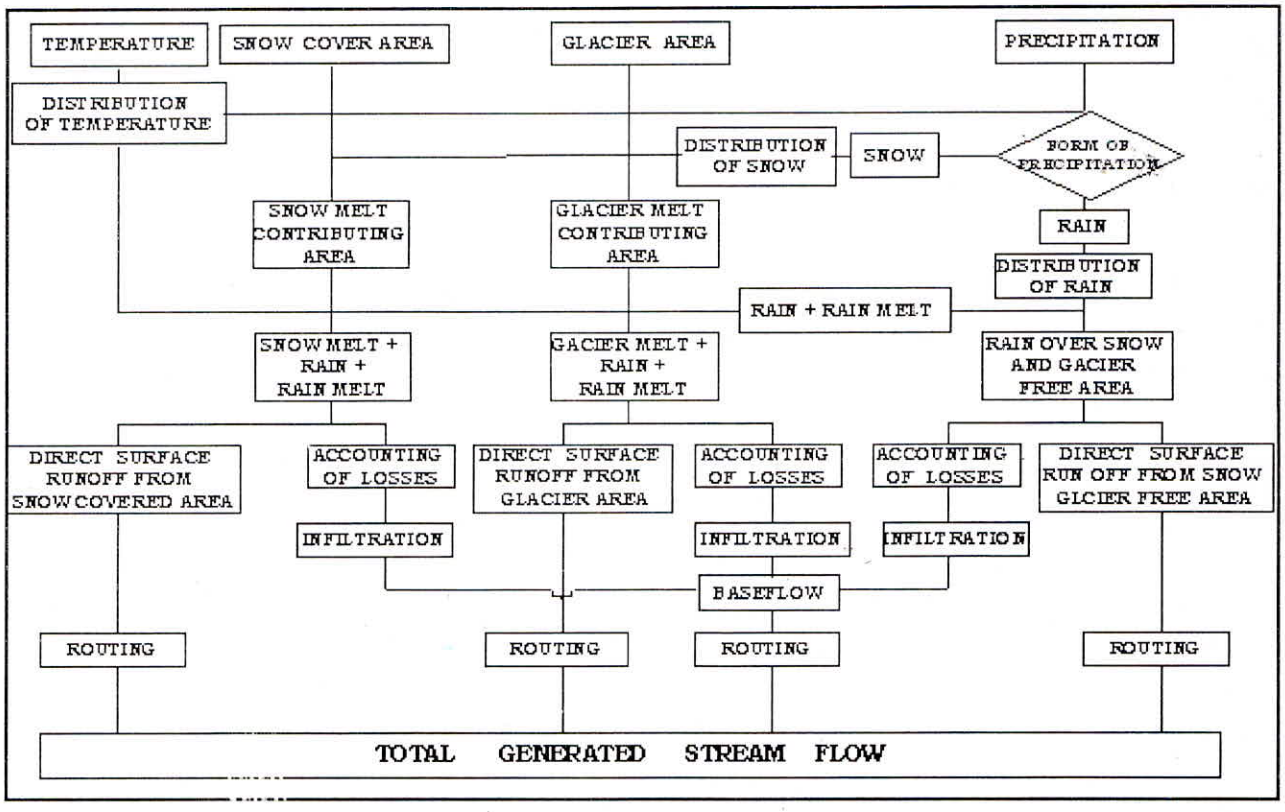

Figure – 1 Flow chart of *SNOWMOD*

constitute the total runoff from the basin. The model has been calibrated and validated for few Himalayan basins. The model structure is given in Figure-1.

The ability of the model to simulate snowmelt runoff and rainfall runoff separately enabled to estimate the contribution of each component to the seasonal and annual streamflow. The model can be applied to estimate the contribution from snowmelt and rainfall into seasonal and annual flows.

ENVIRONMENTAL IMPACT

It will not have any adverse effect on the environment.

ECONOMICS

The model can be used to estimate the water availability at potential sites for small, medium and large multipurpose projects. In case of completed projects, it will provide the tangible and intangible benefits. A better planning and utilization of available water resources would improve the economy of the region/country.

BENEFICIARIES

All organizations dealing with development, planning and management of water resources in the Himalayan region, including those involved with hydropower and irrigation, will be benefited by such studies. Beneficiaries include Bhakra Beas Management Board (BBMB), Electricity Boards, Public Health and Irrigation Departments of the States like, Jammu and Kashmir, Himachal Pradesh, Uttaranchal etc.

INTELLECTUAL PROPERTY RIGHTS

The methodology and the software have been developed at the National Institute of Hydrology, Roorkee. Therefore, the Institute owns the Intellectual Property Rights for this technology.