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A preliminary assessment of the role of glaciers in the hydrologic regime of the Nepal Himalaya

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The hydrologic regime of the Himalaya is not well-defined and there is a lack of a basic data to support the understanding of the runoff sources and timing in many mountain rivers of the region. Because of this absence of data, applying of hydrologic concepts and models developed for mountain catchments in Europe or North America is often impossible and likely to be inappropriate. Thus, determining the impact of the retreat of Himalayan glaciers on regional-scale water supplies is problematic. Current concerns about the retreat of Himalayan glaciers have been accompanied by little, if any, comprehensive analysis of the actual role of glaciers in the total hydrologic regime and such assessments have typically disregarded mass balance relationships across the approximately 3,000 meters of topographic relief between the glacier termini and the highest accumulation zones. The ultimate purpose of the study described here is to assess, and begin to quantify, the role of complete glacier systems in the hydrologic regime of the Nepal Himalaya, and to develop estimates of the potential impact of a continued retreat of these glaciers.

There are approximately 3250 glaciers in the Nepal Himalaya, covering an area of slightly more than 5,300 km2, and containing some 460 km3 of ice. These glaciers cover approximately 4% of the total 147,000 km2 surface area of Nepal, and are located on, or near, the crest of the Himalaya, with the bulk of the ice contained in basins that are at altitudes generally between 4,000 – 6000 meters above sea level. In this study we apply methods which disaggregate available data sets to reflect the altitudinal gradients that define the mountain hydrologic regime. For glacier mass balance estimates, the input variables are: 1) surface areas of both basins and glaciers, 2) basin and glacier area-altitude distributions, 3) glacier equilibrium line altitudes, 4) slope of the ablation gradient for the glaciers of Nepal, 5) maximum altitude of the 00 C. isotherm each year, and the altitudinal range through which it moves annually. For orographic runoff estimates, the variables are: 1) area-altitude distribution of each catchment basin studied, and 2) disaggregated hydrometric data, to reflect the importance of scale and location in the analysis of mountain hydrologic systems.

The ablation gradient, the rate of increasing specific ice melt with decreasing altitude in the ablation zone, is determined to be 1.4m/100m, a probable value for the latitude of the Nepal Himalaya based on measurements found in the literature which are representative of a range of latitudes. The mean maximum altitude of the 00 C. isotherm during the ablation period is approximately 5400 m, determined by extrapolating low altitude air temperature values. This altitude defines the location of an equilibrium line altitude (ELA), the dividing line between zones of net accumulation and ablation on the glacier surface. The volume of ablation between the ELA and the glacier terminus is estimated as the product of specific ice melt values taken from the ablation gradient and the area-altitude values of corresponding belts in the glacier ablation zone. The resulting mass balance calculations are considered to be "best-estimate" meso-scale approximations which could be refined with field measurements.

It is currently estimated that the contribution of glacier melt water to annual streamflow volume in the study area varies among catchment basins from 2-13% of total annual flow measured at low altitude hydrometric stations, and represents 2-3% of the total annual streamflow volume of the rivers flowing out of Nepal. The preliminary results from this continuing study indicate that this relationship will not be affected significantly in the near future by a continued retreat of the glaciers.