

HYDROLOGICAL ASPECTS OF THE HIMALAYAN REGION



Donald Alford

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Foreword

This paper was initially prepared by the author for the "International Symposium on Mountain Environmental Management in the Hindu Kush-Himalayan Region", which was organised jointly by ICIMOD and UNESCO/MAB at ICIMOD Headquarters during April 1989. It was subsequently revised by the author in its present form. This paper deals essentially with two major aspects of water resources in the Himalayas, viz, (i) the impact of human use of the natural environment on the hydrological regime of watersheds in the Himalayas, and (ii) analysis of existing data of the Kosi Watershed of Eastern Nepal, as an illustration of examination of the interactions that have an impact on the water budget of a mountain watershed in the Region. As the author has pointed out, *'primary data describing water resources are essentially unavailable for the Hindu Kush-Himalayan Region'*. However, it is also seen that even available data have not been well analysed to understand the hydrological aspects of major or minor rivers in this Region.

It is hardly necessary here to emphasise the importance of water resources in the overall development of the Hindu Kush-Himalayan Region. As the world's highest towers of snow and ice, the Himalayas are also the largest storehouse of fresh water and sources of such mighty rivers as the Indus, Ganges, Brahmaputra, and Mekong. As the abode of snow, as their very name suggests, they have not only been the sources of these mighty and perennial rivers but have been the sustaining sources of major ancient civilisations in these river basins also.

Despite the vast regional potential for development of water resources for multifarious uses, scientific understanding of the complex interaction between natural forces and human impact on the hydrologic regimes in these highly energised and sensitive mountain environments are far from adequate. Furthermore, the unique combination of extreme factors, such as intense seasonal precipitation and highly steep topography due to a sharp rise in altitude within a narrow width, has not only inhibited the collection of data in the difficult mountain watersheds, but has also placed serious limitations on the use of standard hydrological principles, techniques, and models which are basically developed in the more temperate and less extreme environments of Europe and North America. Thus it is not possible to apply general solutions developed elsewhere to the hydrological problems of the Region, as is emphasised by the author in his conclusions. The paper also indicates that simple models could probably be developed to deal with such problems and improve the use of resources for development.

I am happy to say that ICIMOD is already engaged actively, jointly with the UNESCO/IHP and in cooperation with national institutions of the participating countries of ICIMOD and the WMO, in developing a **Regional Programme on Mountain Hydrology** in the Hindu Kush-Himalayan Region. This joint initiative has been welcomed by all concerned.

In the above context, I hope that the publication of this paper will help towards a better appreciation of the problems associated with proper understanding of the hydrological processes in the Himalayas which affect both the uplands and lowlands in the Region. It might also help towards realisation of the urgent need for regional cooperation and international support for the ongoing and proposed programmes on hydrological studies in the Region, such as the one already initiated jointly by ICIMOD and UNESCO/IHP. It is also hoped this publication will be of use not only to hydrologists but also to all those who have interest in the development of water resources in these complex mountain environments.

Dr. E. F. Tacke
Director General

Preface

The countries of South Asia -- Pakistan, India, Nepal, Bhutan, and Bangladesh -- are dependent to varying degrees on the annual cycle of water flowing into, through, and from Himalayan and Trans-Himalayan mountain ranges. Though water resources of South Asia are of obvious importance in the development of the region, the flow of water through Himalayan watersheds has received almost no serious scientific consideration.

In general, mountain hydrologic systems are relatively unstudied. Where studies have been undertaken, as in the European Alps or the mountains of western North America, only a few workers have attempted regional generalisations. Most of the information has been presented as site-specific studies of individual basins. The bulk of the results discussed in the technical literature has been obtained from so-called "black-box" studies of basins of relatively small size. Such studies commonly consider only a single relationship; such as that between changes in vegetation cover and the resulting changes in streamflow or sediment transport. Such studies lump all other controls on the water or sediment balance together as an unstudied variable -- the "black-box". Black-box studies are very difficult to generalise. It is often the case that factors that are critical in determining variations in the water or sediment budget of a basin -- such as climate -- are varying simultaneously with the control under study.

The initial impetus for the present study was provided by a request from Dr. Colin Rosser, the former Director of ICIMOD, to prepare a paper on water resources and environmental management for a Workshop on Mountain Environmental Management, jointly sponsored by ICIMOD and UNESCO/MAB. Both the purposes of the workshop and the nature of this paper changed over the course of time. From a study of the role of environmental management in managing the water resources of the Hindu Kush-Himalayan Region, the focus of the study gradually narrowed to a consideration of the hydrometeorological aspects of a smaller part of the region -- the Nepal Himalayas. The final result reflects concerns that existed or evolved during the preparation of the paper, namely that:

- the relationship between human use of the natural environment and subsequent changes in the hydrologic regime of Himalayan watersheds has not been well-defined; and
- the existing data bases describing this relationship for the region have not been analysed in any meaningful way.

This paper represents an attempt to consider the water resources of the Himalayan Region from these two aspects: (1) what are the basic interactions that determine the water budget of a mountain watershed in the region and, specifically, (2) what do the data bases tell us about the nature of these budgets? In many ways, these are not compatible topics. A consideration of basic water budget interactions in any environment involves a discussion of the most elementary hydrometeorological and geomorphological principles, while an analysis of the existing data bases represents a higher level of sophistication. Of necessity, this means that the paper will contain aspects of interest to at least two very different audiences. I hope that readers from both professional and lay audiences will recognise the needs of the other, as well as the fact that far too much time has passed without any serious discussion of either aspect of the problem of water resources' development in the mountains of South Asia.

For a variety of reasons, primary data describing water resources are difficult to obtain for the Hindu Kush-Himalayan Region. This paper, therefore, is based almost exclusively on secondary sources of information. Emphasis has been placed on the nature of the concepts associated with the interpretation of water resources' data and the bulk of the references cited in the text deal with the literature describing these concepts in more detail. In almost all cases, references are only single illustrative examples of an extensive literature describing the sciences of hydrology, climatology/meteorology, and fluvial geomorphology. They are included primarily to direct the interested reader to this literature. The discussion of the water resources of eastern Nepal is based upon specific data available in publications of the Government of Nepal.

Much of the data upon which this study is based were assembled and organised during the Spring of 1989, during which time the political differences between India and Nepal forced a virtual closing of ICIMOD. The bulk of the manuscript, therefore, has been written from my home in Montana, USA. I would like to thank Dr. Colin Rosser for making this study possible. I am particularly grateful to Prof. Suresh Raj Chalise for his patient encouragement. Thanks, too, to Dr. Corneille Jest who helped me keep my sense of perspective. In fact, there are far too many people who helped me through the data collection phase of this study to be listed, and I hope that each of them remembers something of what we shared.

Donald Alford

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